Project for International Math-teacher Professionalization Using Lesson Study at Tokyo Gakugei University

A non-profit corporation dedicated to the collaborative improvement of teaching and learning

IMPULS - LSA
Lesson Study Immersion Program 2019
Final report

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1. Introduction

The lesson study immersion program(LSIP) is 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 to discuss how to improve mathematics teacher professional development programs. To accomplish this, participants immerse themselves in authentic Japanese lesson study and to observe mathematics research lessons in elementary and lower secondary grades.

Since 2012, IMPULS (Project for International Math-teacher Professionalization Using Lesson Study at Tokyo Gakugei University) organized LSIP every year funded various support organizations, Ministry of Education, Culture, Sports, Science & Technology of Japan(MEXT) ;2012-2016, Tokyo Gakugei University; 2012-2018, Mills College Lesson Study Group for "Gates School-wide Lesson Study Project" by Gates foundation; 2017, Lesson Study Alliance; 2018-2019 and individuals. These supports over 8 years allowing 271 participating international educators to go through the immersion program from 11 different countries including U.S.A. (177), U.K. (44), Netherlands (20), Australia (12), Singapore (9), Malaysia (3), Ireland (2), Portugal (2), Canada (2), Qatar (1) and Switzerland (2).

Table 1. Number of participants and country

			Number of participants and country (*number of participants whose particpnation and accomodation fee had not covered by TGU's b										
JFY	Number of applicants	Total number o participants	U.S.	U.K.	Australia	Singapore	Malaysia	Irealand	Qatar	Netherland	Portuguese	Canada	Switzerland
2012	48	44	38 (20)	2	2	2	-	-	-	-	-	-	-
2013	17	17	10 (1)	5 (1)	2	-	-	-	-	-	-	-	-
2014	17	16	10	4	2	-	-	-	-	-	-	-	-
2015	45	27	8	11 (5)	3	-	2	2	1	-	-	-	-
2016	50	34	12	11 (5)	3	2	1	-	-	2	2		1
2017 June	29	29	22 (22)	7 (7)	-	-	-	-	-	-	-	-	
2017 November	30	29	4 (4)	-	-	5 (5)	-	-	-	17 (17)	-	2 (2)	1 (1)
2018	45	42	38(38)	3(3)	-	-	-	-	1(1)	-	-	-	-
2019	37	33	31(31)	1(1)						1(1)			
Total	318	**271**	177 (115)	44 (22)	12 (0)	9 (5)	3	2	2(1)	20 (18)	2	2 (2)	2 (1)
※ 1 external evaluator is included in the total number of particiants													
※There were more applicants but no exact data of U.K and U.S. because they had preliminaly selection to apply.													

Participants in the 2019 LSIP used a combination of self-funding and funding obtained from institutions. A total of 33 participants attended the program; 31 from the U.S. ,1 from the U.K. and 1 from the Netherland. The 10-day immersion program focuses on in-school observations and discussion, along with follow up meetings with IMPULS faculty.

This report provides information about the visible program features of the 2019 program and profiles the participants that attended. It summarizes, by referring to the Shelley Friedkin and Laura Henn's way of describing in the *IMPULS Lesson Study Immersion Program Final Report of 2017*(http://www.impuls-tgu.org/cms/uploads/File/news-letter/2017report.pdf), 3 of key pathways of impact on participants' beliefs and dispositions as derived from their written reflections, written lesson reports and responses to survey questions. The report also reveals changing participants' view for Lesson Study which may possible to effect to accelerate Lesson Study cycle of participants' working community.

A detailed appendix including participant and faculty information, program schedules, and presentation can be found at the end of this report. School research reports, research lesson plans and participants completed lesson reports are also included.

2. Participants

Geographic/occupational identities

33 participants attended the program; 22 teachers, 7 University-based professionals, and 4 professionals working in roles that support teachers (3 math coaches and 1 mathematics textbook providers). Of the 22 teachers attending 4 were Kindergarten, 14 were Grade 1-6, 3 were Grade 7-12, 1 was principal (figure 1). Of the 33 total, 31 participants were from the U.S., 1 from the U.K. and 1 from the Netherland. Five U.S. schools were participated as a group of more than 3 teachers: 3 schools in San Francisco Unified School District (SFUSD), 1 school in Oakland Unified School District (OUSD), and 1 school in Chicago Public Schools (CPS). Referring to application information, 32 out of 33 participants had teaching experience of K-G12 level at least 2 years (figure 2).

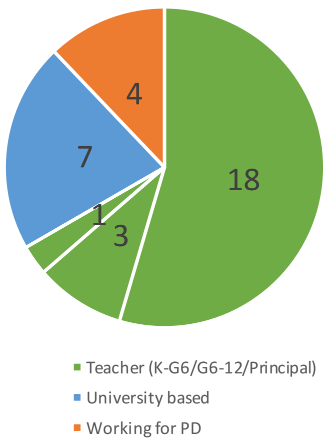


Figure 1; Current role of participants
*as of the day of application

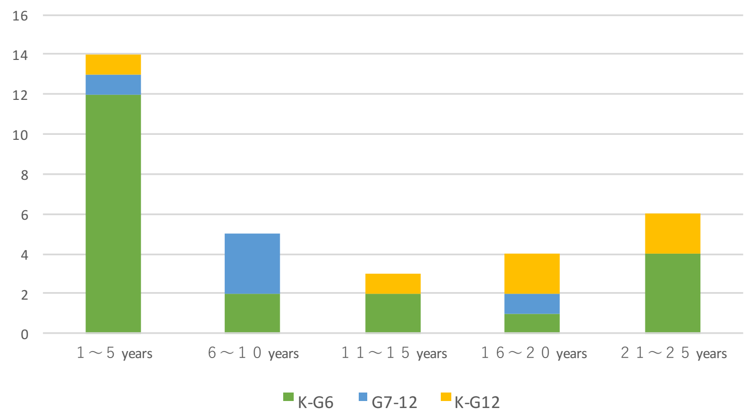


Figure 2 "How many years of teaching experience do you have (and at what grades)?"

Prior experience with lesson study

Participants had different levels of experience with lesson study: 4 participants had limited prior experience except introducing about Lesson Study or using some part of Lesson Study process in the university level, 4 had less than a year of experience of school-wide Lesson Study, 8 had between one and three years of experience, 2 had over ten years of experience, and rest of all 14 had experience of observing research lessons and/or teaching research lessons although they didn't specified years of experience. 3 out of 33 participants had prior experience of observing Japanese Lesson Study: 2 had at Futabakai Japanese Elementary School and 1 had at LSIP 2018.

3. Preliminary Assignments for Program

One month prior for participating the program, all participants were asked to read the following three articles and write short insights.

- Takahashi, A. (2014b). Supporting the Effective Implementation of a New Mathematics Curriculum: A case study of school-based lesson study at a Japanese public elementary school. In I. Y. Li & G. Lappan (Eds.), Mathematics curriculum in school education (pp. 417-441). New York: Springer.
- Fujii, T. (2016). "Designing and adapting tasks in lesson planning: a critical process of Lesson Study." ZDM: 1-13.
- Takahashi, A. (2008). Beyond Show and Tell: Neriage for Teaching Through Problem-Solving – Ideas from Japanese problem-Solving Approaches for Teaching Mathematics. Paper presented at the 11th International Congress on Mathematics Education in Mexico (Section TSG 19: Research and Development in Problem Solving in Mathematics Education). Monterey, Mexico.

At this moment what questions do you have about school-based lesson study in public schools in Japan?

There are various questions about school-based lesson study are raised based on their prior experience, knowledge and reading of assigned articles. These questions were sorted 7 categories below. 1) -3) are related to community involvement and 4)-7) are related to each steps of lesson study.

1) Participation of different grade level and/or subject teachers.
   - *Do lesson study teams ever form when the grade-levels are not close together?*
   - *What does this look like for kindergarteners?*
   - *Is it as powerful at the high school level and what changes, if any, would make sense to implement for that specific audience?*
   - *How adding non-math teachers to the post discussion changes things and enhances them.*
2) Building time and community.
   - *Is most of the collaboration work done outside the work day?*
   - *Are teachers paid for their time?*

- *Do the teachers control what will be done during this time or it is directed by administration?*
- *I was also curious about the SRC and how this group of teachers is formed.*

3) Involvement university-based professionals.
    - *How are Japanese schools are cooperating with universities during the executing of the Lesson Study-cycle?*
4) Setting goal and selecting content of lesson study
    - *I'm curious about the research themes and theory of studies that Japanese schools explore. Do Japanese schools also get more specific with their themes and theories of study?*
    - *How do you decide what content to focus on?*
5) Lesson planning
    - *Does the teacher who is teaching lesson need to necessarily create a draft lesson plan in order to allow the meeting time to be used wisely for planning the research lesson?*
    - *Is it common for the teacher to generate the draft lesson plan on their own prior to the first planning meeting*
6) Data collection and showing result
    - *What kind of data is collected? What is the rigor on collecting and analyzing data? How is this data processed and presented?*
    - *How can schools present an effective method of showcasing our findings and learning during lesson study in a meaningful and clear manner to share with educators and parents?*
7) Post lesson discussion
    - *What strategies can be used with teachers to promote meaningful discussions during the post-lesson discussion?*
8) Others
    - *Is lesson study primarily used for math or is it done in other subjects there as well?*
    - *Do pre-service mathematics teachers learn the lesson study model when they are preparing to become teachers in university credentialing programs?*
    - *I am curious to learn more about the mentioned "demonstration lesson" by an invited teacher.*

In addition to above, there were many questions related to teaching through problem solving especially for *Neriage* and summary phase.

Please share your ideas for your school to extend lesson study to school-wide professional development after reading the articles?

Participants reported their various ideas for school-wide professional development. These ideas were sorted 4 categories below.

1) Encourage all teacher to participate by;
   - encourage teachers to work with grade-band team, but not single grade alone
   - set a bulletin board or publish news letters to share discussion points and progress or results throughout the process of lesson study
   - involve other subject teachers and special needs education teachers
   - making small group of teachers who are realizing the importance of problem solving
2) Deepen teacher's understandings about lesson planning by;
   - asking teachers to reflect the traditional American approach and teaching through problem solving approach using *neriage*, to proceed to a discussion about the usefulness of planning out student responses and structuring the group discussion
   - working together to solve the problems and anticipate responses with all of which are either misconceptions or approaches based on past experience that students might use
3) Involve administrators and parents for;
   - managing time to meet all teachers
   - managing the students' release time with parents support
   - networking with other schools
4) Use lesson study as;
   - initial teacher training programs
   - professional development days with public research lessons for other school teachers to observe

What is the nature of Neriage and why Japanese teachers believe its important for teaching mathematics?

29 out of 33 participants summarized about Neriage from the view point of nature of Neriage, teachers' role for Neriage and expectation for students as shown below. All replied participants seemed to grasp overall feature of Neriage by using their own paraphrase (Table 2).

Table 2; Nature of Neriage (before participating the program)

What is the nature of Neriage ?
1) Nature of discussion
crafting/facilitating the whole group discussion
discussion led by the teacher
post listen discussion
extensive discussion with students facilitated by teacher.
creating, crafting and coaxing discussion around math.
heart of the whole culmination of the students' learning and teachers' own display of knowledge/skills and their professional development
mathematical learning happens through conversation and connection making
curated and orchestrated experience
students to have equal opportunities to learn mathematics.
2) Students work / idea
share and discuss how they solved the problem.
solutions are the foundation to build Neriage
very purposeful piecing together of all of the students work
ideas are disected by the students from the anticipated list of responses.
about the similarities and differences between students' solution paths with the goal of deepening students understanding of and skills in mathematics
compare the ideas and mathematical thinking presented by the children to deepen their understanding of what is a reasonable and efficient strategy.
connections are made for students
connections between prior and new learnings are made
analyzing the strategies presented by their peers.
helps students with any misunderstandings by comparing and discussing students' different and varied approaches.
polish student ideas.
3) Learning objective
sum up the objective of what they the big take away is from the lesson of the
develop the content goal of the lesson
mathematical ideas get developed
ideas get deepened and developed.
leads to understanding of new mathematical concepts.
conceptual learning and understanding should take place.
further their understanding of the content
develop deeper meaning into the content
ensure that students come out of a lesson with new understandings of content
guided to develop deeper mathematical understanding
creating a more concrete understanding

Especially 3 participants noticed necessity of careful planning to organize Neriage, at this moment before participating the program (Table 3).

Table 3; Role of teacher for Neriage (before participating the program)

Teacher will/need to…
1) Teachers' role during Neriage
teacher faciliciates a discussion
steering the direction of the learning towards the content goals and problem
help facilitate and orchestrate student talk
led discussion that compare and contrast similarities and differences between the strategies that students have demonstrated on the board.
facilitate the students' rich discussion while comparing and analyzing their peers' work and problem-solving methods.
teacher highlights the student's shared work and thinking to push the conceptual understanding of the desired mathematics.
teacher uses the students prior knowledge to deep in mathematical
facilitate conversation between their students that help them connect to prior learnings, connect their ideas to other classmates, and to further their understanding of a mathematical concept past just getting the answer
use the students own work as a basis for teaching new mathematical concepts which gives students more ownership of their learning process.
highlights important mathematical ideas and concepts which is the vital part of Neriage to try and meet the goals of the lesson.
highlight or ask a question that leads to deeper thinking and learning of mathematical concepts and ideas
teach new math ideas by using the students' work.
address common misconceptions
synthesize strategies shared by various students, both low achieving and
2) Teachers' role for planning Neriage
by anticipating strategies teachers are able to facilitate a meaningful discussion that brings out the lesson goal.
teacher aids in the development of student thinking around the lesson's topic through strategic planning of boardwork and how we can utilize strategic questioning to move students thinking forward in critical ways.
take time and plan by preparing the discussion after students have shared their ideas and solutions.

About half of participants (12) noticed this is important because Neriage could encourage students to build their mathematical concepts or mathematical way of thinking (Table 4).

Table 4: Expectation for students (before participating the program)

Students will be able to…
1) Learn from others' idea
access ideas from their classmates
see the thinking of their friends and learn from each other
make comparisons and connections between what their peers did.
see each other's thinking and hear it explained. They can see what they did done differently and could help them truly understand their own math.
students lead the discussion about the mathematical process and thinking of how they went about solving the problem and noticing in their peers work.
share their work and look for similarities and differences in the solution paths.
explain their ideas and thinking while also learning from each other.
equal opportunity to express their idea and have their own idea represented, which lets students think more.
hearing their peers ideas, defending their own and possible coming to
2) Build mathematical concepts and contents
students can compare and highlight the similarities and differences and extend in this way their understanding of mathematical concepts.
students engage in learning mathematical content and developing math
students demonstrate and understand the content of the lesson.
better understand the mathematics behind the problem
to make connections and build mathematical understanding by reveling in the details of each other's thinking.
3) Build mathematical way of thinking
student engage in prioritizing what solution is “best.” to make meaning on their own and puts value into their own ideas.
they can understand the why and how behind it.
able to figure out things such as if a method is unreasonable, if it has limits,
students build connections, gain efficiency, and accuracy.
students are able to process and learn something new whether it be a more effecient way or an error they made.
understand the problem, and build mathematical thinking that will help them
leads students to acquire new ideas in mathematics through challenging

What is your plan for observing Neriage during the lesson study immersion program?

There are many concrete plans for observing Neriage focusing on 5 categories shown below table 5.

Table 5; 5 focuses for observing Neriage

Category	Total # (out of 33)
(1) **General teacher's technical aspect** e.g.; how the teachers lead the discussion, timing and how the Neriage leads to the summary, how the teacher facilitates the discussion, teacher actions during Neriage	21
(2) **Student's thinking** e.g.; own students' work, how each student think and express their idea, peer-to-peer conversations, how these students expand on their mathematical thinking	14
(3) **How teacher select student's idea** e.g.; how the teacher decides on which students to share, seeing how teachers respond to unexpected moments, how do they handle wrong answers	9
(4) **Teachers' questioning** e.g.; types of questions that the teacher asks to guide the students, types of questions the teachers develop based on their classroom/student interactions	6
(5) **Lesson plan** e.g.; how the teacher anticipates student's responses, board plan	4

4. Overview of Program Activities in Japan

Whole activities and schedule of this program is summarized as below. 5 research lessons (2 for school-based, 1 for district-wide, 2 for cross district) and its post lesson discussion and 3 usual mathematics lesson (2 for elementary school, 1 for junior high school) were observed.

Date	AM	PM
June 18 (Tue)	General Orientation	Workshop: Japanese mathematics lessons and lesson study
June 19 (Wed)	<School visit 1> Kunitachi Daigo Elementary School School tour and Cultural exchange	Research lesson & PLD observation (1) *School-based LS Welcome dinner with Japanese teachers
June 20 (Thu)	<School visit 2> Fuda Elementary School	Lesson observation and discussion (1)
June 21 (Fri)	Move to Yamanashi by a charter bus <School visit 3> Oshihara Elementary School	Research lesson & PLD observation (2) *School-based LS Dinner at the Hotel (Japanese style)
June 22 (Sat)	<School visit 4> Research lesson & PLD observation (3)(4) * Cross-district LS	Move back to Tokyo *Sightseeing at Takeda shrine and Mt.Fuji
June 23 (Sun)	Free	Free
June 24 (Mon)	<School visit 5> Fuchu Daiichi Elementary School Lesson observation and discussion (2)	Reflection and disusssion
June 25 (Tue)	<School visit 6> TGU Koganei Junior High School Reflection and disusssion	Lesson observation and discussion (3)
June 26 (Wed)	<School visit 7> Denen Chofu Elementary School	Research lesson & PLD observation (5) * District-wide LS
June 27 (Thu)	Discussion to wrap up the Lesson Study Immersion Program	Discussion to wrap up Farewell Party

Day 1: June 18

For the first day of the program, there were introductive workshop about Japanese lesson study and teaching through problem solving led by Akihiko Takahashi. He started introducing current situation of lesson study outside Japan, and posed question why we need to continue to do lesson study. Following session, different types of lesson study and its role, structure of school-based lesson study with general Japanese school system, historical practical research on teaching through problem solving in Japan were introduced and highlighted why Japanese teacher do lesson study.

There were several questions posed, e.g. how to manage regular classes when a teacher go to observe research lesson at other class, how to set the research goal practically, why a Japanese 4th grade teacher will observe a research lesson held in grade 1, why a school nurse will observe mathematics lesson, how Japanese textbook is used in the lesson for teaching through problem solving and so on.

In the afternoon session, 3 examples to deepen understanding for teaching mathematics through problem solving are examined among participants. The first example was series of problem-solving lessons to develop conceptual and procedural understanding address a standard(s) to find area from parallelograms. The second example was designed to deepen/extend understanding to find area of L shapes. The third example was problem-solving using open-ended problems, like finding number of different size of square by using geoboard.

Day 2: June 19

For the second day of the program, participants visited a public elementary school to observe school-based research lesson and its post-lesson discussion. Prior to observing the research lesson, cultural exchange program with grade 1-6 students was held in each class rooms. They introduced about school and students by showing pictures and Japanese students ask questions about students in U.S., for example. They also experienced Japanese school lunch and observed how they serve by themselves.

This school set the research theme as “nurturing students who can make connections among their ideas through problem solving” and conducted research lesson by focusing on the unit of “Let’s investigate the way quantities change” for grade 5. The lesson was held at the gym, special arrangement for this program participants, and all teachers in this school came to observe the research lesson (details is reported on attached “Lesson Report”). Some participants shared their insight of bansho (board writing), as it organized very well and students’ note book were also well organized as well. Others posed question how research team examine the selection of number in the table. Finally, 4 members of representing the group summarized their new insight about this lesson as below;

- number choice and how much data to shown in the table of the task
- clarification of appropriateness of goal for grade 5
- setting the situation of the task
- utilize a scaling definition (or using number line) of proportional relationship
- use of the notebook was a powerful tool for students to record their thinking
- organized board work provided a powerful learning tool for students

At the informal session after the post-lesson discussion, they celebrate the teacher and his team.


Day 3: June 20

For the third day of the program, participants visited a public elementary school to observe usual mathematics lesson. In the morning, they had reflective discussion what they observed yesterday about setting the situation and number to show and how students used the table by referring and sharing each of note taking.

In the afternoon, they observed grade 5 lesson of the first lesson of the unit "Let's Think about the Division of Decimal Numbers". 3 class rooms, where students are re-grouped by proficiency course level of A, B and C, are opened to observe with special arrangement of having abbreviated lesson plan. Some of them concentrated to observe only class and others tried to observe other 2 classes as well. After observing the lesson, participants shared their findings of these lessons. They found that there are variety of lesson flow under the same lesson objective. In one of the class, students showed different solutions of the task and sorted them with the support of teacher. In the other one of the class, students and teachers reviewed previous knowledge by using textbook. After observing lessons, they had time to question to teachers and a principal. One of the biggest question raised was how and why students are sorted by different proficiency level to learn mathematics. Finally, 4 members of representing the group summarized their new insight about this lesson as below;

- still wondered about the impact on the students' mindsets and their identity if students learn mathematics 3 separate classes.
- the board work was well thought out and showed the progression of learning throughout the lesson
- the teacher had clearly anticipated scaffolds that might be needed by the students
- the teacher adjusted the timing of the lesson based on student understanding and gave them extra time to work on the double number line.


Day 4: June 21

There were 2-day trip to Yamanashi. For the first day, they visited one of public elementary school to observe school-based lesson study. Before observing research lesson, they had chance to observe beautiful school facilities opened to local community and usual lesson for all graders and subjects. Many participants had chance to observe a usual mathematics class for grade 6, division of fraction and noticed teaching mathematics through problem solving is realized in the usual dairy lesson in Japan. They are also warmly invited to school lunch at each classroom and enjoyed talking with pupils.

In the afternoon, the research lesson aimed students to "think about how to process remainders based on problem situations and are able to reason about and explain the process" was conducted for grade 3 students. One advisory teacher from board of education and associate professor of mathematics education were invited as knowledgeable others. At the post-lesson discussion, detailed student's evidences are reported by teachers.

Finally, 4 members of representing the group summarized their new insight about this lesson as below;

- teacher was very responsive to the needs of the students so they could make sense of each others' thinking and grasp the problem
- importance of being mindful of setting the context
- administrators seems to have a solid understanding of the math being taught, what is happening in the classroom
- The lesson provided us the opportunity to see the benefit of establishing the context for a problem directly connected to a real world


Day 5: June 22

For the second day in Yamanashi, they visited University of Yamanashi Model Elementary School to observe cross-district lesson study. Under this school's general research theme "Students Connecting Learning: Providing lessons that approach the essence of the subject", 15 research lessons of all subjects were opened to public. Program participants observed 2 mathematics research lessons, under the specified research theme of mathematics department "Creating Mathematics Lessons that Deepen Learning by Connecting Students' Questions", for grade 1 "What is Left and What is the Difference?" and grade 4 "Let's think about ways to express the size of angles". At the post-lesson discussion, 1 advisory teacher from board of education, 1 associate professor of University of Yamanashi and 3 cooperative teachers from public schools gave comment and facilitate the discussion.

Finally, 5 and 3 members of representing the group summarized their new insight about 2 lessons as below for example;

- students were talking, but it was unsure if their debates were enough to resolve and satisfy any conflict.
- the teacher acted as the slowest student at times throughout the lesson, telling students "I couldn't understand can someone explain what he said to me?" which may impact to making sure all students are engaged.
- lesson illuminates the importance of hearing from students throughout a lesson
- lesson highlighted the importance of teacher questioning


Day 6: June 24

On the 6th day of the program, they visited a public elementary school in Tokyo to observe usual mathematics lesson for grade 5 “division with reminder”. 4 classrooms, where students are re-grouped by 4 proficiency course levels. They observed by setting own observation focus points to investigate own interest and discussed what they observed.

Finally, 4 members of representing the group summarized their new insight about these lessons as below for example;

- despite being the advanced class, there were students who would have greatly benefited from seeing multiple ways of thinking.
- we need to facilitate the discussion and board work so that all learners in the room, not just those with the correct answer, can understand the day’s goals.
- students would have benefited over a discussion around the context of the problem and the models that support that situation
- this lesson proved why teachers need to highlight misconceptions for the entire class to see through board work, as evidence showed students who solved the problems incorrectly in this lesson often erased their errors in their journals and copied the correct answers off of the board.

After observing the lesson, they are warmly welcomed with performance of dram and fife band of grade 6 students and had chance to communicate with these students through Japanese traditional games.


Day 7: June 25

On the 7th day of the program, they visited a Koganei Junior High School attached to Tokyo Gakugei University to observe usual mathematics lesson. Through the today's task of "Let's find the rule for the quick calculation" the teacher aimed "through the examination of a calculation technique, students will understand the merits of expressions of sums and products and the base-10 numeration systems. Students can investigate the essence of the calculation technique and try to extend the idea". Post-lesson discussion was led by Akihiko Takahashi, to deepen from each observer's report. At the second half of the discussion, the teacher participated to answer questions. They posed many questions how he grasp each student's learning progress, what kind of responses did he anticipated when he plan the lesson and so on.

Finally, 4 members of representing the group summarized their new insight about these lessons as below for example;

- the post lesson discussion provided a great deal of insight into how the teacher moni tors and assesses student understanding
- there was a clear partnership with the university that allowed this level of teacher development as well
- the most important takeaway from this lesson is the necessity to really know the students that you teach. This teacher is so thoughtful in his approach to collecting classroom data.
- Identifying important problem-solving approaches is a high leverage practice that can be used as a guide for connecting students' mathematics during whole class discourse, as well as a way to set targets for their development


Day 8: June 26

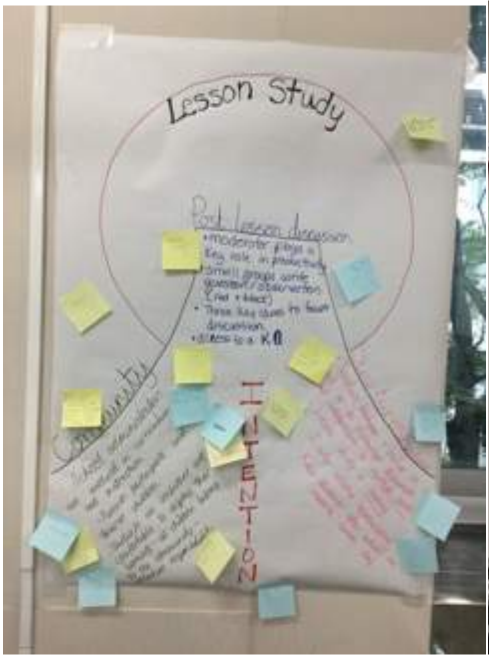
On the 8th day of the program, they visited a public elementary school to observe district-wide lesson study in one of a ward in Tokyo. In the lesson plan, under this ward's research theme "designing lessons in which students will make use of mathematical ways of observing and reasoning and deepen their learning", detailed plan is developed based on the results of the readiness test of this school students. At the end of post-lesson discussion, knowledgeable other from Tokyo Gakugei University made comments by posing a key question "what is about thinking from the perspective of today's students". Then he introduced student's concrete evidences by relating van Hiele's criteria as one of example to see how students see figures. He also posed stirred question to all participated teachers whether a teacher should write today's objective on the board at the beginning of lesson. 2 of program participants made reflective comments about how students construct mathematics with teachers support and how students to tell their opinion to other students.

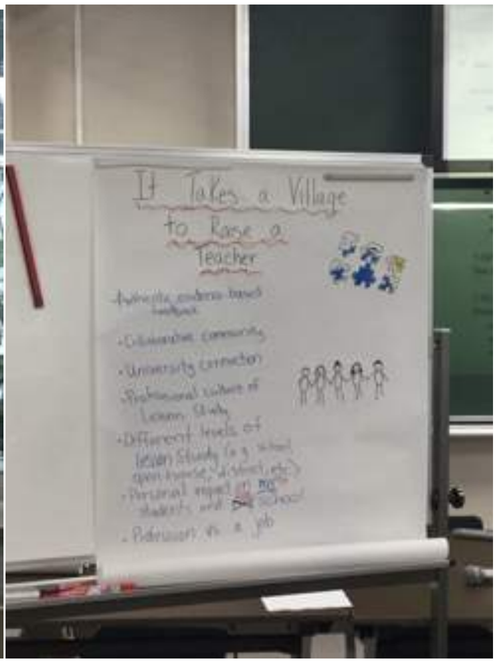
Finally, 3 members of representing the group summarized their new insight about these lessons as below for example;

- it was fascinating to see all of the participants, the sharing out of each group respective of the tools used and group work and how helpful they, and the comments from the knowledgeable other.
- student to student, teacher to student interaction provides opportunities for students to construct knowledge, encourage student thinking, and test out ideas.

Day 9: June 27

On the final day of the program, they discussed about lesson observed previous day mode deepen and Akihiko Takahashi and Tad added comments about comment by knowledgeable others. In the afternoon session, each group of school district discussed and summarized "how their view of lesson study had changed?" and "plan of next steps" by making posters. There were many insights reported about their change of view "from my students & my school to our students & our school", "teachers' community became shared professional community" and so on (details will be summarized in following chapter 5&6). Finally, it is highlighted there is space to be improved for every single lesson and it is important to proceed lesson study with considering how ideal lesson study should be.





5. Pathways of impact (1) Teacher Beliefs/Dispositions about routines and norms of professional learning

On the final day of the program, each 5 of group reflected and made a poster which to explain how their view of lesson study had been changed after participating the program. Contents written on those posters are categorized into 3 aspects; teaching as professional work, lesson study as teacher learning community and inquiry stance for each stages of lesson study. Referring to *IMPULS Lesson Study Immersion Program Final Report of 2017 (*Friedkin&Henn*)*, visible program featured of this program 2019 and key pathways of impact (1) on participants' beliefs and dispositions about routines and norms of professional learning is described as below.

LSIP 2019

Visible Program Features:

- Seminars on Teaching through Problem-Solving and Lesson Study in Japan
- Opportunity to do the mathematical tasks to anticipate student responses before research lesson
- Observe 3 live usual lessons
- Observe 5 live research lessons with detailed lesson plans
- Observe 4 post-lesson discussions
- Reflect on learnings of each lesson
- Time to reflect with other participants, University professors, and Japanese teachers

↓

Pathways of Impact (1)

Teacher Beliefs/Dispositions about routines and norms of professional learning:

1. **Teaching as professional work**
   - Teaching is a professional practical
   - Envisioned "perfection " takes multiplying forms and hard in any culture
   - Lesson Study is not about show-casing your best lesson. it's about how to best teach a topic that is difficult to teach or difficult for children to understand
2. **Lesson Study as teacher learning community**
   - I observed how the whole community from students, parents stuff and admistration are involved in actively participating and learning from the research
   - Teachers work together and learn from colleagues across the district, not only at their school sites
   - Personal impact on "our" students and "our" school
   - Students are confident and comfortable to display their learning -all children belong to the community-collective responsibility
   - Teachers' lounge vs set up to encourage discussion and collaboration on multiple levels
   - University connection
3. **Inquiry stance for each stage of lesson study**
   - Japanese Lesson Study is focused on a specific research question.
   - We deepen our understanding of the importance of the different parts of the lesson study process; Researching misconceptions, Anticipating student responses, Planning out board work, Strategically plan guiding for neriage
   - The data collection and post lesson discussion should focus on specific research question.
   - Post lesson discussion will be helpful when it is structured. Moderator plays a key role in productivity

6. Pathways of impact (2) Concrete vision for next step

On the final day of the program, each 5 of group reflected and made a poster which to explain their next steps to do. Participants had chance to look around those posters and give comments each other. Contents written on those posters are categorized into 3 aspects, pedagogy and daily classroom instruction, teacher's preparation, and building community of lesson study.

Pathways of Impact (2)

Concrete vision for next step:

1. **Pedagogy and daily classroom instruction**
   - Give students more opportunities to build more knowledge on their own.not just teachers giving more knowledge.
   - Pacing of launch, independent work,discussion so that the end isn't rushed to force them into a summary.
   - improve teacher questioning so that conversation can't be more between peers and bocked up with board work examples
   - Emphasize the importance of notebooks-why do we use it?
   - Guiding to students in using previous notes in their notebooks to inform how they may approach the task
   - Refine student notebook, structure , color systems , feedback
   - purposeful Neriage
   - Giving students more responsibility
   - Elevating and improving quality of student reflections
   - Strategic questioning to focus board work discussion
   - Focus on shifting T→S S→T to TSSS
2. **Teacher's preparation**
   - Improve daily data collection with seating charts with data
   - plan out board work
   - Focus on strong sequence of lesson (unit planning)
3. **Building community of lesson study**
   - Increasing voluntary participation across grade bands and subjects
   - Encourage and cheer on teachers to set aside fear/anxiety of opening themselves to lesson study
   - Observe more lower a grade lessons and everyday lessons from teachers from other schools so there is more collaboration inside and outside schools
   - How can we improve T engagement &interst in lessons outside of their grade level
   - Collaboration with site coaches to emphasize the continual culture of observational cycles across subjects.
   - Applying lesson study to other subjects
   - Inviting other schools to participate (district wide and in SanFrancisco)
   - Open house to include families/community
   - Norm setting and trust building for Authentic feedback
   - More direct, constructive critism to improve practice
   - Collectively reflect on how we can improve /deepen lesson debriefs
   - Newsletter
   - Identify key highlights of lesson study learning from this trip and share with staff
   - Share impact of lesson study practice with parents,families (PTA)

7. Pathways of impact (3) Teacher knowledge/beliefs about teaching and learning mathematics

After 10-days program in Japan, 30 out of 33 participants submitted their own reflective journal about mathematics teaching and learning in Japan and about Japanese Lesson Study as it was one of the conditions for participating the program. Most documents were submitted around July to the end of August 2019. By reviewing those reports from 30 participants, there were 2 main findings, deepened individual reflection about their understandings of Lesson Study and knowledge/beliefs about teaching and learning mathematics.

For the first finding, in addition to pathways to impact (1) about their understandings of Lesson Study summarized already as group, all participants reflected more deeply and concretely what they took away from Japan by contrasting their own school situation and own current responsibility. These examples show how they described what they learned about lesson study in Japan. Each of them could impact on teacher beliefs/dispositions about routines and norms of professional learning.

1. **Teaching as professional work**

One of common reflection is that lesson study can highlight that teaching is professional activity and create culture to trust each other as professionals.

> *"Lesson Study highlights the professional nature of teaching and provides an intellectual focus and challenge for all participating. It deepens conceptual understanding of specific content, as well as on the vertical progression. With grade levels getting to decide on the unit of focus each year, there is definite choice to help with the buy in for the teachers. In addition, teachers are able to watch other teachers teach multiple times each year. This gives teachers an opportunity to develop a shared understanding of what good teaching looks like, as well as to help even out the quality of instruction."*

> *"Visiting Japan allowed me to experience and be part of a professional community of dedicated educators. It was clear that every participant in the community was involved and valued the work around lesson study."*

> *"As a teacher, I often feel that it is my responsibility to create professional development opportunities or to grow my practice by seeking out books, courses, and lectures. However, what I observed in Lesson Study in Japan, teachers are constantly collaborating to grow."*

> *"Japanese teachers treat their colleagues as professionals. This is based on my observation of the post-lesson study discussion sessions. There is a clear protocol that all staff members follow, where every member of the learning community has the opportunity to share their ideas and comments without interruptions from colleagues. When there are conflicting opinions, Japanese teachers give specific constructive feedback rather than making general"*

"Japanese teachers do not use lesson study professional development to showcase their best practices. Instead, they use lesson study as an opportunity to identify a topic that is difficult to teach, research it, collaborate on planning it, executive the lesson, and reflect on the outcome and design of the lesson."

2. **Lesson Study as teacher learning community**

One of the common impressed findings of this program is that all grade teachers including administrators and school nurse are involved in school-based lesson study in Japan and it create culture or norm to educate "our" students. Because some of these aspects are introduced through reading assignments before participating the program, evidences what they looked in Japan might back up their questions why Japanese teacher participate process of lesson study even who are different grade level and/or subject teachers.

"In Japan, it was shocking to see how the entire building and community took part in Lesson Study. From the parents who were outside directing traffic at each intersection, to the lunch staff and nurses taking part in post lesson discussion, all the way up to the highest levels of published university professors giving final comments; in Japan, Lesson Study is a thing that the entire community takes part in and it makes it very powerful."

"One of the differences that I found to be most interesting is that the entire school is involved in the live research lesson. It creates a school culture in which no student is "your student" or "my student," but where every student is "our student.""

"It is clear that there is a clear, established, and strong culture for supporting lesson study on an individual, school, district, and national level in Japan. I could see many other added potential benefits, such as helping to establish norms for professionalism, pedagogy, and collaboration; strengthening partnerships with universities; providing meaningful feedback on the curriculum; and celebrating strong instructional practices."

"In the Japanese schools we observed, administrators not only attended the lesson study events, they actively participated in the discussions. Their suggestions and questions showed deep levels of pedagogical and mathematical understanding and set the tone for the events. Additionally, all teachers at each school attended the lesson study lessons."

In addition to above shared findings, one of the participants pointed that there is so called "Professional Learning Communities (PLCs)" existing and it hold great promise for reforming education. However, compared with lesson study in Japan, she found PLC has missing point, which is development of contents knowledge with vertical progression of contents.

*"In PLCs, teachers work together as professionals to improve instruction. …
Yet, I believe that the PLC process has a missing ingredient: development of pedagogical expertise and content knowledge. That is why your PLCs need lesson study."*

"Developing Teachers' Content Knowledge: Japanese lessons study also develops teachers' knowledge of the content they teach. They learn content at all grade levels and develop an

understanding of the vertical progression of content. The knowledgeable other provides content expertise to deepen the professional learning of all staff."

3. **Inquiry stance for each stage of lesson study**

Compared to their individual experience to be involved in lesson study as observer, experience in Japanese influenced more their inquiry stance for each stage of lesson study, from goal setting, focus of observation & discussion and organize constructive discussion.

> *"It is so important to start lesson study with a theme (what is the problem or area of concern) and have a relevant task, problem or question that is intellectually challenging and invites students to use deeper mathematical thinking."*
>
> *"Another valuable learning point for me was the structure of the post-lesson sessions. I learned that:*
> *a. it is important to make a short list – in cooperation with the participants - of subjects you want to discuss during the post-lesson session;*
> *b. important items to discuss during a post-lesson sessions are: tasks; the data (results) of the students to the task; how the task worked out; the anticipations of the students' results vs. the information they received, and the outcome: what does it mean for the next step; has the task has made a change in the thinking of the students?"*
>
> "*One of the biggest lessons that I have taken from the Lesson Study Program is how the culture of constructive criticism influences all aspects of the teaching process. These math discussions amongst the educators and staff are also essential for a productive lesson study. The honest post-lesson discussion can provide data to be used to improve future lessons. By having enriching discourse, the teachers and staff and can share their noticings and use their background knowledge of the students to give customized, useful information for the teacher to use. For example, an observer can bring new insights that the lead teacher may have missed during the lesson. This is needed for student growth."*
>
> *"The lesson study moderator's role is so important to the productivity of the post lesson discussion. For example some moderators asked observers to focus the discussion on task, learning objective and grouping, student interactions, errors, questioning. Once the discussion begins, teachers ask questions focused on understanding reasoning behind instruction choices made during planning or teaching. I was impressed by the level of commitment and thought that colleagues put into questioning during the debrief. The questions were based on evidence observed and usually asked for insight into the metacognition of the teacher about their instructional choice."*

For the second finding from their individual reflection was about mathematics teaching and learning in Japan. It might directory influence for their teaching and learning mathematics, and impact teachers' knowledge and belief about teaching through problem solving. Based on reading assignments and introductive workshop about TTPS, there were many aspects of TTPS were reported in lesson observation report prepared by each group. In individual reflective report, after observing 8 live lesson in Japan in 7 schools, it is found that they highlighted about structured board writing and its role for student discussion. Finally, I summarized as pathways to impact (3) as below.

Pathways of Impact (3)

Teacher knowledge/beliefs about teaching and learning mathematics:

1. **Students discussion and role of board work**
    - completed board work should tell the story of the class discussion and ought to reveal shifts in student thinking and learning.
    - with the help of the board work (colourful, with paperwork) they used students' input to demonstrate the progression in the understanding of a concept.
    - the board work records and reflects the mathematical reasoning that students present during neriage
    - the boardwork discussion (neriage) is such a crucial point in a TTP lesson that can significantly leverage the opportunities to collectively dispel student misconceptions and move the students' thinking forward,
    - board work further communicated respect for students: through the time taken to plan, the care taken to execute that plan, and the careful commemoration of student voices for all to see.
    - having the visual progression on the board it allows students to more easily make connections between

These are excerpts from 7 participants who had explicitly connected board writing and whole class discussion.

- *I learned that intentional board work and organization is crucial. Completed board work should tell the story of the class discussion and ought to reveal shifts in student thinking and learning.*

- *I will make a rough analogy of delivering a lesson in lesson study with the human body: neriage is the muscle and board work is the skeleton or bones that provide structure to the lesson. I noticed that the board work records and reflects the mathematical reasoning that students present during neriage, which is the whole class discussion. It has a logical sequence. It involves mathematical concepts, relationships, operations and algorithms. It is a visual tool for students to see and clarify misunderstandings after working independently solving a problem.*

- *From observing the classroom lessons, I was able to see students' listen to each other's ideas and share with the whole class, as well as the teacher jotting down students' ideas on the board.*

- *The boardwork discussion (neriage) is such a crucial point in a TTP lesson that can significantly leverage the opportunities to collectively dispel student misconceptions and move the students' thinking forward, that I definitely want to find ways to keep them engaged during the discussion.*

- *On a number of occasions, we observed expert practitioners exemplify exquisite board-work that served to both record the content of the lesson and visualize the lesson structure. This board work further communicated respect for students: through the time taken to plan, the care taken to execute that plan, and the careful commemoration of student voices for all to see.*

- *Japanese teachers use the board as a visual aid so students can participate in the discussion as well as build understanding of the mathematics involved.*

- *By using boardwork to record each student's thinking the progression of strategies and learning is clear and visual. This could really help students that might need more time to push their own thinking toward the lesson objective. My biggest realization about boardwork was that by having* *the visual progression on the board it allows students to more easily make connections between strategies that can lead to generalizations and meaningful reflections.*

Although we haven't asked them to reflect about their understandings of "Neriage" after participating the program, it is remarkable that 7 out of 33 participants could found that *Neriage* could be done with structured board working. At the same time, I need to say it was difficult for them to see this connection clearly because other participants didn't mention about their new understanding of *Neriage*. By contrasting with their answer to the preliminary questionnaire, "What is the nature of Neriage and why Japanese teachers believe its important for teaching mathematics?" (see table 2, 3 and 4), only 1 participant had explicitly connected board writing and *Neriage* before participating the program as below. Actually he was the one who participated this program for the second time.

"teacher aids in the development of student thinking around the lesson's topic through strategic planning of boardwork and how we can utilize strategic questioning to move students thinking forward in critical ways."

In addition to above impact on participants' knowledge or belief about board writing, it was cleared that they also took away new knowledge about students in Japan. These are some examples.

"There was much to learn about how Japanese schools support student learning but one thing that stood out was how independent and responsible students were throughout the day."

"One aspect that really stuck out and remained constant throughout all the schools we visited was the independence the students had no matter the grade level. The classrooms are run by the students from the start of class period to the end of the class period, even lunch! Because the students have so much ownership inside the classroom, it transfers to the ownership they have during instruction time. I've never seen a classroom/school/district that has had that high level of independence and several questions pondered."

"When Japanese teaching strategies are discussed, Americans often feel that these same strategies would not work with their kids. While there are definitely unique cultural factors that affect Japanese education, I was happy to observe that kids are kids everywhere. We observed kids who were really struggling to understand concepts, gave wrong answers, and did not participate. Sometimes a teacher failed to get a good discussion going on the first try. I really admired how the teachers didn't use these children as an excuse for why a problem-based approach can't work. The teachers asked additional questions or employed other strategies and did not give up. This reminded me that no classroom of kids is perfect and we shouldn't expect them to be so."

8. Summary

Although there are still remaining individual questions about teaching mathematics through problem solving (e.g. how to engage all kids in the neriage) or issues to establish teachers community for lesson study, key path ways to impact by this program were summarized as below.

LSIP 2019

Visible Program Features:

- Seminars on Teaching through Problem-Solving and Lesson Study in Japan
- Opportunity to do the mathematical tasks to anticipate student responses before research lesson
- Observe 3 live usual lessons
- Observe 5 live research lessons with detailed lesson plans
- Observe 4 post-lesson discussions
- Reflect on learnings of each lesson
- Time to reflect with other participants, University professors, and Japanese teachers

3 pathways of Impact

Teacher knowledge/beliefs about teaching and learning mathematics:

1. **Students discussion and role of board work**
   (e.g. board work records and reflects the mathematical reasoning and connections that students present during neriage, demonstrate the progression in the understanding of a concept)

Teacher beliefs/dispositions about routines and norms of professional learning:

1. **Teaching as professional work**
   (e.g. teaching is a professional practical, Lesson Study is about how to best teach a topic that is difficult to teach or difficult for children to understand.)
2. **Lesson Study as teacher learning community**
   (involve whole community of school includes all grade teachers, other subject teachers, administrators, parents., shifting to "our" students and "our" school)
3. **Inquiry stance for each stage of lesson study**
   (e.g. the data collection and post lesson discussion should focus on specific research question)

Concrete vision for next step:

1. **Pedagogy and daily classroom instruction**
   (e.g. refine structure of student notebook, using previous notes to inform how they may approach the task, strategic questioning to focus board work discussion)
2. **Teacher's preparation**
   (e.g. improve daily data collection with seating charts, plan out board work, unit planning)
3. **Building community of lesson study**
   (e.g. increasing voluntary participation across grade bands and subjects, share key highlights of lesson study learning by newsletter)

Appendix;

(1) List of participants

(2) Lesson plans

(3) Lesson observation report

(4) Final reflection report

IMPULS Immersion Program 2019 Schedule

Date	Time	detailed contents
June 18 (Tue)	9:00	Meet at the hotel lobby *IMPULS staff will guide to TGU.
	9:30	Welcome by IMPULS General Orientation
	10:00	Mathematics teaching and learning in Japan,Lesson Study in Japan,Teaching through problem solving and Kyouzai-Kenkyu
	11:15	Group Photo
	11:30	***Lunch on your own***
		Please note that we plan to take a group photo sometime during the day for our website.
	13:00	Welcome remark by president of TGU
	13:30	Workshop: Japanese mathematics lessons and lesson study
	15:00	About Research Lesson Report
	16:00	To be ready for the lesson observation (June 19 Tad)
	16:30	End of the program
		Dinner on your own
June 19 (Wed)	9:00	Meet at the hotel lobby
		Move to Kunitachi Daigo Elementary School by public transportation (train and bus)
	10:00	School tour
	11:25	Cultural exchange program with grade 1-6 students.
		Note: You will visit a classroom for G1 to G6 then be asked to introduce your own culture for 3-5 minuites.Please prepare something you want to introduce to students.
	12:15	School Lunch with students
		Note: You will stay with the students to have a school lunch together. It is one of the excellent opportunities for giving a small gift to the students.
	13:15	<Research lesson 1> Kunitachi Daigo Elementary School (Schol-based LS) (Grade 5, Proportional relationship)
	14:15	Post Lesson Discussion
	16:00	End of the program
	17:00	Welcome dinner with Japanese teachers @ "Sakanaya"
June 20 (Thu)	9:45	Meet the hotel at lobby *Please bring your own lunch
		Move to Fuda Elementary School by public transportation
	11:00	Post-lesson discussion of the research lesson on June 19 Preparation for the lsson observation ( )
	12:30	Lunch on your own
	13:40	<Lesson observation 1> Fuda Elementary School (Grade , 5)
	14:30	Reflection and discussion (Akihiko)
	15:00	Preparation for the lsson observation (Tad, Makoto)
	16:30	End of the program at the school
		Dinner on your own
June 21 (Fri)	8:30	Meet at lobby, Check out *You can leave your big baggage at the hotel
	8:45	Move to Yamanashi by a charter bus
	11:00	Arrival at Oshihara Elementary School
		School lunch with pupil
		Note: You will stay with the students to have a school lunch together. It is one of the excellent opportunities for giving a small gift to the students.
	13:55	<Research Lesson 2> Oshihara Elementary School (School-based LS) (Grade 3, Division with Remainders)
	15:15	Post Lesson Discussion
	17:00	Move to Hotel by a charter bus
	19:00	Dinner at the Hotel (Japanese style) with Japanese teachers

Date	Time	detailed contents
June 22 (Sat)	7:00	Breakfast at the hotel
	8:00	Meet at lobby
	8:15	Move to University of Yamanashi Attached Elementar School by a charter bus
	8:30	Arrive at elementary school attached to Yamanashi University
	9:00	<Research Lesson 3>University of Yamanashi Attached Elementary School, Cross-district LS (Grade 1, Subtraction)
	10:00	<Research Lesson 4>University of Yamanashi Attached Elementary School, Cross-district LS (Grade 4, Measurement of Angles
	11:00	Post Lesson Discussion
	12:30	Lunch(bento box)
	13:30	Move back to Tokyo *Sightseeing at Takeda shrine and Mt. Fuji
	17:00	Arrive at Mets Kokubunji, check in
		Dinner on your own
June 23 (Sun)		Free
June 24 (Mon)	9:00	Meet at lobby
		Move to Fuchu Daiichi Elementary School by public transportation (train and bus)
	10:00	Arrive at school, School introduction
	10:40	<Lesson observation 2> Fuchu Daiichi Elementary School (Grade 5)
	11:30	Exchange program with students
	12:15	School lunch with pupil
	13:00	Reflection and discussion (Including lessons observed at Oshihara and Yamanashi Univ.)
	16:30	End of the program at the school
		Dinenr on your own
June 25 (Tue)	9:30	Meet at lobby
		Move to TGU
	10:00	Reflection and discussion inlucing Q & A
	12:00	Lunch on your own
	13:20	<Lesson observation 3> TGU Koganei Junior High School (Grade 9)
	15:00	Reflection and discussion
	16:30	End of the program at the school
		Dinenr on your own
June 26 (Wed)	9:30	Meet at lobby *Please bring your own lunch
		Move to Denen Chofu Elementary School by public transportation (train and bus)
	11:00	Preparation for the lsson observation ( )
	12:30	Lunch on your own
	13:45	<Research Lesson 5> Denen Chofu Elementary School , District-wide LS (Grade 4, Quadrilaterals)
		Post Lesson Discussion
	16:30	End of the program at the school
		Dinenr on your own
June 27 (Thu)	9:30	Meet at lobby, move to TGU
	10:00	Discussion to wrap up the Lesson Study Immersion Program
	11:30	Lunch on your own
	13:00	Discussion to wrap up the Lesson Study Immersion Program
	16:00	Colosing session
	17:00	Meet at lobby *1st (max 27) team by shuttle bus , 2nd team by public transportation
	18:00	Farewell Party @Umenohana
June 28 (Fri)	11:00	Check out
		Departure Day

IMPULS - LSA Lesson Study Immersion Program 2019 List of participants

	Name	
1	Berenice Heinlein	Grade 4 Teacher,CPS: Peirce Elementary School
2	Brian Girard	8th Grade Algebra/Math Teacher,CPS: Peirce Elementary School
3	Jeffrey Rossiter	7th grade math teacher,CPS: Peirce Elementary School
4	Jinny Gerhardt	Grade 8 Inclusion Teacher,CPS: Peirce Elementary School
5	Israel Hernandez	4th grade bilingual teacher,CPS: Prieto Math & Science Academy
6	Wendy Ottinger	grade 5 teacher,LGUSD: Blossom Hill School
7	Henk Logtenberg	Lecturer,Marnix Academie
8	Francisco Luis-Llaguno	Kindergarten Teacher,OUSD: Acorn Woodland Elementary School
9	Maira Lopez Cruz	2nd grade bilingual teacher,OUSD: Acorn Woodland Elementary School
10	Malia Vitousek	1st Grade Teacher,OUSD: Acorn Woodland Elementary School
11	Lucy de Anda	4th grade teacher, Lesson Study Coach,Palo Alto Unified School District/ Silicon Valley Math Initiative
12	Anthea Oppong-Kwarteng	Year 5 class teacher,Sandringham Primary School
13	Denise Kleckner	Grade 3 Teacher,SFUSD: Bret Harte Elementary School
14	DeVaughn D Exum	Grade 4 Teacher,SFUSD: Bret Harte Elementary School
15	Jacqueline Smith	Kindergarten Teacher, Spanish Immersion,SFUSD: Bret Harte Elementary School
16	Jade Lucerito Meza	grade 2 teacher (Spanish Immersion),SFUSD: Bret Harte Elementary School
17	Christina Isles	Kindergarten Teacher,SFUSD: Carver Elementary School
18	Daisy Sharrock	Math Network Project Director,SFUSD: High Tech High Graduate School of Education
19	Ashley Hughes	Grade 3 teacher,SFUSD: Hillcrest Elementary School
20	Elisa Szeto	Grade 1 teacher,SFUSD: Hillcrest Elementary School
21	Katerina Palomares	Principal,SFUSD: Hillcrest Elementary School
22	Joseph Mannarino	5th grade bilingual teacher,SFUSD: John Muir Elementary School
23	Justin Stoddard	Grade 3 Teacher,SFUSD: John Muir Elementary School
24	Maiya Coilton	Kindergarten Teacher,SFUSD: John Muir Elementary School
25	Yekaterina Milvidskaia	Improvement Coach,SFUSD: The Center for Research on Equity and Innovation
26	Heather Dallas	Executive Director,UCLA Curtis Center for Mathematics and Teaching
27	Helen Chan	Director of Professional Development and 8th grade Algebra teacher,UCLA Curtis Center for Mathematics and Teaching
28	Julie A McGough	District Elementary Math Coach,UCLA Curtis Center for Mathematics and Teaching
29	Michelle Sidwell	Middle School Specialist,UCLA Curtis Center for Mathematics and Teaching
30	Stephanie Hauki Kamai	University Faculty,University of Hawai'i - West O'ahu
31	Nancy Sirois	Elementary math coach and interventionist,PORTLAND PUBLIC SCHOOLS
32	Shusaku Uchida	Consultant,Japan Math Corp.
33	Kim Hollowell	District math coach,San Diego Math Network
34	Osvaldo D. Soto	Math Project Director,University of California San Diego

June 19 , revised

○

Grade 5 Mathematics Lesson Plan

Name of the Unit: Let's investigate the way quantities change
Date: June 19, 2019
Teacher: UNO, Naohito

1 Research Theme

Nurturing students who can make connections among their ideas through problem solving.

2 Goal of the unit

Through examinations of two co-varying quantities using tools such as tables, students will understand proportional relationships.

3 Assessment standards

(1) Interest, Eagerness, and Attitude
Students will become interested in the relationships of two co-varying quantities and examine them on their own accord using tools such as tables.

(2) Mathematical Way of Thinking
Students can examine two co-varying quantities using proportional relationship as a viewpoint.

(3) Mathematical Skills
Students can identify proportional relationships when they were given in tables or other formats.

(4) Knowledge and understanding
Students will understand that when one quantity becomes 2, 3, … times as much, the other quantity also becomes 2, 3, … times as much, the two co-varying quantities are in a proportional relationship.

4 Capacities students are beginning to built in this unit

When this unit, "Let's investigate the way quantities change," was taught, students tried to grasp the relationship between two co-varying quantities through activities to summarize the relationship between the quantities in a table and expressing the relationship in equations, using symbols such as □ and ○ if necessary. Students examined what pattern they could identify in the change of one quantity as the other quantity changed by manipulating diagrams and representing the changes in a table. Then, students expressed the pattern they identified in equations using symbols such as □ and ○. However, there were a number of students who could identify the pattern but had trouble expressing the pattern in an equation. The contents discussed in this unit is a part of a series of topics discussed in Grades 4 through 6, and these topics are developed through a spiral approach. The focus in this unit is to help students build the capacity to represent the relationship between two quantities using an equation by noticing the idea of the change in one quantity that corresponds to the change of 1 unit in the other - that is, the proportional constant – through activities to record the changing quantities in a table.

As far as students' capacity to communicate and connect their ideas, it was noticed that not a small number of students had difficulty figuring out how to explain their ideas even if they had worthwhile ideas during a lesson. As a result, they simply listened to each other's ideas. We believe students' learning can be facilitated further if we can help them build the capacities to explain their ideas by making use of mathematical terms that describe changes in quantities appropriately and to organize their explanations based on the equation they have written. Moreover, by representing the relationship in equations with symbols symbols such as □ and ○, we want students to realize the usefulness of the equation because by substituting a number in one symbol, we can determine the number for the other symbols as well. This will in turn build the capacity to make use of equations in various situations. In order to achieve this goal, we will design lessons where students realize the values of communicating each other's ideas because mathematical ideas are built up through whole class discussion.

5 Capacities we want to build in this unit (from the perspective of students connecting their ideas)

Ideal students the mathematics group aims for --- students who can share their reasoning and ideas and who can also feel others' reasoning and ideas

(1) Students will be able to share their ideas based on their observations of the changes in the quantities. By listening to others' ideas and comparing them to their own, students will be able to express themselves more effectively using their own words and use mathematical terms appropriately.

(2) Instructional strategies

- When students are examining a particular proportional relationship, we will ask students to figure out missing values in the table. They will be asked to explain why they chose those values and explain how those values can be viewed as changed from other given values. In this way, students can build their capacity to justify their ideas. [Students will make use of diagrams and equations]
- As we define proportional relationships, we will make sure that students will understand that when one quantity becomes "○ times as much," the other corresponding quantity also becomes "○ times as much." Students will be encouraged to use phrases like "proportional relationship" and "○ times as much" as they explain their ideas. They will also represent the relationship of the quantities in an equation using the symbols such as □ and ○. In this way, they can build their capacity to communicate the rationale for their ideas. [Students will explain their ideas using mathematical terms appropriately]

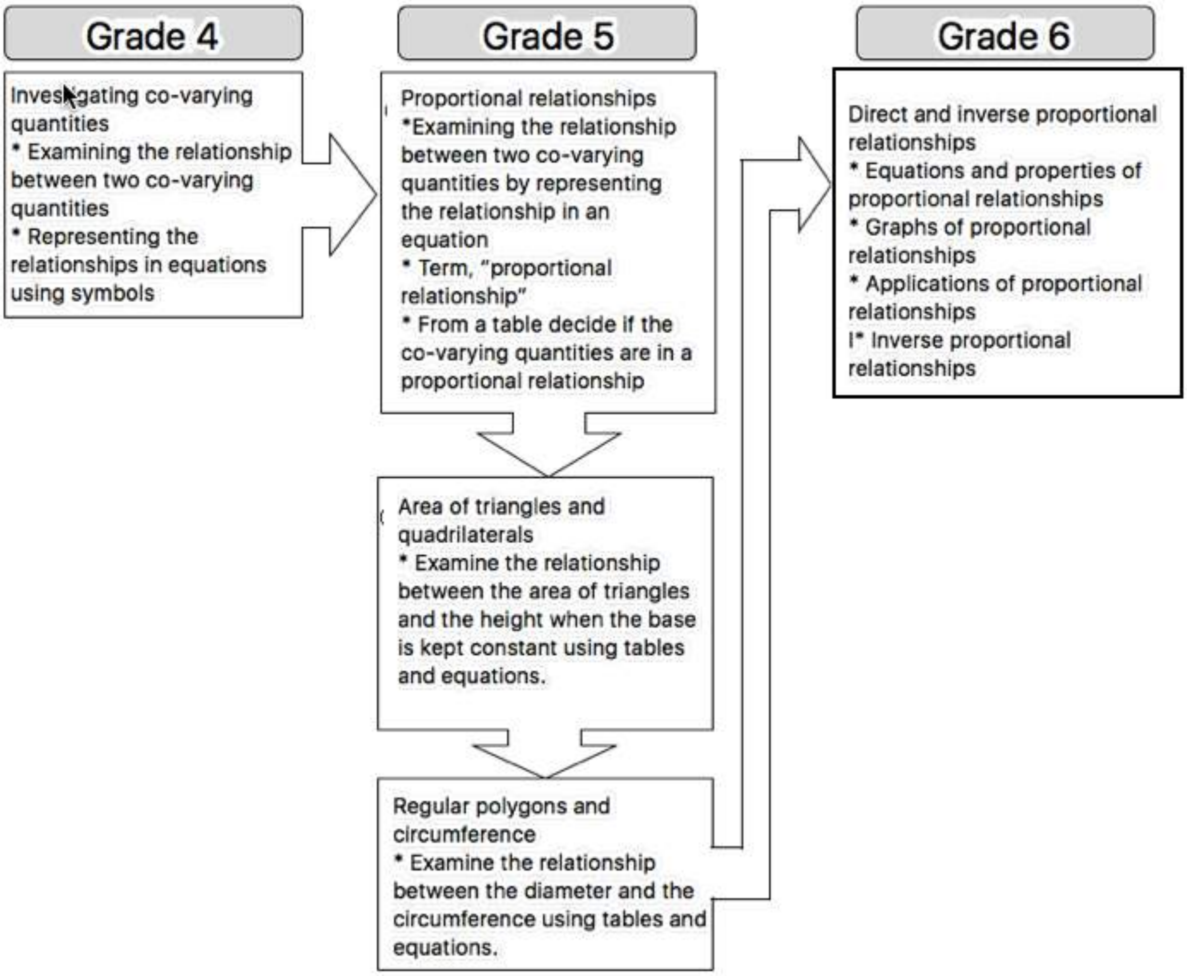
6 About the unit

(1) Unit plan (Total of 3 lessons; today's lesson is lesson 3)

	Goals	Main learning activity	◇ Instructional strategy ☆Evaluation
1	○ Students will understand the relationship between the number of busses and the maximum number of passengers (total). They will understand the term "proportional relationship."	• Students will investigate how the maximum number of passengers (total) will change as the number of busses is made 2, 3, … times as many. • Based on the relationship between the two quantities, students will think about how one of the quantity changes while the other quantity becomes 2, 3, … times as much. • Students will learn the term, "proportional relationship."	◇ Given 2 tables, think about which one shows the relationship when the values of ○ becomes 2, 3, … times as much, the values of △ also becomes 2, 3, … times as much, while writing the times as much relationship in the tables. ☆ Students will become interested in the relationships of two co-varying quantities and examine them on their own accord using tools such as tables. [(1) through observation and students' notebooks] ☆ Students will understand that when one quantity becomes 2, 3, … times as much, the other quantity also becomes 2, 3, … times as much, the two co-varying quantities are in a proportional relationship. [(4) through observation and students' notebooks.
2	○ Through activities to examine the relationship between two co-varying quantities, students can identify and verify a proportional relationship.	• Investigate how the area of room will change when one of its dimensions becomes 2, 3, … times as long. They will summarize that the area of a rectangle is in a proportional relationship with the length of one of its dimensions. • Using the comments and diagrams on pages 141 – 142 in our textbook, students will verify that a proportional relationship may be represented on a number line. • Students will represent a proportional relationship between two quantities in an equation using the symbols □ and ○.	◇ Have students examine the relationship between two co-varying quantities by representing their values in a table. ☆ Students can identify proportional relationships when they were given in tables. [(3) through observation and students' notebooks]

3	Today's Lesson ○ Through the activity to examine the relationship between two co-varying quantities in a concrete situation, students can solve problems based on the fact that the two quantities are in a proportional relationship.	• For the two quantities that are in a proportional relationships, students will determine the constant of proportionality and represent the relationship using an equation. • Students will tackle an application problem which requires them to judge if the given co-varying quantities are in a proportional relationship.	◇ Have students think about ways to figure out the missing values in a table based on the proportional relationship. ☆ Students can examine two co-varying quantities using proportional relationship as a viewpoint. [(2) through observation and students' notebooks]

(2) Scope and sequence



7 Today's lesson (Lesson 3 of 3) --- Grade 5 Classroom 1

Lesson observation points

- Was the emphasis on drawing a table that focuses on the changes of values effective in helping students deciding whether or not the given relationship is a proportional relationship and communicating their ideas to each other?
- Was it effective to review terms and prior learning that are used in this unit for students to communicate their ideas mathematically?

(1) Goal of the lesson

- Students can examine two co-varying quantities using proportional relationship as a viewpoint.

(2) Flow of the lesson

<table>
<tr><th>Main learning activity</th><th>Anticipated students' reasoning・decision making・expressions</th><th>◇ Instructional strategy
☆Evaluation standards and methods</th></tr>
<tr><td>○ Grasp the problem situations and organize the quantities in a table to examine if the two quantities are in a proportional relationship.

○ Students will grasp that the main idea for today's lesson is to examine the relationship between duration and the depth of water by focusing on their dependency relationship.</td><td>[Problem situation]
We are going to fill the pool with water.
For every □ minutes, ○ cm of water is being poured.

T: Let's make a table that shows the depth of water at various duration.

T: Is the depth of water in a proportional relationship with the duration?
C: When the duration becomes 2 times (10 minutes) and 4 times (20 minutes) from 5 minutes, the depth also became 2 times and 4 times. So, I think they are in a proportional relationship.

<table><tr><td>T</td><td>0</td><td>3</td><td>5</td><td>9</td><td>10</td><td>12</td><td>15</td><td>20</td><td>36</td></tr><tr><td>D</td><td>0</td><td>9</td><td>15</td><td>27</td><td>30</td><td>36</td><td>45</td><td>60</td><td></td></tr></table></td><td>◇ By giving students the information about duration and depth in a ramdom manner, help students realize the usefulness of organizing them in a table.

◇ Confirm that the quantities are in a proportional relationship.</td></tr>
<tr><td colspan="3">[Goal] Let's investigate if the depth of water and the time are in a proportional relationship and represent their relationship in an equation.</td></tr>
<tr><td>○ Think about ways to fill in the blank cell in the table. (Independent problem solving)</td><td>T: What can we do to figure out the depth of water at 36 minutes?</td><td>◇ If any student seems to be completely stuck, suggest if the idea of a proportional relationship may be used and/or if it is possible to think by how much the depth increases in 1 minute.</td></tr>
</table>

○ Students will explain each other's idea in a small group. ○ Share the ideas and discuss.	C1: In 1 minute from 9 minute to 10 minute, the depth increased by 3 cm. So, I think we can keep adding starting with the amount at 20 minutes. At 20 minutes --- 60 cm 60 + 3 + 3 + 3 + …. + 3 = 108 C2: 36 minutes will be 3 minutes, 3 minutes, 10minutes, and 20 minutes. So, add the depths for those times. 9 + 9 + 30 + 60 = 108 C3: Because in 1 minute from 9 minutes to 10 minute, the depth increased by 3 cm, we can just multiply the amount of increase in the depth in a minute by 36. 3 x 36 = 108 C4: Because the duration is 3 times as much, make the depth also 3 times as much. 3 x 36 = 108 C5: Because these quantities are in a proportional relationship, and because 36 minutes is 3 times as much as 9 minutes, multiply the depth at 9 minutes by 4 27 x 4 = 108 T: Let's share how you thought about the problem. C: The water depth is increasing 3 cm every minute. C: C3 and C4 both used 3 times as much. C: I think C1 could have used multiplication, too. C: I think the "3" is the amount of increase in water depth. C: I think we can represent the relationship in an equation. C: If we use □ for the duration and ○ for the depth, □ x 3 = ○ shows the relationship. C: We can figure out the duration if we know the depth, too. C: If we use the equation, we can figure out unknown durations, too, not just unknown durations.	◇ If any student thinks like C1, ask if there is a more efficient way to figure out. ◇ Have students think about the commonality between C3's and C4's ideas by focusing on the ways the values are changing. ◇ Make sure students understand that C2's, C3's and C5's ideas idea is based on the proportional relationship. ◇ Encourage students to use phrasing that describes the way quantities are changing, such as "for every minute, the depth is increasing 3 cm." ◇ Help students realize that the situation is related to multiplication. ◇ Have students discuss their ideas in pairs or in groups so that the whole class discussion will lead to the equation. ☆ Students can examine two co-varying quantities using proportional relationship as a viewpoint.

○ Have students tackle application problems. ・Are the quantities in a proportional relationship? ・Represent the relationship using an equation using symbols.	T: Can we say these quantities are in a proportional relationship? If they are, how can you represent their relationship in an equation? ① The number, ○, of 90-yen notebooks and the total cost, □ yen. ② When you buy ○ pieces of 20-yen candies and one 100-yen juice, the relationship between the number of candies, ○, and the total cost, □ yen. ③ When you read ○ pages everyday, the number of pages left, □ pages, in a 300-page book. C: In problem (1), if we make the number of notebooks 2, 3, … times as many, the cost will also become 2, 3, … times as much. So, they are in a proportional relationship. C: In problem (2), when the number of candies, ○, becomes 2, 3, … times as many, the cost, □, does not become 2, 3, … times as much. So, they are not in a proportional relationship. C: In problem (3), when the number of pages read, ○, becomes 2, 3, … times as many, the number of pages left, □, does not become 2, 3, … times as many. So, they are not in a proportional relationship.	◇ Have students use specific numbers to examine if the quantities are in a proportional relationship. ◇ If students can write an equation for problem ①, ask them to figure out equations using □ and ○ to represent problems ② and ③also.
○ Have students write their learning reflection.	T: Please write your lesson reflection about what you understood in today's lesson and things you thought about. Also, please write your reflection on what you learned in the unit.	

(3) Student evaluation

	Anticipated student's actions
A Very satisfied	Students can examine two co-varying quantities using proportional relationship as a viewpoint and explain their ideas using values and appropriate terms.
B Acceptable	Students can examine two co-varying quantities using proportional relationship as a viewpoint.

∗ Support strategy for students who do not reach B --- help students realize that they can figure out the depth if they use the amount of change in every minute.

School Year '19 - '20

School-wide
Lesson Study

Nurturing students who can make connections among their ideas through problem solving

国立市立国立第五小学校

Rationale for the research theme

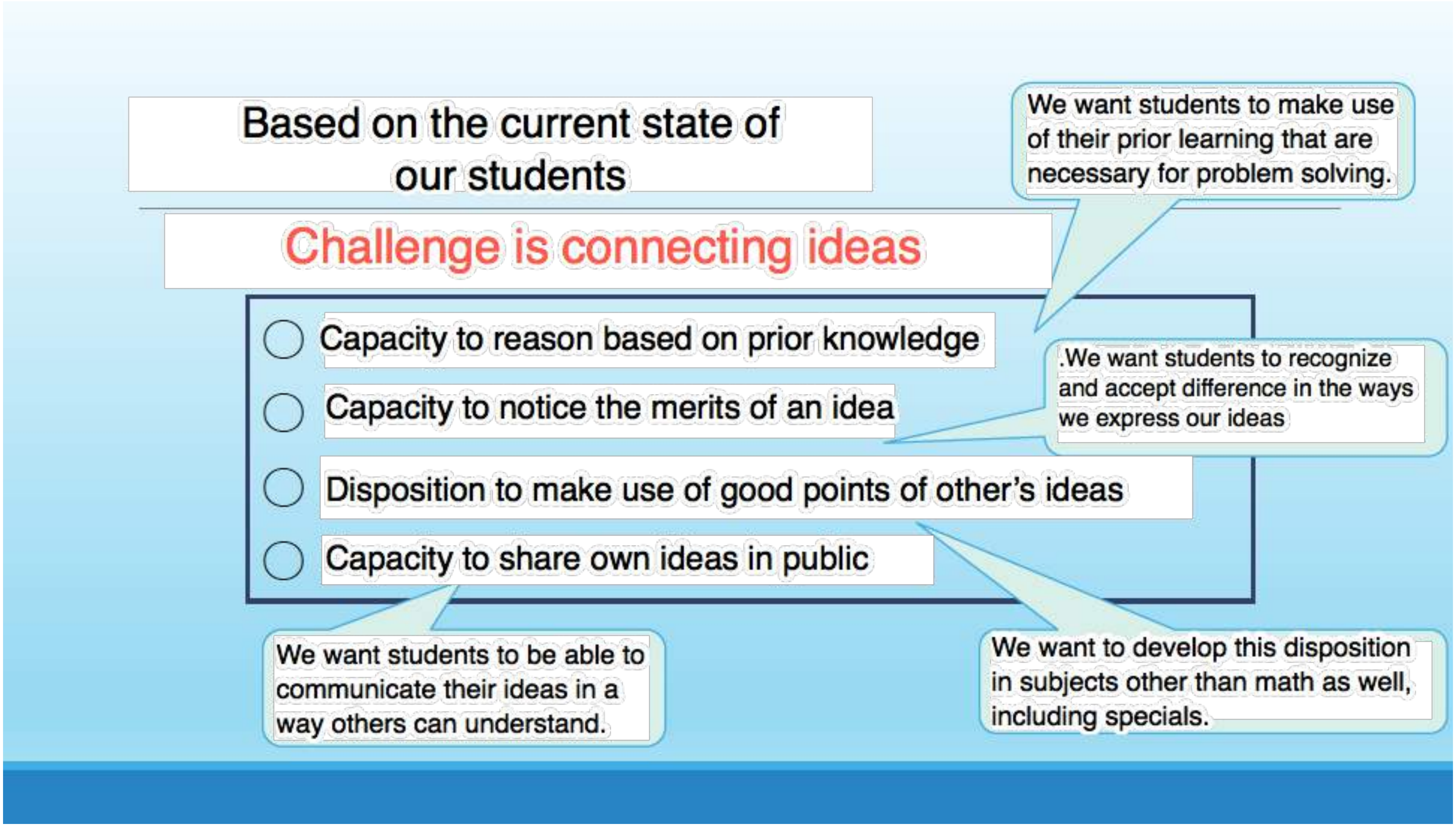
Societal Background

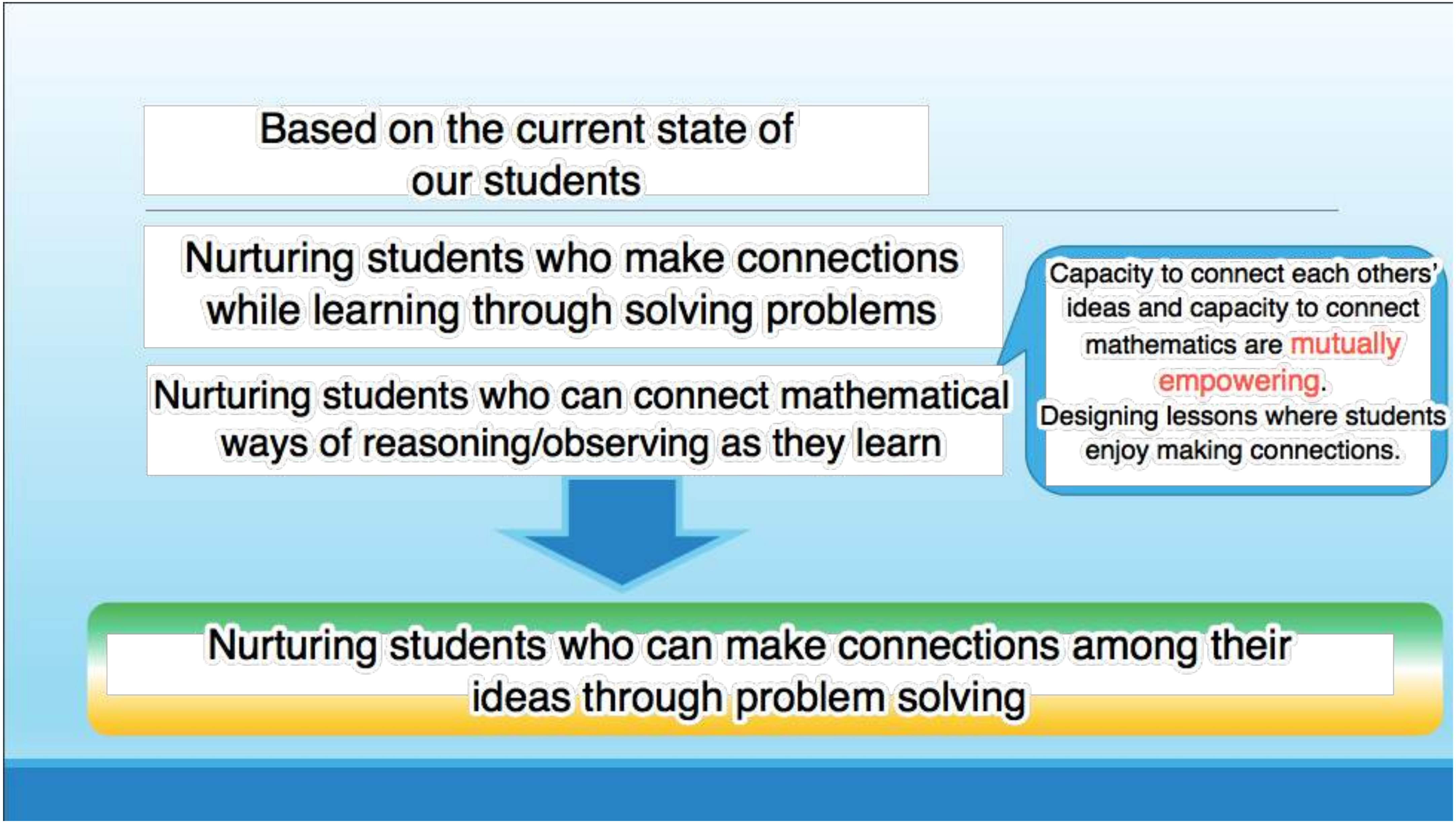
* Decreased working age population
* Further advancement of globalization
* Increased need for collaboration and mutualism with people with diverse value systems;
* Rapid informatization and technological advancement
* Evolution of artificial intelligence

Qualitative transformation of Schooling

* New National Course of Study
* From "what to teach" to "what to be learned"
* Focus on capacity building
* Collaboratively solving problems

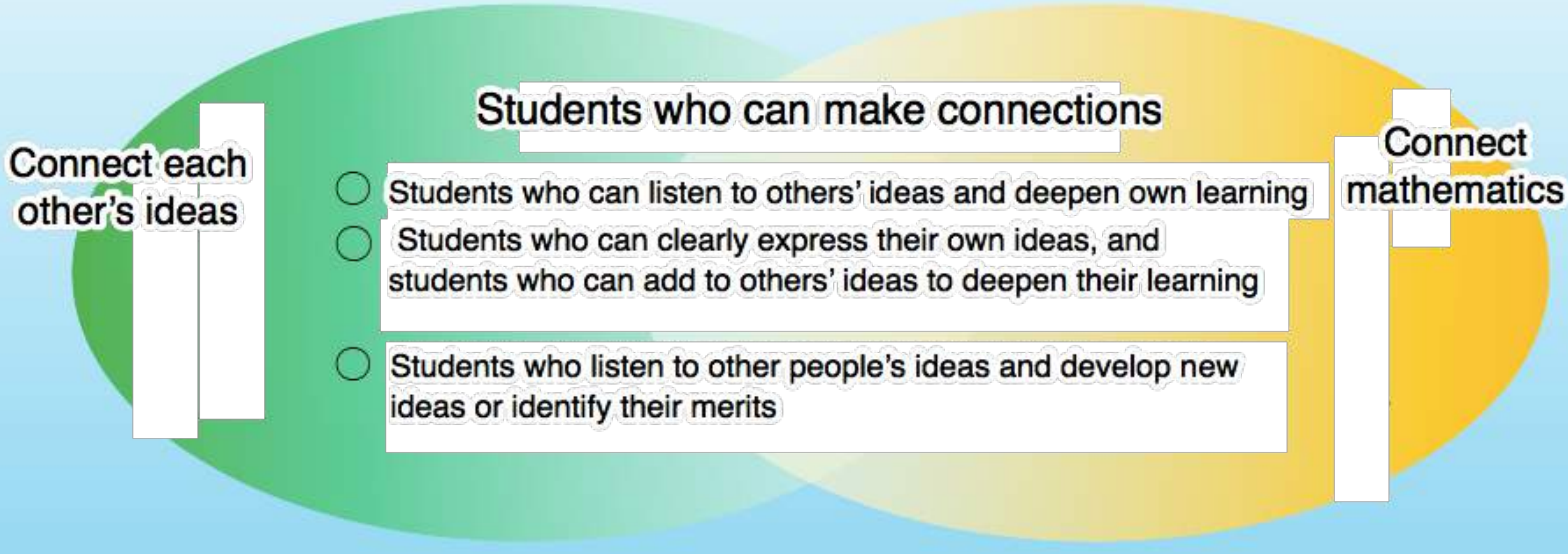
Integrating and further developing knowledge and skills acquired → Solving problems while reasoning, judging and expressing themselves


Based on the current state of our students
Challenge is connecting ideas
Capacity to reason based on prior knowledge
Capacity to notice the merits of an idea
Disposition to make use of good points of other's ideas
Capacity to share own ideas in public
We want students to make use of their prior learning that are necessary for problem solving.
.We want students to recognize and accept difference in the ways we express our ideas
We want students to be able to communicate their ideas in a way others can understand.
We want to develop this disposition in subjects other than math as well, including specials.



Based on the current state of our students
Nurturing students who make connections while learning through solving problems
Nurturing students who can connect mathematical ways of reasoning/observing as they learn
Capacity to connect each others' ideas and capacity to connect mathematics are mutually empowering.
Designing lessons where students enjoy making connections.
Nurturing students who can make connections among their ideas through problem solving

What does it mean for "students to make connections"?



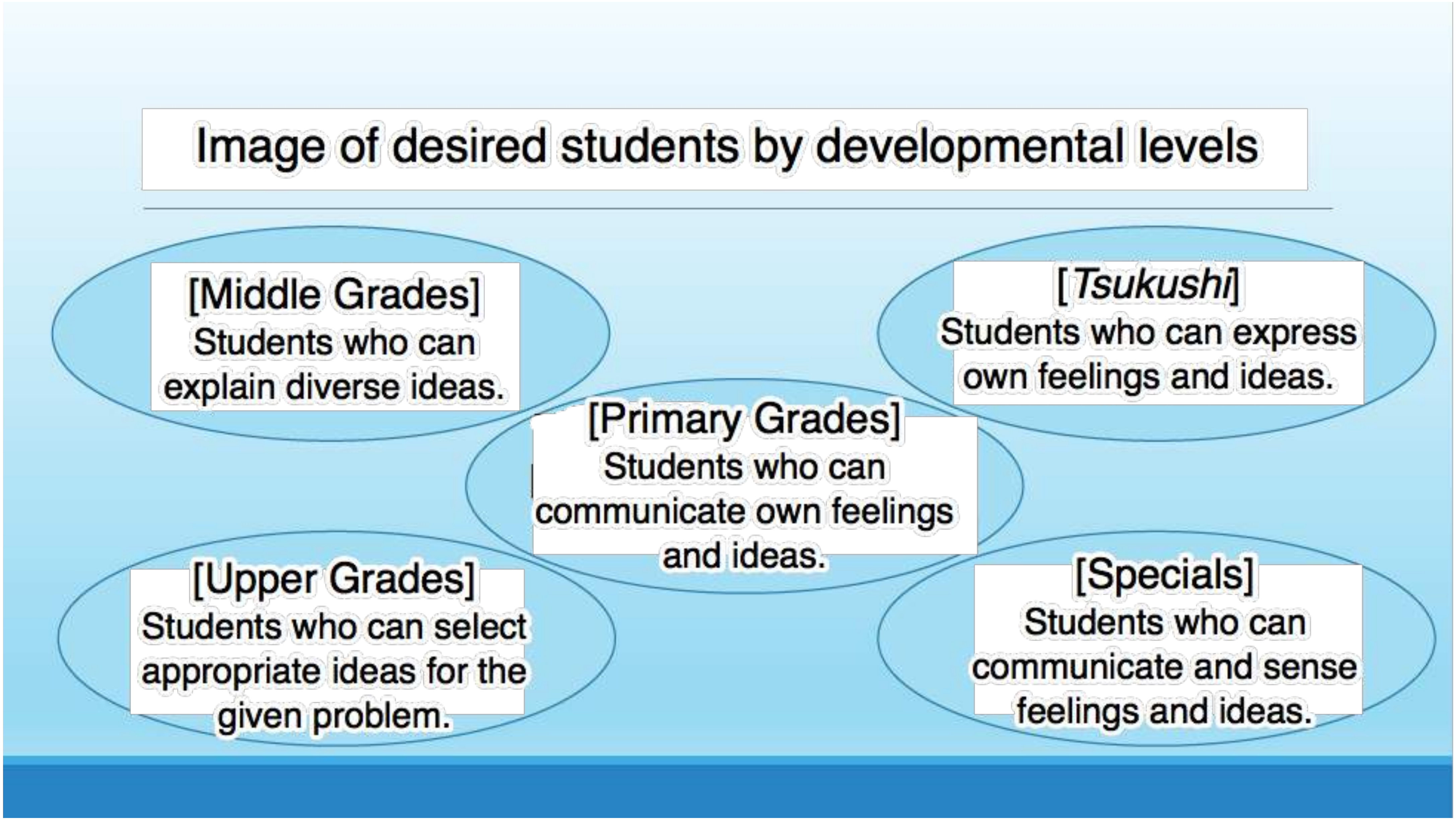
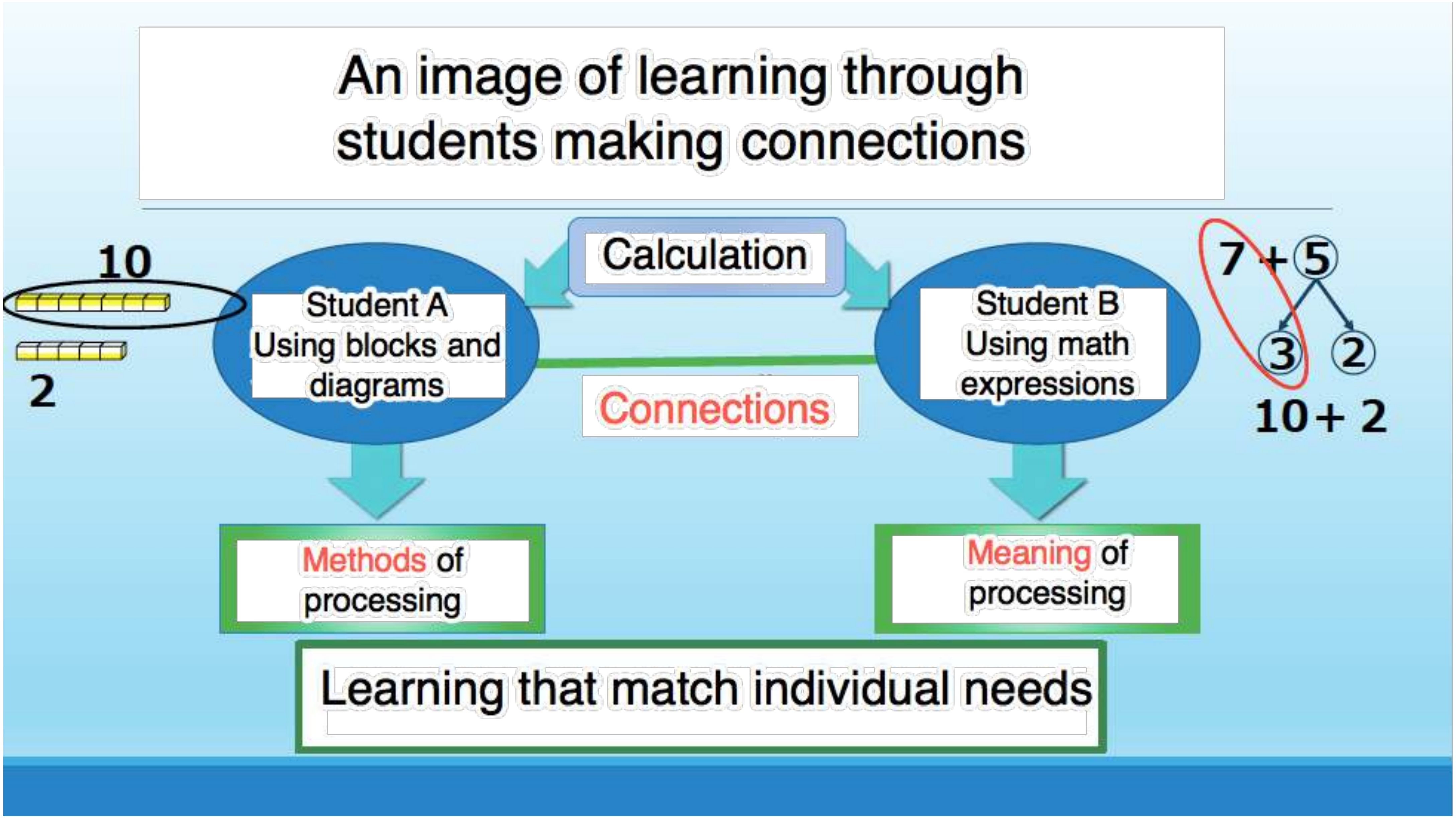
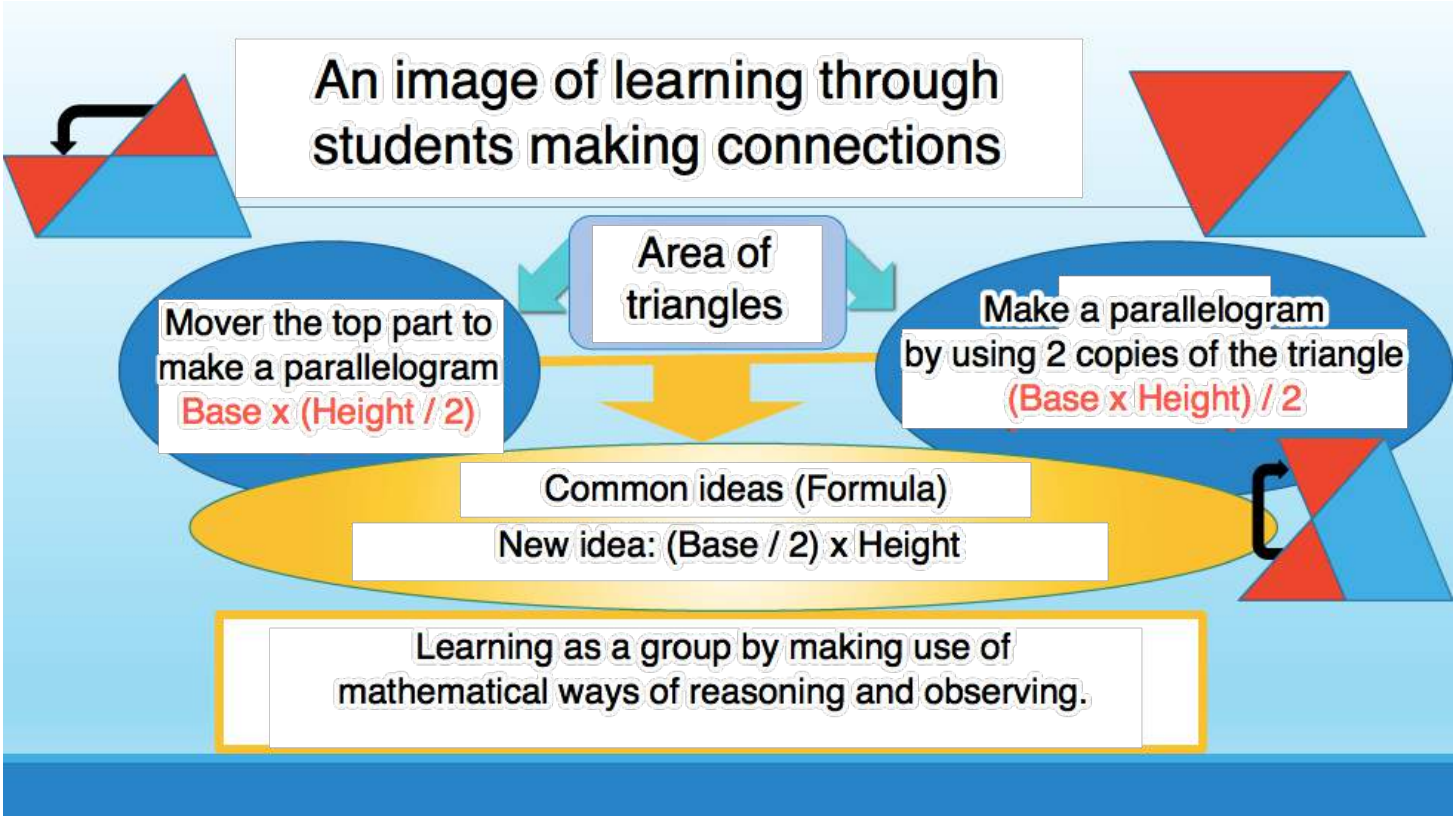


Image of desired students by developmental levels
[Middle Grades]
Students who can explain diverse ideas.
[*Tsukushi*]
Students who can express own feelings and ideas.
[Primary Grades]
Students who can communicate own feelings and ideas.
[Upper Grades]
Students who can select appropriate ideas for the given problem.
[Specials]
Students who can communicate and sense feelings and ideas.


An image of learning through students making connections
Calculation
10
2
Student A Using blocks and diagrams
Connections
Student B Using math expressions
7 + 5
3
2
10 + 2
Methods of processing
Meaning of processing
Learning that match individual needs


An image of learning through students making connections
Area of triangles
Mover the top part to make a parallelogram
Base x (Height / 2)
Make a parallelogram by using 2 copies of the triangle
(Base x Height) / 2
Common ideas (Formula)
New idea: (Base / 2) x Height
Learning as a group by making use of mathematical ways of reasoning and observing.

Research Approach

Strategies to design “lessons that promote connecting of ideas”

In order to "connect friends' ideas"

Revising own idea based on others' ideas

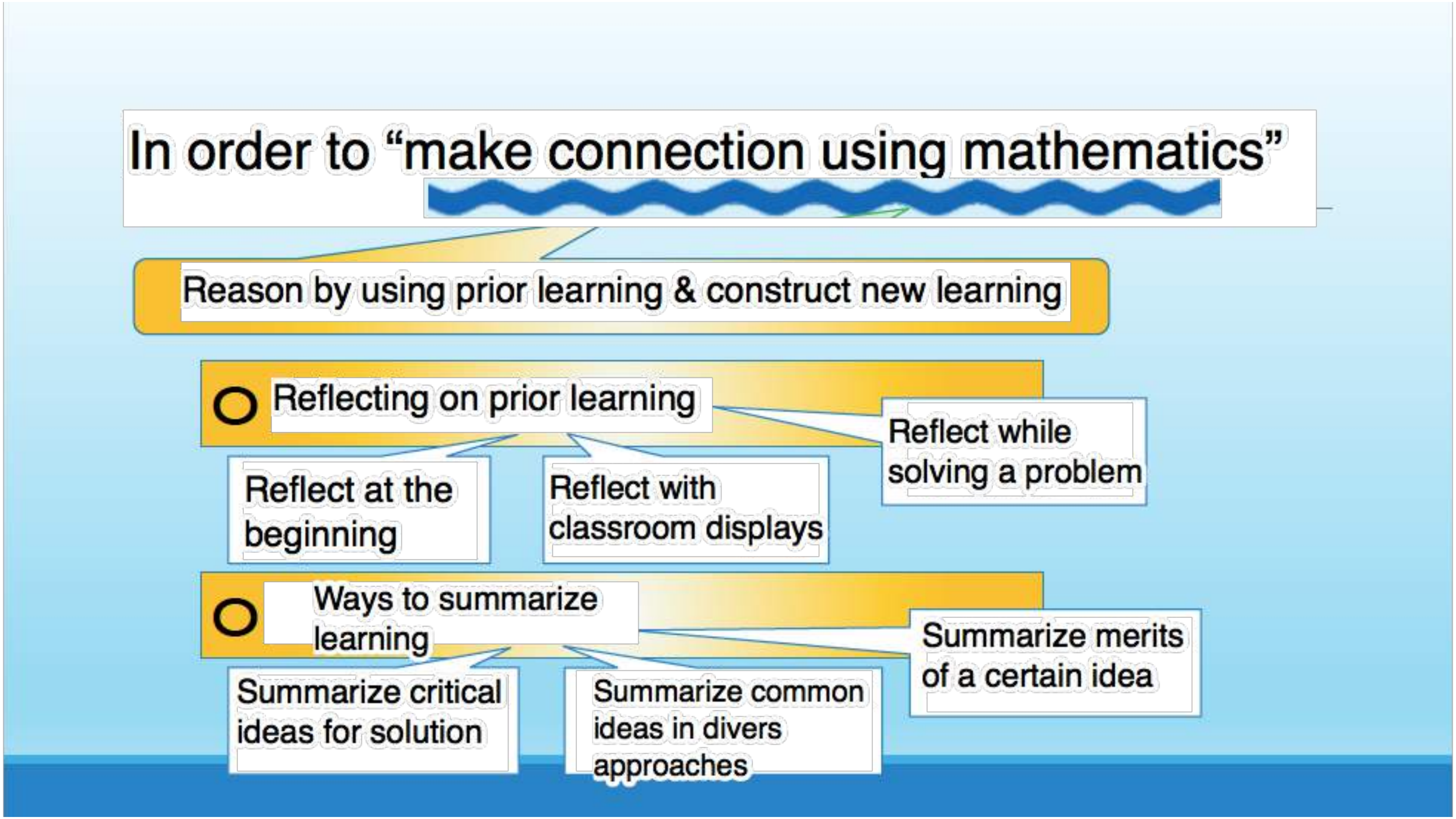
○ Pair and small group discussion activities

* To communicate own ideas
* To make discussion more lively

* To know diverse ideas
* Multiple students share their ideas

○ Examining different ways of expressing ideas

* To make sense of friends' ideas
* To discover new ideas from friends' ideas


In order to “make connection using mathematics”
Reason by using prior learning & construct new learning
Reflecting on prior learning
Reflect at the beginning
Reflect with classroom displays
Reflect while solving a problem
Ways to summarize learning
Summarize critical ideas for solution
Summarize common ideas in divers approaches
Summarize merits of a certain idea

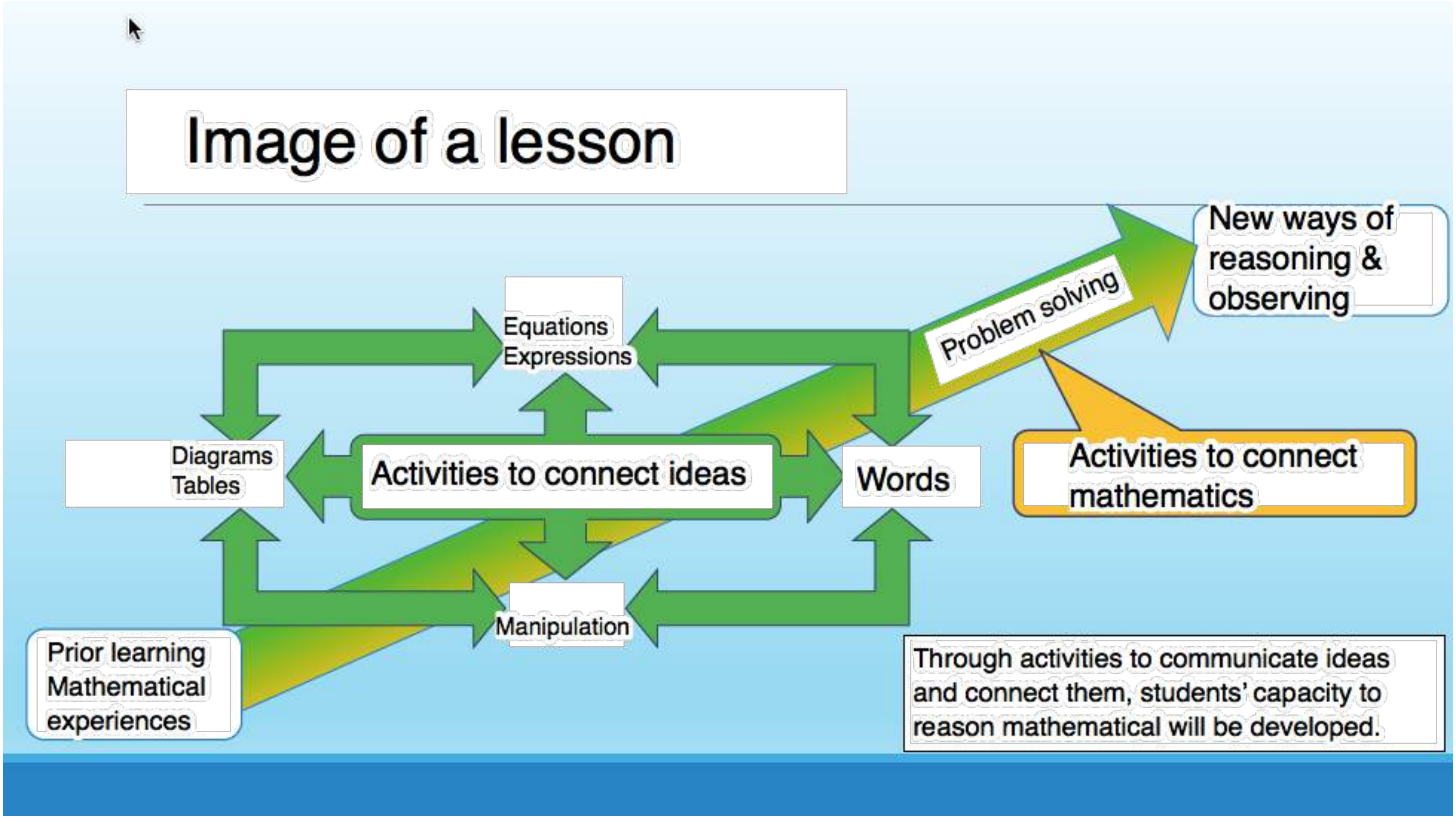


Image of a lesson
New ways of reasoning & observing
Problem solving
Equations
Expressions
Diagrams
Tables
Activities to connect ideas
Words
Activities to connect mathematics
Manipulation
Prior learning
Mathematical experiences
Through activities to communicate ideas and connect them, students' capacity to reason mathematical will be developed.

Results and further challenges

Results & Challenges "connecting friends' ideas"

Results

* We were able to observe students comparing and contrasting their ideas and learning from each other.

* Students are noticing merits of other people's ideas.

Challenges

* How to help students' discussion more focused

* Strategies to help students make connections and devising questions that might be effective

Results & Challenges "connecting using math"

Results

* Planning lessons that are intentionally connected to students' prior learning

Challenges

* Strategies to help students realize the necessary prior learning on their own

* Consolidating the basic and foundational ideas

2019 - 20 school year research

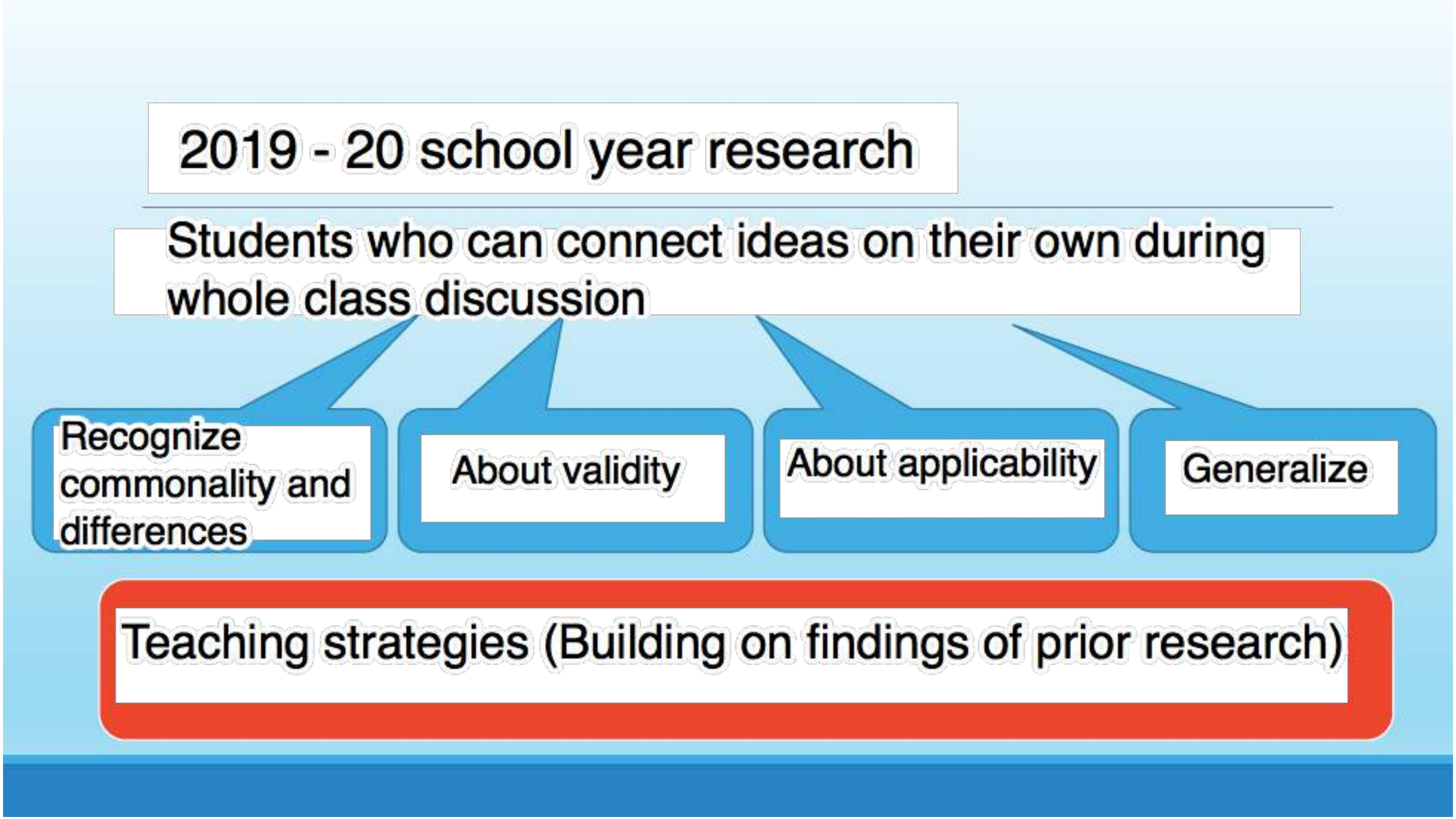
Challenges

* Strategies to help students realize the necessary prior learning on their own

* Consolidating the basic and foundational ideas

Grasping Problem → Independent problem solving → Discussion → Summarizing and reflecting

Students who can connect ideas on their own


2019 - 20 school year research
Students who can connect ideas on their own during whole class discussion
Recognize commonality and differences
About validity
About applicability
Generalize
Teaching strategies (Building on findings of prior research)

June 20

Grade 5 Mathematics Lesson Plan
(Abbreviated Plan)

Date & Time: 5th Period, Thursday, June 20, 2019
Instructors & Proficiency Course Level:

C Course (Basic), KUNITOMI, Sawako [Grade 5, Class 1 Teacher]
A Course (Advanced), TAKAOKA, Tadashi [Grade 5, Class 2 Teacher]
B Course (Standard), HONDA, Satomi [Teacher in charge of mathematics proficiency level instruction]

1. **Name of the Unit:** Let's Think about the Division of Decimal Numbers (Tokyo Shoseki Textbook)
2. **Goals of the Unit:**

Students understand the meaning and method for division calculations in which the divisor is a decimal number

Interest, Motivation, and Disposition	Students use calculations of whole numbers and the base-ten numeration system as the basis for thinking about and generalizing division to calculations when the divisor is a decimal number.
Mathematical Reasoning	Students can apply number line representations and the properties of division to think about, explain, and summarize the meaning and method of division calculations in which the divisor is a decimal number.
Skills and Procedures	Students perform division calculations in which the divisor is a decimal number.
Knowledge and Understanding	Students understand the meaning and method of division calculations in which the divisor is a decimal number.

3. **Unit Instructional Plan (a total of 14 lessons):**

Lessons	Goals	Learning Activities
1 This Lesson	○ Understand the meaning of dividing by a decimal number and think about how to calculate whole number ÷ decimal number.	• Establish a math sentence on their own. • Think and explain using number lines and word math sentences.
2	○ Understand how to calculate.	• Think about how to calculate 300 ÷ 2.5. • Summarize how to calculate 300 ÷ 2.5.
3	○ Understand how to calculate decimal number ÷ decimal number.	• Think about the math sentence. • Think about how to calculate decimal number ÷ decimal number and summarize the method.
4	○ Understand how to calculate decimal number ÷ decimal number and be able to carry out the calculation	• Think about how to calculate decimal number ÷ decimal number using the algorithm. • Practice calculations.
5	○ Understand the fact that the quotient is greater than the dividend when dividing by a proper decimal number (when the divisor is a decimal number between 0 and 1)	• Compare the sizes of quotient and dividend • Summarize the generalization that a quotient is greater than the dividend when the divisor is a proper decimal number

6	○ Understand the meaning of the "remainder" in division of decimal number and be able to find remainder.	• Think about decimal division with remainder. • Summarize where to put the decimal point for the reminder.
7	○ Understand how to express a quotient as an approximate number when the divisor is a decimal number.	• Think about the weight of 1L of sand. • Think about how to express a quotient when it is indivisible division and express the quotient as an approximate number with two places from the highest place. • Summarize how to express a quotient with an approximate number.
8	○ Use number lines to deepen understanding about how to decide what operation to use when dividing decimal number problems.	• Use number lines to think about math sentences that represent ~~when~~ finding the weight of a 1m hose and the length of a 1 kg hose.
9	○ Understand that even when the quantity being compared and the base quantity are decimal numbers, the "times as much" relationship can be found using division.	• Think about how to find the base quantity when decimal numbers are involved. • Summarize the understanding that even when the quantity being compared and the base quantity are decimal numbers, the "times as much" relationship can be found using division.
10	○ Understand that even when the number expressing "times as much" is a decimal number, the base quantity can be found by expressing a multiplication sentence using [ ] to represent the unknown, and using division to find the [ ].	• Think about how to find the base quantity when the "times as much" factor is a decimal number. • Summarize: When finding the base quantity, students can express the math sentence with multiplication and a symbol for the unknown [ ].
11	○ Understand that comparison problems can be solved by finding the difference between quantities, as well as the "times as much" relationship (multiplicative relationship).	• By calculating 150 ÷ 120 and 1530 ÷ 1500, compare how the prices increased using "times as much." (multiplicative relationship)
12	○ Student solve problems applying what they learned in this unit	• Solve Power Builder problems.
13 & 14	○ Check student understanding of math learning content and assess whether their understanding is solidified.	• Solve Mastery Problems.

4. About the Unit:

(1) Place in the Course of Study

Grade 5, A. Numbers and Calculations, Multiplication and Division of Decimal Numbers.

○ Through mathematical activities involving multiplication and division of decimal numbers, help students acquire the following knowledge and understandings:

A. Acquire knowledge and skills

a. Understand the meaning of multiplication and division calculations in which the multiplier and divisor are decimal numbers.

b. Be able to perform calculations of multiplication and division of decimal numbers. Moreover, understand the size of remainders.

c. Understand that the properties of calculations of whole number multiplication and division applies also to the calculation of decimal number multiplication and division.

B. Acquiring thinking, decision making, and expressive abilities

a. Pay attention to the meaning of multiplication and division and reconsider the meaning of multiplication and division when the multiplier and the divisor are decimal numbers. Moreover, think about how to calculate problems when the multiplier and divisor are decimal numbers. Lastly, use the calculations apply to problem situations in daily life.

(2) About Instruction:

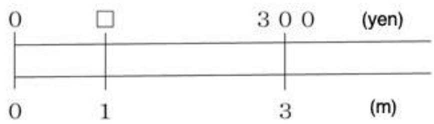
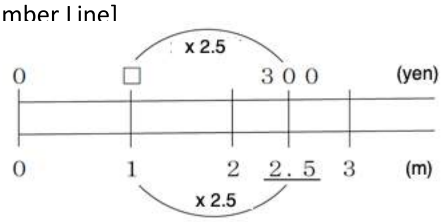
Student learned whole number division in Grade 3 and decimal division calculations in which the divisor is a whole number in Grade 4. The learning goal of this unit is for students to learn the meaning of decimal division calculation in which the divisor is a decimal number (expanding the meaning of division) and learning how to calculate such calculations. Students will become fluent in the calculations and utilize this understanding and skill to solve problems. Students understand the relationship of multiplication and division by understanding the meaning of "times as much" when the quantity to be compared and the base quantity are decimal numbers. In the previous unit (multiplication of decimal numbers), students learned the meaning of multiplying by a decimal number and also how to perform the algorithm calculation. Since this unit (division of decimal numbers) has a similar unit structure to previous division learning, the flow of learning is similar and will be familiar to them. Therefore, I will teach this unit with its similar flow and in the same manner ~~way to the~~ as the previous unit, by paying attention to the unique characteristics of multiplication and division.

Division has two meanings and applications: partitive division and quotative division. In the beginning of the school year, the textbook introduced partitive division problem situations with decimal number divisors (e.g., 300 ÷ 2.5). In the problem situation discussed here, students have difficulty understand the meaning "divided by decimal numbers," because "divided by a decimal number of *equal parts*" does not make sense to them. Therefore, the meaning of division needs to be expanded to include "finding the unit quantity."

5. Instruction of Today's Lesson: (The first of 14 lessons in the unit) **[B Course (Standard), C Course (Basic)]**

(1) Goal: Students understand the meaning of dividing by a decimal number.

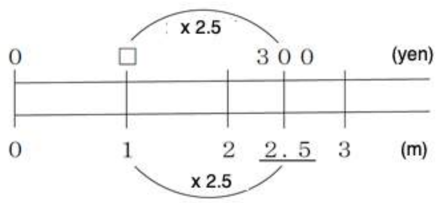
(2) Flow of the Lesson:

Accumulative Time	Learning Activities	Assessment
10 minutes	1. Let's look back at what we learned before about division. [Not only how to find the answer but also the calculation process.] (1) Review the calculation of 72 ÷ 8. 72 ÷ 8 = 9 (2) Review the calculation of 84 ÷ 21. 84 ÷ 21 = 4 (3) Review the calculation of 7200 ÷ 800. 7200 ÷ 800 = 9 Think about the calculation of 72 ÷ 8 = 9 as the base. (4) 80 ÷ 25 = 3.2	[Knowledge & Understanding] Students understand the meaning of division and how to calculate it.
20 minutes	Let's think about how to calculate division with decimal numbers. When I bought a 3 meter ribbon, the cost of it was 300 yen. What is the cost for 1m ribbon? ○ Math Sentence: 300 ÷ 3 [Number Line]  300 ÷ 3 = 100 Answer: 100 yen	[knowledge & Understanding] Students understand the meaning of division and how to calculate it.
35 minutes	When I bought a 2.5 meter ribbon, the cost was 300 yen. What is the cost of 1m of ribbon? What is the math sentence? ○ Math Sentence: 300 ÷ 2.5 Explain why the math sentence is 300 ÷ 2.5. [Verbal math sentence] Cost ÷ Length bought = Cost for 1m [Number Line] 	[Interest, Motivation, Disposition] Students recognize that they cannot use the meaning of [Total quantity ÷ Number of groups] in the case of dividing by a decimal number, so they try to think by expanding the meaning of division.
45 minutes	[Summary] Even if the length of a ribbon is a decimal number, to find the cost of 1 meter of ribbon, we use division just like we did with whole numbers.	

5. Instruction of Today's Lesson: (The first of the 14 lessons unit) **[A Course (Advance)]**

(1) Goal: Students Understand the meaning of dividing by a decimal number

(2) Flow of the Lesson:

Accumulative Time	Learning Activities	Assessment
10 minutes	2. Let's look back what we learned before about division. [Not only how to find the answer but also the calculation process.] (5) Review the calculation of 56 ÷ 8. 56 ÷ 8 = 7 (6) Review the calculation of 81 ÷ 27. 81 ÷ 27 = 3 (7) Review the calculation of 6300 ÷ 700. 6300 ÷ 700 = 9 Think about the calculation of 63 ÷ 7 = 9 as the base. (8) 133 ÷ 38 = 3.5	[Knowledge & Understanding] Students understand the meaning of division and how to calculate it.
20 minutes 35 minutes	Let's think about how to calculate division with decimal numbers. When I bought a 2.5 meter ribbon, the cost of it was 300 yen. What is the cost for 1m ribbon? <u>What is the math sentence?</u> ○ Math Sentence: 300 ÷ 2.5 <u>Explain why the math sentence is 300 ÷ 2.5.</u> [Verbal math sentence] Cost ÷ Length bought = Cost for 1m [Number Line]  Let's think about the answer of 300 ÷ 2.5. About how many yen is that going to be? ○ 300 ÷ 3 = 100 ○ 300 ÷ 2 = 150 ○ Therefore, I think it will be about 120 to 130 yen.	[Knowledge & Understanding] Students understand the meaning of division and how to calculate it. [Interest, Motivation, Disposition] Students recognize that they cannot use the meaning of [Total quantity ÷ Number of groups] in the case of dividing by a decimal number, so they try to think by expanding the meaning of division.
45 minutes	[Summary] Even if the length of a ribbon is decimal number, to find the cost of 1 meter ribbon, we use division just like we did with whole numbers.	

June 21

Grade 3, Mathematics Lesson Plan

Place: Showa City Oshihara Elementary School
Teacher's Name: Midori SHIBAKITA

1. **Name of the Unit:** Let's Think about Division (Division with Remainders)

2. **Goals of the Unit:**
Students understand division when there is a remainder in the quotient. The lesson is designed to further students' understanding of the meaning of division, including applying their knowledge and understanding about remainders in division problem situations.

   - Using cases of division when there is no remainder (divisible division), students try to understand the meaning of and how to calculate division when there *is* a remainder (indivisible division), by connecting division to their understanding of multiplication and representing and modeling indivisible division with concrete objects. **[Interest, Motivation, and Disposition]**
   - Students see that division with divisible cases and indivisible cases both represent unified division cases. They express the meaning of division and division calculations using concrete objects, diagrams, and math sentences. **[Mathematical Reasoning]**
   - Students perform indivisible division calculations and find solutions that are quotients with remainders. **[Skills and Procedures]**
   - Students know what remainders represent and understand the size relationships between remainders and divisors, as their understanding of division increases. **[Knowledge & Understanding]**

3. **About the Unit:**
In Grades 2 and 3, my students thought about the meaning of multiplication and performed multiplication calculations to explore the properties of multiplication. In the everyday life problem situations they solve in my classroom, students have shown a solid understanding of how to use multiplication when a whole is divided equally into several equal parts.
In addition to previous grade levels, in this grade's fourth unit, entitled "Division," students learned that division is a reversed calculation of multiplication (i.e., division as inverse of multiplication). In that unit, the division students learned was all problems with dividends that "matched" the products of multiplication facts they were familiar with. That is, when my students thought about the divisor and the multiplication facts (multiples) of the divisor, they saw how the dividend reflects multiplication of the divisor. They used this relationship between multiplication and division to find the quotient of division problems.
However, in the present unit, the dividends do not match whole-number products of multiplication facts. Now, students need to think about how to carry out division calculation in these situations. In the process of thinking about how to solve these division problems, some students do not question when a remainder is greater than a divisor. Some do not think about how different cases of problem solving situations mean they have to think about the remainder differently, too. Therefore, it is important for students to use diagrams to represent and explain their thinking. Then they can see how they may be misunderstanding the situation, because they are not representing the situation correctly.
In this unit, students learn division with remainders, the division case that is indivisible. To do a division-with-remainder calculation, students must find the largest product that does not exceed the dividend; then, they can use that product to find the quotient and the remainder. For example, in the case of calculating 13 ÷ 4, when the missing product of 4 x [ ] or [ ] x 4 is less than 13 and closest to 13, we can find the whole number quotient and the remainder. The

quotient shows the greatest quantity of each of the equally divided parts or the greatest number of equally divided quantities. Moreover, the remainder is less than the divisor. These are important ideas students need to understand. In addition, when students understand the relationship, (divisor) x (quotient) + (remainder) = (dividend), they see how they can use this relationship to check their calculation answers. I am hoping that students will recognize and come to understand the difference between the division they learned previously (divisible division) and the division they encounter in this unit (indivisible division).

In problem situations, there are cases when it is important to find both the quotient and the remainder, consider the remainder as part of the quotient, and add 1 to the quotient. Then there are those situations when only the quotient – without the remainder – represents the problem solutions. Students need to understand and recognize the difference between these two division situations, so they identify correctly how to process remainders.

The division situations in the previous Unit 4 "Division" introduced division via the partitive division problem situation; however, in this unit, "Division with remainders," division was introduced in quotative division problem situations, because these situations help students understand the meaning of remainders. Through these situations, students learn they can write division math sentences just as before, even in the case of indivisible division situations. I would like to incorporate activities where students manipulate concrete materials and draw diagrams, using these visual representations to explain their ideas and better understand the indivisible problem situations and solution process. Finally, there are additional cases when the answer to an indivisible problem situation cannot be answered by using only the quotient and remainder, so I would like to provide opportunities for students to think, explain, and reason to help them develop their deep understanding of remainders and how to process remainders.

4. Knowledge and Skills that I Would Like to Foster Among the Students:

In students' daily life, there are situations or phenomena that students should connect to the mathematics that underlies the situations/phenomena, as they improve how to think, justify, and problem solve. In this way, students need to be equipped with skills for grasping problem situations and process these situations appropriately to find solutions. Therefore, I would like to help students develop skills to connect everyday-life problem situations with mathematics and use mathematics to think and process. In addition, I would like to help students see and feel how very useful mathematics is.

Included in not only this unit, but across units, I would like to draw from problems that are connected to students' daily lives and engage them in activities that provide ample opportunities to think and explain using concrete materials, diagrams, and math sentences to problem solve. Moreover, I would like to provide opportunities for students to reflect on the solution process and think about the meaning of the solution as part of my instruction.

5. Unit Plan of the Instruction and Assessment:

Lessons	Goals	Instructional Activities	Main Assessment Points
(1) Division with Remainders Total of 6 Lessons			
1	[Prologue] • Through discussing a review of previously learned division (divisible division) and the points students know about division, help students notice there are cases of division that are indivisible (division with remainders) and become interested in learning more about division.		
2	• Students understand how to perform calculations in which the divisor and quotient are both 1-digit and the dividend is indivisible.	• Students think about how to find the answer of 14 ÷ 3. • Students present their ideas and confirm the answer. • Students discuss how to process the remainder. • Students understand the meaning of remainders.	[IMD]* Students are thinking about how to perform division calculations in indivisible cases using their previously acquired knowledge of divisible cases as a basis. [MR] Students are thinking about how to perform division calculations in indivisible cases using their previously acquired knowledge of divisible cases as a basis. They explain their methods using aids such as concrete objects, diagrams, and math sentences.
3	Students understand the relationship between the remainder and the divisor.	• Students investigate the relationship between remainder and divisor in the case of division, 14 ÷ 3.	[K&U] Students understand that the remainder is to be smaller than the divisor.
4	Students understand that indivisible cases of division can be applied in partitive division, as well as quotative division.	• Students grasp the problem situation, establish a math sentence, 16 ÷ 3, and think about how to find the answer. • Students present their ideas and confirm the answer. • Students solve word problems.	[MR] Students think about how to calculate indivisible partitive division problems using divisible cases of partitive division as a basis; and they explain using tools or models such as concrete objects, diagrams, and math sentences.
5	Students understand how to check the answers of indivisible division calculations.	• Students think about how to check the answers of indivisible division calculations.	[K&U] Students understand how to check answers to indivisible division problems.
6	Students practice division calculations, including those that are indivisible.	• Students practice division calculations and check the answers.	[S&P] Students can perform indivisible division calculations and solve for the quotient and remainder.

(2) Problems Dealing with Remainders Total of 2 Lessons			
7 This Lesson	Students think about how to process remainders based on problem situations and be able to explain the process. (Problem situation: quotient plus 1).	• Students grasp the problem situation, establish a math sentence, 23 ÷ 4. • The calculation shows the quotient is 5 and remainder is 3. Students discuss if the answer should be 5 or not. • Students summarize why the answer will be the quotient plus 1.	[MR] Students understand how to process quotients and remainders based on the problem situation and are able to explain why they used this process.
8	Students think about how to process remainders based on problem situations and are able to explain the process. (Problem situation: No need to add 1 to quotient)	• Students grasp the problem situation, establish a math sentence, 30 ÷ 4. • The calculation shows the quotient is 7 and remainder is 2. Students discuss if the answer should be the quotient plus 1 or only use the quotient.	[MR] Students understand how to process quotients and remainders based on the problem situation; and they are able to explain why they used this process.
Summary Total of 2 Lessons			
9	Student apply what they have learned about division in this unit to solve problems.	• Students solve “Power Builder” problems.	[S&P] Students solve problems using previously-learned content appropriately.
10	Students check and reinforce their understanding of the math content in this unit	• Students solve “Mastery Problems.”	[K&U] Students have acquired a basic understanding of the content in this unit.

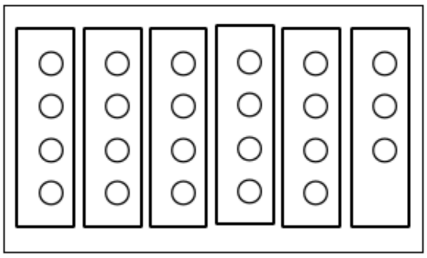
*[IMD] Interest, Motivation, and Disposition, [MR] Mathematical Reasoning, [S&P] Skills and Procedures, [K&U] Knowledge & Understanding

6. About this lesson

(1) Date and time: 5th period, Friday, June 21, 2019
(2) Place: Grade 3, Class 2 classroom
(3) Goal of the lesson:
Students think about how to process remainders based on problem situations and are able to reason about and explain the process.

(4) About Instruction
In the past, students have learned about division problems by answering questions, such as: “How many people receive [*n*] sheets of papers and how many sheets will be left?” “How many sheet of paper will each person get and how many sheets will be left?” These problems ask, “How many are left?” so students become accustomed to finding the remainders and using the quotient and remainders to answer these questions. However, the problem the students face in this lesson do not have a question that directly asks about the remainder. Therefore, students will learn to consider how the remainder should be processed to find an appropriate answer to the question the problem is asking. This is the primary task and object of this lesson. In this lesson, the problem the students solve is: “To carry all the tennis balls, how many containers do we need?” Since the answer is the quotient plus 1, the students need to think about how to deal with the remainder. In other words, students must think about whether the calculation and answer (quotient and remainder) is appropriate for answering what the problem is asking. I would like to provide opportunities for students to explain their own solution ideas and use diagrams and math sentences to try to understand their friends’ ideas. In addition, I would like to help them think about how to process the remainder appropriately, so they can be confident that they answered the question the problem is asking.

(5) Instructional process

Time	**Instructional Activities** **○ Anticipated Student Responses**	**Things to Remember**	**Notes**
Grasp 10 min.	1. Grasp Today's task. ① Grasp the problem situation There are 23 tennis balls. A tennis ball container can hold 4 balls. How many containers do we need if we want all the balls in containers so we can move them to another location? ② Think about the math sentence ○ 23 ÷ 4 ③ Grasp Today's task Let's think about how many containers we need.	• Help students understand that containers are necessary to carry balls from place to place. • Discuss the problem, so students confirm that a container can hold only 4 balls. • Show concrete materials. • Confirm with students that the math sentence is 23 ÷ 4, from the discussion. • Write the task on the board so the students grasp the task clearly.	
Think 10 min.	2. Write your own idea in notebook. A: 23 ÷ 4 = 5 R3 <u>Answer: We need 5 containers and 3 balls are left</u> The answer to the calculation is 5 R3, so we need 5 containers and 3 balls will be left. B: 23 ÷ 4 = 5 R3 <u>Answer: 5 containers</u> The 3 balls left over cannot be in the container, so the answer is 5 containers. C: 23 ÷ 4 = 5 R3 <u>Answer: 6 containers</u> We need to put the 3 balls in a container also. So, we need one more container. The answer is 6 containers. (If we show it with a diagram) 	• When finding students who are having difficulty calculating, ask them to recall what they did in the past. • Walk around the classroom and monitor students' progress and ideas. • When finding students writing their own explanation in addition to their answers, provide some positive feedback. • So they make connections among diagram, explanation with words, and math sentences in later discussions, encourage students to represent their ideas in multiple different ways.	◎ Students understand how to process quotients and remainders based on the problem situation and are able to explain why they used that process. (Notebook)

Pursuit 20 min.	3. Discuss the solution (whole class). ① Explain your solution. A: ○ The answer to the calculation is "5 R3," so we need 5 containers and 3 balls are left. ○ There are only 3 balls left, so we can't put them in the container. I think we need only 5 containers. ○ We don't need to think about the remainder. B: ○ 5 containers and 3 balls left, so 5 containers. C: ○ We need to put the 3 balls in a container, so we need 6 containers. ○ We need to put all the balls in the containers, so we need to put the 3 balls in a container. ○ We need 5 containers to put all the balls away. ○ If we draw a diagram, we can see that we need another container. ○ If we write it in a math sentence, 5 + 1 = 6. ② Compare each solution and relate the solutions to each other: ○ There are answers that show the remainder and add one more container to include the remainder. ○ There is an answer that does not think about the remainder. ○ If we don't use another container, we need to carry the 3 balls by themselves. ○ The problem says, "all the balls in the containers," so we need to put the three balls in a container also. ○ 6 of the 6 containers means 5 + 1. ③ Summarize the discussion ○ I thought I needed to find the remainder at first, but I understand that I need one more container to carry all the balls. ○ I thought I didn't need to think about the remainder, but now I understand that I need to add one more container. ④ Think about if the remainder is 1 or 2 (instead of 3) ○ We need to use another container to put in the remaining balls, even when there are only 1 or 2 balls.	• Write down each student's idea on the board and help students organize their thinking. • Carry out the discussion focused on how to deal with the remainder 3. • Carry out the discussion focused on how to deal with the remainder 3. • Compare with the problem situation that requires showing remainders. Confirm that in this problem they do not need to find the remainder. • Confirm that the answer is the quotient plus 1. • Confirm that there are cases that even if the remainder is 2 or 1, they will need to add 1 to the quotient to answer the problem.	⦿ Students understand how to process quotients and remainders based on the problem situation. They are able to explain why they used that process. (Notebook, presentation)

Summarize 5 min.	4. Summarize how to process quotient and remainder ○ If we have 3 or 2 left, we need another container. ○ Even if there are only 2 or 1 left, there are cases when we will need to add 1 to the quotient. There are cases when we need to add 1 to the quotient, because there is a remainder.	• Summarize the learning using what students discussed. • Confirm that there are cases when we need to find the remainders, when we don't need to find the remainders, and when 1 is added to the quotient to answer the problem.	
	5. Students write reflections ○ I understand that sometimes I have to add 1 to the quotient based on the problem situation. ○ I understand that when we have 3 or 2 left, we need to add 1 to the quotient. ○ I did not know what to do with the remainder at first; but as I listen to my friends' explanations, I understand why we need to add 1 to the quotient.	• Remind students that they need to write in their reflections what they understand, what they noticed, and their thinking after they listen to their friends' explanations. • Tell students that there are problem situation cases when they won't need to think about remainders at all. (This should pique their interest, as they foresee what is coming in the next lesson.)	◉ Students understand how to process quotients and remainders based on the problem situation; and students are able to explain why they incorporated a given process. (Notebook)

(6) Evaluation of the lesson:

Did students understand how to process quotients and remainders based on the problem situation and were they able to explain why they chose a specific process? [Mathematical Reasoning]

7. References:

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< Mathematics Department Research >

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1. Theme of Research

Creating Mathematics Lessons that Deepen Learning by Connecting Students' Questions

2. About the Research Theme

(1) Reasons for Setting up the Theme

Our department has been conducting research on student questions. In the previous year's research[1] under the research theme of "Creating lessons that students truly understand by connecting to classmates' questions," we saw some progress in developing lessons that helped students truly feel they understand. To achieve this progress, we developed some necessary strategies such as: setting up well-thought-out tasks for the lesson, thinking about questions that should be asking to include in the lesson by considering students' anticipating questions, and anticipating the sequence of students' questions. Earlier research focused on lessons designed so that students naturally think of their own questions[2], lessons which pay attention to how students question each other continuously,[3] and lessons that make and build on students' making connections to other students' questions.[4]

While we were doing research on students' questions, we realized the importance of continuing our research focus on the relationship of "mathematical views and thinking," "deeper learning," and "talent and ability" to the idea of student questions and how those connections help develop students' learning and skill set/understanding. It is clear that studying what students are doing in classrooms every day is important.[5] For example, we studied students' behaviors/learning/understanding when faced with new problem situations; such as, when students refer back to what they learned previously, when students need to think about how they could use what they have learned in daily life, and when students are asked what they want to learn or explore next after having learned something new from the lesson. In these cases, a survey we administered found students' responses to be lower compared to other items included in the survey. The survey's results indicated that students did not think of how the learning from the lesson overlaps with learning from previous or subsequent lessons, rather they appear to see learning from one lesson as being specific to and ending at the end of a lesson. Students did not appear to think that something they learned in a lesson could be used for

[1] 算数科総括 [Summary of Research of Mathematics Department] (2018)

[2] 山梨大学教育人間科学部付属小学校研究紀要 [Research Summary of University Attached Elementary School, Facility of Education Human Sciences, University of Yamanashi] (2004)

[3] 山梨大学教育人間科学部付属小学校研究紀要 [Research Summary of University Attached Elementary School, Facility of Education Human Sciences, University of Yamanashi] (2008)

[4] 山梨大学教育人間科学部付属小学校研究紀要 [Research Summary of University Attached Elementary School, Facility of Education Human Sciences, University of Yamanashi] (2011)

[5] 山梨大学教育人間科学部付属小学校研究紀要 [Results from the Survey of Student State of Learning: National Scholastic Ability & Learning Achievement Survey] (2018) and 本校算数科アンケート [Math Department Survey] (April 2019)

(applied to) other problem situations, other subject areas, or in their daily life. Furthermore, the results did not indicate that students were motivated or eager to apply what they have learned. Given these observations and findings about the status of the students, we believe we need to create lessons that result in students' utilizing a mathematical view and thinking that connects to the essence of our mathematics department's goals; i.e., that students deepen their learning by considering the state of their own and other students' learning.

The first year of the school's general research theme was "Students Connecting Learning: Providing lessons that approach the essence of the subject." Based on the issues we have discussed here, our present belief and thinking is that fostering students who connect their own and others' learning, we hope to nurture students' view of mathematics in service to cultivating a better future for our society. Therefore, our goal is to continue to do research by utilizing the experience and knowledge gained from our past research and our new view of the importance of looking at "students' questions." For these reasons, we established our current research theme as: "Creating Mathematics Lessons that Deepen Learning by Connecting Students' Questions"

(2) About Creating Lessons that Deepen Student Learning[6]

In order for students to deepen their learning, it is necessary to provide fruitful mathematical activities that enhance their mathematical view and thinking about mathematics. The definition of the "mathematical view and thinking" is, as follows:

> Grasp a phenomenon by paying close attention to its quantities, geometric figures, and relationships; think logically based on evidence; and think comprehensively and expansively.

In other words, develop ways of seeing (viewpoints) and ways of thinking in order to better grasp mathematical concepts/mathematics, and make this essential and the central focus of students' developing the meaning of learning in lower and secondary school mathematics. As students develop talents and abilities, they will connect what they learned in the past with new learning and the activities of daily life, acquire the ability to cultivate their future learning, and develop these habits of learning through persistence and perseverance. Moreover, students' learning will become more deeply ingrained as they acquire active and discussion-oriented learning.

The appearance of students who deepen their learning in this way includes the following characteristic behaviors: Students who don't stop learning after they have an answer to a problem; reflect on their own thinking; compare their ideas to other ideas and seek and find relationships among ideas; think about a better idea; generalize ideas to grasp the primary learning idea of the problem; and seek to expand their learning, at times connecting previous to novel ideas/solutions. In addition, these students can see the connection between what they have learned in one unit to other related units in mathematics, the connection between what they have learned across units and in different domains of mathematics, the connection between other or related topics in different subject areas, the connection with the activities of daily life, and the desire to

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[6] Tokyo Shoseki. 新学習指導要領のポイントと授業づくり vol 1 & 2 [The Key Points of the New Course of Study and Developing Lessons]. P.18

utilize what they have learned. Finally, by conducting this expansive learning process, our department is working toward and looking for evidence that our students will continuously come up with their own questions, contribute to their learning and that of their peers', and the learning becomes even deeper for all students.

Next, as we think about the essence and the approach to lessons, the key important ingredients include the students, instructional materials, and the teacher. It is important that these three elements are connected and function together seamlessly. Therefore, lessons should not be teacher-led (driven by the teacher's thinking), nor should the lessons follow or be led by students' interests without following the purpose of the curriculum. Lessons should be conducted by students coming up with their own questions and engaging in problem solving that is aimed at and reflects the mathematical goals. In order to design these lessons, we need to study and analyze problems that are familiar and interesting to students. In our department, we studied Nakamura's research (1989) which revealed the importance of organizing the conditions of problems and activities that facilitate students' questions and question-posing. These conditions include questions that do the following:

- can be solved by students on their own using previously learned knowledge,
- produce disagreement and agreement or conflict and consent/understanding,
- present students with a common task,
- produce new tasks,
- and can be solved in multiple ways.

Considering these ideas, we designed lessons that are: equipped with instructional materials that produce and encourage students' questions; clearly indicate how teachers can orchestrate students' learning to achieve the goals; and consider ways that unify students, teacher, and instructional materials.

In the process of the lesson, students will use mathematical views and thinking, the essence of mathematical learning, to deepen their understanding. Students' questions will show evidence of their mathematical view and thinking.

(3) About "Student Questions"

There are several types of questions that students ask during a lesson. Among those questions, the questions that relate to a mathematical view and thinking we will call "students' questions that should be asking." Nakamura'[7] (1993) organized "questions" into the following categories:

- asking about previously learned content
- asking about a different way to solve
- asking about evidence
- asking about a commonality or similarity
- asking about differences
- asking about a generalization

[7] Takashi Nakamura (1993). 自ら問う力を育てる算数授業 [Mathematics Lessons that Foster Students Who Ask Questions of Their Own]. pp. 15 – 16.

- asking about expandability, and
- asking about merit

These student questions represent students' thinking and are the driving force of learning during lessons. Also included in these questions are students' questions that should be asking because they are closely related to the mathematical view and thinking to be developed by the lesson. In regard to a person who is striving to deepen his thinking, Sugiyama[8] (2006) said:

> The person who is thinking is not thinking about the question that he was asked but is also asking questions that should be asking to himself and he is answering the question that he asked himself. He advocates the importance of thinking inside the individual that helps to deepen thinking.

In addition, Sugiyama said that educators need to have a view of the lesson that is, as follows:

> Lessons (classroom practice) are formed by thinking which occurs inside an individual person that are then expressed outside into the class; and the questions, answers, discussion that is facilitated in the class will foster thinking that goes directed back inside the individual person. Lessons are the places where the process of thinking (continuous questioning via the "students' questions that should be asking") appears. When a student answers a question, the teacher should ask a question in response, and the teacher could be accepting the role for asking the question, so that the "students' questions that should be asking" are asked. The asking of these questions can be done by students also. In the end, both teacher and students together do the process of questioning and deepening their thinking.

As you can see, Sugiyama also talked about the importance of the teacher's role as well as interaction of students, in addition to individual thinking, for acquiring deeper thinking.

When we think about "students' questions" from the point of view discussed above, a "student question" is not just an act of an individual student's thinking. A "student's questions" appear in other students' minds as well as in the classroom or between student and teacher or one student to another student. This means the teacher's role is vital and of utmost importance. We feel it is critical that we foster the connections created by "students' questions" to deepen students' learning and create a rich learning environment for mathematics and for our learners.

(4) About Connecting "Students' Questions"

① What it means to connect *students' questions*

To our research group, the meaning of "connecting students' questions" refers to students' questioning during a lesson; i.e., students ask questions about evidence, previously learned knowledge, and the similarities and differences among solution ideas. Students establish an understanding of what they discussed together with

[8] Yoshishige Sugiyama (2006) 確かな算数・数学教育をもとめて [Seeking Certain Mathematics Education]. Pp.73 – 79.

others and connect this understanding to other students' questions. Students continue to connect the series of questions to solve the problem posed in the lesson.

We, as teachers, should not go along with a series of questions that may randomly come up from students. Rather, we need to carefully design questions that appear in instructional materials that are to be used by students and teachers, so that the value of questions asked by students meet the standard of questions that students should be asking. Students, teacher, and instructional materials are all important for raising the value of questions. A student might raise the value of questions by connecting a series of his own questions. A teacher might pick a student's question or statement and use it to raise the value of the discourse to meet the level of what we are calling "students' questions that should be asking." By carefully selecting and designing a problem that facilitates students' asking questions that should be asking, students might naturally come up with questions that raise the value of questions to reach "students' questions that should be asked." Even when students' thinking slows down, the teacher may direct students to reread and think again about the problem, which triggers students' thinking of a new question. This new question may lead to other questions which help deepen students' learning.

At the end of a lesson, when we think about how to evaluate the deepening of student learning, we could evaluate the questions that students asked, the questions used from the instructional materials, and the teacher's questions. For example, some evidence for concluding that the learning was deepened by connecting questions may include the observation that students', teacher's and instructional materials' questions matched, and the series of questions met the criteria of "students' questions that should be asking." Conversely, reasons why questions may not connect well could include evidence of a gap between the questions students asking and the question(s) that the teacher asking or had in mind, which resulted in the teacher being unable to facilitate students' questions that meet the criteria for "students' questions that should be asking."

② From the students' point of view

From an analysis of past National Scholastic Ability Test results, Nakamura[9] (2012) cited a high rate of non-response to questions, so it is important to decrease the number of non-response questions and discuss incorrect solution ideas or misunderstandings and misconceptions during lessons. This practice will help students develop an enriched view and thinking that leads to students' acquiring certain target knowledge and skills. To deepen student learning, it is important that students think of their own questions. Even if a student cannot think of his own questions, by sharing what he doesn't understand and listening to what other classmates don't understand, the student is likely to see more clearly what is wrong and to apply this new insight. This process helps the student to modify his original question or think of an entirely-new question. Moreover, the new question acquired helps lead the student to use the mathematically-valued "students' questions that should be asking" via learning through interactions with other students. A student's

[9] Yamanashi Prefecture's *Mathematics Education Alliance Magazine* (2012)

question might also become a question the whole class engages in and, thus, helps deepen everyone's learning.

③ From an instructional material point of view

Nakamura (1989) describes the characteristics that instructional materials and problems have that produce student questions. These characteristics include problems that can be solved by students on their own by using previously-learned knowledge, materials that produce a common task that students pursue, problems that can be solved in multiple ways and/or produce a range of agreement to disagreement or conflict and consent/understanding, and materials or problems that produce new tasks to pursue.

By designing a task that includes these conditions and engages students in problem solving, students' questions will improve and reflect deeper understanding of the content being studied. These student questions lead to establishing subsequent new questions, and the process continues. This process of student questioning facilitates students' view of and thinking about mathematics, which in turn nurtures the talent and ability of our students to think deeply and mathematically.

④ From the teacher's point of view

Students come up with many different kinds of questions during a lesson. From these questions, teachers need to use the students' voices wisely to orchestrate and formulate a question to pose to the class to consider. By following how the teacher uses the questions and ideas posed by classmates, the students who could not think of their own question(s) will learn and begin to think about questions in the future. In addition, the teacher's move helps foster students who continue to think of and ask questions on their own. However, there are cases when the students' questions and the question the teacher is aiming for do not match. This mismatch may happen even when teachers grasp the students' state of learning and design lessons with well-thought-out instructional materials and problems. In cases like these, the teacher needs to redirect a line of questioning by asking questions that correspond to students' questions but flexibly move student thinking to a place where it will more closely approach the teacher's intended line of questioning.

We would like to foster students who deepen their learning by making the connection among the three important elements[10] that are important for developing lessons and questions.

3. Connection to School's General Research

(1) Image of "Lessons that Approach to the Essence of Mathematics Department Goals"

In order to conduct lessons that approach the essence of mathematics department goals, students have to operate on their mathematical views and think through mathematical activities to increase their talent and ability to think mathematically. In the school's general research document, it defines "Lessons that Approach the Essence

[10] Lecture by Professor Takashi Nakamura at 第５８回山梨県数学教育研究（峡南大会） 58th Yamanashi Prefecture Mathematics Education Research (Kyonan Conference) (2015)

of a subject's goals" as lessons that provide a structure for learning content by connecting individual knowledge and skills by operationalizing "views and thinking" that match the characteristics of a subject/content area, instead of merely increasing the amount of knowledge or skill without a general structure or framework. As we described in (2) in section 2, About Creating Lessons that Deepen Student Learning, students should not stop thinking (or asking questions) when they find an answer in the process of problem solving. It is important for students to continuously ask questions, such as "why does …?" and then answer these questions by asking about and looking for evidence or asking themselves and classmates if there is any other way to solve the problem or an easier way to solve the problem. We believe that problem solving includes connecting and continuing a line of questioning that leads to other new questions in the lessons that approach the essence of mathematics. Students' attitude about interdisciplinary learning, such as "I wonder if we can apply what we learned in the other subject areas?" is also important. Students' attitude about thinking uniformly and expansively is important. Students will ask questions, such as "What previously learned knowledge is connected with this learning?, What is the basis of this learning?, and Where can we apply this idea?" In this way, students are more likely to ask "questions that should be asked" that connect to their own mathematical views and independent thinking by and ultimately result in lessons that deepen learning.

4. Content of Research
   (1) Measure of "Lessons that Approach the Essence of Mathematics Department Goals"

In order to conduct lessons that approach the essence of mathematics department goals, it is important students experience "questions that should be asking" during lessons and reflect on the result and process of problem solving, reconsider the result, come up with a new problem, etc. to think uniformly and expansively. Here are the three ways of measures we include in such lessons.

① Structure lessons that focus on "questions that should be asking"

In order to create lessons that connect questions to deepen student learning focus on students, instructional materials, and the teacher. Think about the questions that should be asking (questions students need to think about and what kind of "*hatsumon* (question)" the teacher needs to ask his/her students in order for them to recognize the questions that should be asking; i.e., the question the teacher is thinking about/has in mind. Moreover, think about what kind of instructional material would help students come up with/think of the questions that should be asked to deepen understanding and grasp the mathematics of the problem. Consider these points when we plan the lesson.

② Creating lessons that consider mathematical views and thinking clear to students

In order to foster students' talent and ability for mathematical thinking, clarify the mathematical views and thinking that are common in a unit and across units. By doing so, we gain foresight into students' learning and can better identify the mathematical views and thinking that students need to operationalize during the day's lesson. It is important to, first, analyze and organize the mathematical views and thinking in the unit plan and be explicit about the teaching notes and anticipated students' responses, such as how students will express their views and think in words or writing. Then, when observing actual lessons, see if there are places during the lesson that students demonstrated the mathematical views and thinking the teacher anticipated and expressed in the lesson itself.

Based on reflections about what was observed, we engage in and investigate the following: a.) the mathematical views and thinking that are common between and across grade levels; b.) a plan to connect units across different domains using mathematical views and thinking, and c.) connections of the learning in the unit to the student's daily life. An investigation of these three things increases the likelihood that we will be able to conduct lessons that approach to the essence of mathematics.

③ Investigate activities that reflect students' own learning

As described in the general research document, in order to foster students' ability to "connect learning" it is necessary for students to reflect their own learning and thinking. During what situations in lessons do students reflect their own learning? For example, in the learning process of a lesson when students are solving problem on their own, they try to reflect their own learning in order to establish foresights into problem solving by thinking about how they could use what they previously learned to solve the problem they are tackling now. In addition, in the process of discussing and comparing solution ideas, students reflect their own learning when they identify the similarities and differences among the different ideas posed by classmates. In the process of writing their reflection of learning in the section of lesson looking back, students reflect their own learning of the past lessons including the lesson they just learned.

When conducting classroom practice and reflecting on a lesson in this way, teachers can investigate the situations students use to reflect their own learning. Moreover, teachers can analyze the quality of students' reflections and consider how effective the lesson was in its ability to approach the essence of mathematics department goals.

(2) Assessing "Lessons that Approach the Essence of Mathematics Department Goals"

There are several different ways to assess lessons. We use student reflection (writing in notebook) to understand student understanding. The reflection students write at the end of a lesson has four phases (Nakamura, 2002)

The first phase:

Students write their own feelings such as "Learning was fun." and "I want to learn again." There is no writing about the content of the mathematics they learned. This level of reflection writing could be seen in any other subject area students are learning.

The second phase:

Students write about the mathematical content, such as what part of the mathematics the student understands and what part the lesson student finds difficult to understand. In this phase students start to reflect on and write about their own thinking.

The third phase:

Students write about what they thought about other friends' ideas. They include friends' names in the writing, therefore, connecting specific ideas to a specific friend's thinking about the problem or task.

The fourth phase:

Students write a reflection about their own thinking. The writing also reveals their attitude about pursuing mathematically better ways to think about a problem or task by reflecting on their own learning.

By analyzing students' reflections about lessons, the teacher grasps what phase and where each individual student appears to be functioning and can better understand how students' writing about learning is changing. As students move up to the fourth phase of written reflection, their writing includes mathematical views and thinking that approach the essence of mathematics. By grasping how students' thinking changed and how their learning changed across recorded reflections, we can better assess if our lessons are getting closer to meeting the standard of "lessons that approach the essence of mathematics department goals."

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Mathematics Department

What is Left and What is the Difference?

Place: Grade 1, No. 2 Class
Research Lesson Discussion Place: Grade 4, No.2 Class

Grade 1 Mathematics Lesson Plan

Instructor: NOMURA, Miyoko
Students: Grade 1, No.2 class (35 students)

1. About the Unit:

My view of the students

Many of my students have experienced counting numbers and finding the answers to simple addition and subtraction informally before becoming the first grade. During students' daily conversations and in mathematic class, there have been quite a few times when I heard students talking about "addition," "subtraction," or representing subtraction as "○ – □ = △."

When they became the first grade, they learned to group and counted things as a set, compared two quantities of objects by aligning them in two lines and making one-to-one correspondence between the two sets, compared two sizes of quantities using counting and one-to-one correspondence, and stated and wrote numbers accurately. By learning to quantify and compare in this way, students became able to see numbers as sets and recognized how counting objects in a set quantifies the set.

In addition, students learned about the structure of numbers to 10 and composed and decomposed those numbers. They also learned about addition problem situations and the meaning of addition with two 1-digit numbers, then tried to become fluent with calculations. When they were learning about addition, students experienced extensive periods of time manipulating concrete materials, expressing their ideas using diagrams and pictures, and explaining their ideas to other students. That is, these students not only spent time practicing addition calculations, but they also spent time thinking about the meaning of addition.

Calculation of addition and subtraction is very important content for mathematics learning that will become the foundation of elementary and secondary mathematics. At this point in this lesson, I would like to focus the students' learning on understanding the meaning of calculations and why we use a particular operation to answer in particular problem situation. It is important to teach students how to think in this way instead of focusing only on their practicing calculations and teaching calculation procedures.

Subtraction is the operation for finding the number of elements in one of the two sub-sets of a whole when the whole is split into two subsets. In the previous unit, students learned that addition can be used in problem situations of *put together* and *add to* with the understanding of numbers as sets (smaller sets composing the larger or whole set). In the subtraction unit also, students learn that subtraction can be used in the problem situations of *take from*, *take apart*, and *compare* with the understanding of numbers as sets (whole or composite set decomposed into smaller subsets, or two sets compared to find the difference between two sets).

In the case of *take from*, one of of the subsets is taken away from the whole set and it involves change in time and a decrease in the whole quantity. On the other hand, *take apart*" does not involve a change over time or a decrease in quantity. After students learn about *take from* and *take apart*, they learn about the *compare* situation of subtraction. The *compare* situation involves finding the difference between two sets. At this point, the meaning of subtraction is expanded.

In this research lesson, I will focus on the *compare* problem situation. I will help students understand how subtraction can be used in the case of the *compare* situation by utilizing their previously-learned knowledge of subtraction. I believe that providing opportunities for students to think about the meaning of operations, beginning in first grade, will allow them to develop an interest and disposition for understanding the meaning of multiplication and division operations in second grade.

At the start of the school year, the students acquired only few mathematical knowledge and experiences; however, by utilizing the learning from the previous addition unit, I would like to help the students recognize how they can represent and express the *compare* problem situation in a math sentence. To do this, I will provide opportunities for the students to manipulate concrete materials and explain their ideas to other classmates using diagrams and pictures. Through these activities, I would like to engage students in discussing questions, such as "why this situation is a subtraction situation?" and to increase students' ability to explain their own thinking in logical manner.

2. Goals of the Unit:
   - ○ Students recognize and know the problem situations that use subtraction, such as *take from*, *take apart*, and *compare*; and students understand the meaning of subtraction. (knowledge and skill)
   - ○ Students are able to perform subtraction with minuends up to and including 10. (knowledge and skill)
   - ○ Students recognize that the ideas underlying *take from*, *take apart*, and *compare* situations are all connected as kinds of subtraction. (thinking, justification, expression, etc.)
   - ○ Students are able to think about how to calculate subtraction with minuends up to and including 10 by paying attention to the structure (composition & decomposition) of the 1-digit number and are able to manipulate concrete materials to represent and express the calculation process. (thinking, justification, expression, etc.)
   - ○ Students are able to identify the *take from*, *take apart*, and *compare* problem situations in daily life phenomena. They understand the merit of expressing these situations using math sentences and are eager to recognize and use subtraction in daily life. (attitude for learning, human nature, etc.)

3. Connection between this Subtraction Unit and the School's General Research Goals
   (1) <u>Image of Students Learning that "Approach the Essence of Mathematics" in this Unit</u>

   The mathematical views and thinking that I would like students to perform are: Students use concrete materials, diagrams, and subtraction math sentences to think about how to manipulate concrete representations and how to represent a problem situation with subtraction math sentences to find the answer. In the process of thinking through this lesson, I also hope to see the students reflecting back on their process of finding the answer and attempting to explain and discuss why they thought about the problem in this way.

In this unit, at first, students learn about *take from* and *take apart* problem situations. I will help students understand that subtraction can be used in the *compare* situation by providing instruction that leads students to consciously consider how *compare* situations expand the meaning of subtraction. In each subtraction situation, I will help students understand the meaning of subtraction and its mathematical terms and signs; and, finally, help students to be able to perform subtraction with minuends up to and including 10. Through their learning in the previous addition unit and this subtraction unit, my goal is to help students develop a solid understanding of the concept of numbers and make connections with the meanings of subtraction and subtraction math sentences.

In our mathematics department, we believe that we can approach the essence of the mathematics department's goals by deepening students' learning as they actively apply various views of and thinking about mathematics. The image of student learning in this unit includes the following: a.) Students will think about why they can use subtraction in a particular problem situation and the meaning of an operation while manipulating concrete materials; b.) Students will be able to find the similarities and differences across their learning about addition situations and the subtraction situations of *take from* and *take apart*; and c.) finally, students wonder and think further about whether there is another situation that can be represented by subtraction, etc. In this unit, when students' experience these kinds of learning, I believe they will perform well when they extend their thinking and learning in the future, such as how to add and subtract with regrouping, and grasping the meaning of other operations, such as multiplication and division.

(2) <u>About Necessary Measures for a Lesson to Approach the Essence of Math Department Goals</u>

① Create each lesson with questions that students should be asking.

Our mathematics department cares about lessons that focus on students' questions. In this unit, the following questions should surface during the lesson: "What is similar and what is different about these calculations, compared to calculations we learned previously?" "How should we manipulate the concrete materials?" "What kind of math sentence should we write?" "What are the similarities among our ideas or thinking? "If we change the number will the subtraction calculations still work?" By placing these questions at the center of the lesson, as a driving focus, we constructed the lesson.

② Constructing Lessons that Consider Mathematical Views and Thinking

When student think about how to calculate something, it is important for them to understand the meaning of the calculation they are considering. In order for students to be able to do this reflection, we need to provide more opportunities for them to think about how to calculate by utilizing what they have learned previously. Then we need to help them to be able to explain their thinking and calculations using concrete materials, diagrams, and math sentences. Moreover, we need to help students increase their expression and use of important mathematical words to support their ability to conduct and learn mathematically.

③ Explore Students' Activities that Reflect What Their Own Learning Should Be

It is important for students and teachers to develop and demonstrate the disposition to reflect on one's own learning. Because these students are in the first grade, I will create opportunities for them to reflect intentionally and purposefully during lessons. By doing so, I believe that we can foster students who are able to identify situations when they need to reflect consciously on their own learning in future lessons. One measure we can monitor is whether students are able to reflect on their own learning by making sure they write learning reflections in their math notebooks. Therefore, I will plan the lesson, so it shows students' reflecting on their own learning by looking back to consider what they learned during the lesson and writing a reflection.

4. Instruction and Assessment Plan (Total of 8 Lessons)

Assessment: 🄺 knowledge and skills; 🅃 Thinking, justification, and expression; 🄳 Disposition for active learning

Lessons	Goals	Learning Activities	Views and Thinking	Assessment
What is left?				
1	Understand the meaning of a *take from* situation and how to express the situation in a math sentence.	• Grasp the problem situation as finding what it left (*take from)* and represent the situation by manipulating concrete materials and diagrams. • Express the *take from* situation in a math sentence. • Know the meaning of the term "subtraction."	Think about the meaning of subtraction by attending to numbers as sets.	🄳 Identify a problem situation from daily life as a *take from* situation; and try to express it in a math sentence from the manipulating of concrete materials. 🄺 Understand the meaning of subtraction in *take from* situations and know how to express *take from* subtraction in a math sentence.
2	Are able to do subtraction calculations with minuends up to and including 10.	• Practice subtraction calculations with minuends up to and including 10.		🄺 Be able to do subtraction calculations with minuends up to and including 10.
How many are there when you subtract?				
3	Understand the meaning of a *take apart* situation and how to express the situation in a math sentence.	• Grasp the problem situation as *take apart* and represent the situation by manipulating concrete materials and diagrams. • Express the *take apart* situation in a math sentence	Think about the *take apart* situation as similar to the *take from* situations and unify them as subtraction situations.	🄳 Identify a problem situation from daily life as a *take apart* situation, and try to express it in a math sentence from the manipulating of concrete materials. 🄺 Understand the meaning of the *take apart* situation and know how to express *take apart* subtraction with a math sentence.

4	Improve subtraction calculation skills	• Practice subtraction calculations with minuends up to and including 10 using calculation cards. • Look at how minuends and subtrahends appear on subtraction cards organized on a chart, through activities such as identifying missing cards and finding the cards that have the same answers. Understand a number can be represented as a difference of two numbers.		$\boxed{K}$ Be able to do subtraction calculations with minuends up to and including 10.
Subtraction with 0 (zero)				
5	Understand the meaning of subtraction calculations involving zero (0).	• Express problem situations that involve 0 in math sentences and understand the meaning of the problem situations and sentences.		$\boxed{K}$ Understand that even when problem situations involve 0, the situations can be expressed in subtraction math sentences.
What is the difference?				
6 *(This Lesson)*	Understand the meaning of subtraction in a *compare* situation.	• Identify the situation as a *compare* problem situation and express the situation by manipulating concrete materials and using diagrams • Express the *compare* situation in a math sentence.	Knowing two numbers as two sets, think about how to connect and unify the *compare* situation (finding the difference between two sets) with the subtraction situations that were learned previously.	$\boxed{D}$ Identify a problem situation from daily life as a *compare* situation and try to express the situation in a math sentence by manipulating concrete materials. $\boxed{K}$ Understand the meaning of subtraction in a *compare* situation and know how to express it in a math sentence.
7	Deepen understanding of the meaning of the *compare* subtraction situation by solving word problems.	• From word problems and pictures of situations, think about how to answer questions, such as "Which one has more, how many more?" and "What is the difference between ○ and △?" • Confirm the problem situation is a *compare* situation using manipulation of concrete materials or diagrams and expressing the situation in a math sentence.		$\boxed{K}$ Identify the problem situation from the written problem as *compare* situation, represent the situation with math sentence, and be able to solve the problem.

Creating story problems				
8	Deepen understanding of subtraction by creating problem situations ~~by~~ and interpreting a math sentence.	• Create problems by looking at a picture from various view points; and identify *take from*, *take apart*, and *compare* situations by interpreting a math sentence. • Express subtraction situations using pictures and math sentences; present one's work to the class.		$\boxed{D}$ Try to create subtraction problems and stories based on their daily life experiences. $\boxed{T}$ Able to identify subtraction situations from a picture. Think about subtraction problems and be able to express them using pictures, diagrams, and words.

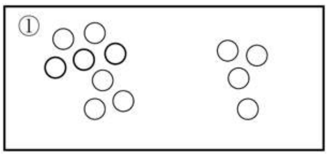
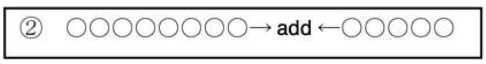
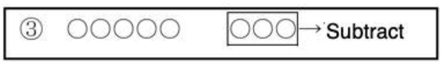
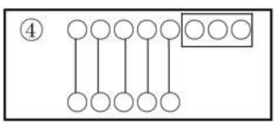
5. About this Lesson
   (1) Date and Time: 9:00 a.m. to 9:45 a.m. on Saturday, June 22, 2019
   (2) Place: Grade 1, Number 2 classroom, University of Yamanashi Facility of Education Attached Elementary School
   (3) Goal of this Lesson:
   ○ Students understand the meaning of subtraction in the *compare* problem situation.
   (4) Intention and Purpose of Instruction:

The image of students who "approach to the essence of mathematics" that I would like to see in this lesson includes: students who can identify the difference between addition and subtraction; students who understand the difference between *take from* and *take apart* problem situations; and students who are able to use subtraction appropriately to represent and solve *compare* problem situations.

In this lesson I will start with students recognizing the difference between *take from/take apart* situations, which students learned previously, and *compare* problem situations. The subtraction the students learned prior to this lesson pertained to the problem situation that deals with one (whole) set that is split into two subsets (parts), and ~~s~~ubtraction is used to solve and find one of the subsets. However, in this *compare* lesson, the problem involves two distinct sets and students need to find the difference between the two sets. In the previous lessons, it was easier for students to identify "what is left" when they manipulated concrete materials. The big difference for students in today's subtraction situation is that they will need to think about the number of objects that cannot be aligned to make a one-to-one correspondence when objects in the two sets are compared. In a *compare* situation, manipulation of concrete objects is different from the *take from* and *take apart* situations; however, I would like to help students understand that - even though the problem is a *compare* situation - they can use the subtraction operation just as they used subtraction for *take from* and take *apart* situations.

The questions students should be asking in this *compare* problem situation lesson are, "How should we manipulate concrete materials?" and "What math sentence should we use?" The anticipated responses for the question, "How should we manipulate concrete materials?" include: "This situation is different from *take from* and *take away* situations;" and "It looks like manipulation of concrete materials will be different from what we did with *take from* and *take apart* situations." The anticipated response for the question "What math sentence should we use?" include: "When we take away the parts that are connected with lines (one-to-one correspondence between two sets), we can find the answer;" and "We are taking away the part that is connected with lines, so we can use subtraction." By connecting the questions that should be asked to bring out student responses (as mentioned above), I will help students recognize the commonality and the difference between how blocks are manipulated in *take from*/*take apart* situations versus a *compare* situation. Moreover, I will help students understand that subtraction can be used to represent and solve a *compare* situation just as they used subtraction in *take from* and *take apart* situations.

(5) Progress of Learning:

Minutes	Main Content and Learning Activities ○ Student Anticipated Responses	Instructional Points to Remember ○ Ideas for making the "lesson approach the essence"
5	**1. Grasp the task of this lesson** • Grasp today's problem by looking at the picture and reading the problem Teachers played *Karuta* Japanese card games. Mr. Nobuyuki took 8 cards. Mr. Yukinao took 5 cards. How many more cards did Mr. Nobuyuki get than Mr. Yukinao? ○ 3 more. ○ I don't know. How did you think about solving the problem?	○ By posing the problem with a picture, help students grasp what they know and what they need to find out.
5	**2. Solve the problem on their own** • Think about how to solve the problem.	• Help students to be able to explain a student's idea to classmates, i.e., how the student solved the problem. • Help students have foresight about how they could solve the problem (e.g., blocks, picture, diagram, draw lines for one-to-one correspondence, etc.)
	① Student thinks about the problem using a picture, diagram, or blocks, but does not successfully find the answer.	
	② Student added the minuend 8 and the subtrahend 5 and found the answer 13.	
	③ Student subtracted the answer 3 from the minuend 8.	
	③ Student made one-to-one correspondence using a picture, diagram, or blocks and found the answer 3.	

25	**3. Compare and discuss** • Think about how to arrange the blocks to represent the problem situation. **How should we arrange the blocks?** ○ I think we can line them up. ○ I think we can put blocks on top of each other. • Discuss the method that added the minuend 8 and the subtrahend 5 to get an answer of 13. **I wonder if the answer 13 is correct.** ○ If the answer is 13, it is different from the answer 3 that I said. ○ It is strange because the number of cards, 13, is more than the cards each teacher got. ○ I wonder if the answer is 3. • Rethink about how to arrange the blocks. **I wonder why the number of cards became more.** ○ I think the arrangement of blocks is different. ○ If you put 8 cards and 5 cards together that means you are adding the numbers of two teachers' cards, so it is not correct. • Think about the problem by showing one-to-one correspondence. **I wonder how we can rearrange the blocks.** ○ Let's rearrange the blocks. ○ Let's put the blocks on top of each other. ○ Connect corresponding blocks with lines. ○ When we connect corresponding blocks with lines, it is easy to tell who has more cards. • Think about the difference of numbers when one-to-one correspondence is made. **What are the numbers 3, 5, and 8 referring to?** ○ 8 is the number of cards Mr. Nobuyuki got. 5 is the number of cards Mr. Yukinao got. ○ There are 3 blocks more where one of the lines of blocks sticks out. ○ The part where we can't connect lines has 3 blocks. ○ Mr. Nobuyuki has 3 more cards. ○ When we subtract 5 blocks that are connected to Mr. Nobuyuki's 8 blocks, 3 blocks are left. • Think about whether subtraction can be used to represent the problem situation. **What math sentence should we write?** ○ We are taking away the part that is connected by lines, so the math sentence should be subtraction. ○ It looks like we can use subtraction.	○ Students manipulate blocks and they explain what they did, which helps them to notice a way to solve the problem. • Start the presentation from idea ①, and help rearrange the blocks in order to see the difference easily through class discussion. • Bring up idea ② and help students to think about what is wrong about this idea by helping them notice that the number of cards (13) is actually more than each teacher's number of cards to start, which does not match the problem situation. ○ Think about the difference from addition. • Confirm with students that the problem is asking to find "how many more cards," so if they add 8 and 5, it does not match what the problem is asking them to find out. So, they cannot solve the problem and find the answer by using addition. • Bring out idea ④ and facilitate an opportunity to talk about why this idea involves making one-to-one correspondence. ○ Recall what students did when they were comparing the length of two things and, likewise, to think about how they need to manipulate these blocks so they can compare the number of blocks using one-to-one correspondence. ○ Ask students what the numbers 3, 5, 8 represents and help them to see that it is the "difference" of 3 that the problem is asking for. ○ Listen for students who voice "taking away" and connect the words with the subtraction operation.

	○ 8 – 3 ○ It is strange to subtract the answer 3. ○ 8 – 10 ○ It is strange because you can't subtract 10 from 8. ○ 8 – 5 ○ 8 is Mr. Nobuyuki's cards, 5 is Mr. Yukinao's cards, so we can take away the 5 that are connected with lines. ○ The answer is 3. ○ "Take away" means subtraction. ○ The difference can be found with subtraction just like "take away." **What is similar about everyone's ideas?** ○ "Take away" is the same idea. ○ We learned about "Take away (take from)" in the past.	• Confirm with students that we can use subtraction for this problem, then ask them to think about the math sentence. • Discuss if we need to subtract 5 that are in pairs in one-to-one correspondence or if we need to subtract the 10 that are included in the pairs of one-to-one correspondence. Then, help students recognize that 8 – 5 can be used to find the part that represents the "how many more." ○ Help students pay attention to which part should be taken away when one-to-one correspondence is made. ○ Help students to recall how "put together" and "add to" situations were expressed in addition and "take from" and "take apart" situations were expressed in subtraction. Then, think about how and why subtraction can be used to express "compare" situations. • The wording of the problem is different from "take from" and "take apart," but the manipulation of the blocks is the same (because we take away the paired "part" that is connected with lines of one-to-one correspondence)
10	**4. Look back** • Summarize today's lesson **What situations can we solve using subtraction?** ○ When we find what is left. ○ When we take away blocks. ○ When we split something into "how many and how many" ○ When we take away the part connected with lines (the part where we showed one-to-one correspondence). ○ When we think about how many more. • Students write their learning reflection. ○ "How many more" is in the kinds of subtraction (similar to *take from* and *take apart)* ○ When we take away the part connected with lines, we can find the answer. ○ We can use subtraction other than "take away" and "take apart" situations.	○ List up the problem situations that subtraction is used and help students to notice how many different situations that subtraction is used. ○ Students write learning reflection by looking back learning from today's lesson.

6. Observation Points of the Lesson

〇 Are the students understanding correctly that subtraction should be used to solve *compare* problem situations? Are the students able to express the *compare* problem situation with manipulation of concrete materials and in their own words.

- Utilizing questions that students should be thinking of or asking, how is the teacher helping to bring out the mathematical views and thinking that are necessary to deepen students' understanding?
- Did we hear words or questions related to mathematical views and thinking from the students?
- Were the reflections that students demonstrated during the lesson functioning well enough to deepen their learning?

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June 22

Grade 4 Mathematics Lesson Plan

Saturday, June 22, 2019
Grade 4 Classroom 2 (34 students)
Teacher: YAMAGUCHI, Kuniyuki

Let's think about ways to express the size of angles

1 About the unit

Prior to this unit, students have learned about rectangles and squares are special geometrical figures with right angles at all of their vertices in Grade 2. In Grade 3, they have learned about the definitions of isosceles and equilateral triangles and their properties, as well as how to construct those triangles using drawing tools. Moreover, they learned about the definition of angles as a geometrical figure and compare their sizes.

Building upon these prior learning, students will extend their understanding of angles as a geometrical figure to angles as the amount of openings created by turns. In addition, they will understand how to express the size of various angles using a right angle as a unit and express the size of angles as 1 right angles, 2 right angles, 3 right angles, 4 right angles, etc. However, since this way of expressing the size of angles can only be used with specific angles but not others, students will realize the need for a unit which is much smaller. The unit of degree (°) is then introduced, and students learn to use a protractor to measure angles. In order to measure angles greater than 180°, students will learn about using addition and/or subtraction to figure out their measurements. They will also learn about how to draw angles and angles on their set squares.

In this lesson, students will make a variety of angles by combining the angles on their set squares. We will set up an opportunity for students to interpret their friends' ideas that have been expressed using words, diagrams, and equations. By making various angles through this activity, students will learn to represent angles flexibly and develop the capacity to interpret their friends' ideas.

2 Goals of the unit

- Students will be able to grasp the size of angles as the size of turns. [**Knowledge and understanding**]
- Students will know the unit of angle measurement degree (°) and be able to measure angles. [**Knowledge and understanding**]
- Students will be able to represent the size of angles in flexible manners and apply it to examine geometrical figures while focusing on the size of angles in the figures. [**Capacity to reason, judge, and express themselves**]
- Students will be able to grasp geometrical figures in their surroundings and make use of them in their daily life while focusing on the size of angles. [**Disposition toward learning, personal characters**]

3 The relationship between the unit and the school research theme

(1) About "the image of approaching the essence of mathematics" and the unit

The mathematical ways of observing and reasoning that we want students to apply in this unit are representing the size of angles flexibly and making use of them in examinations of geometrical figures while focusing on the size of angles. The angles discussed in this unit include those that will be measured as 1, 2, 3, and 4 right angles as well as the angles in the set squares, 30°, 45°, 60° and 90°. We can also measure other angles using a protractor. Angles greater than 180° cannot be directly measured using a protractor. However, by considering those angles flexibly, for example, 210° is 30° more than 180° or 150° less than 360°, they can represent them using their prior learning. By considering angles that they want to measure in diverse ways, they can judge which way be a more efficient way to measure than others.

The mathematics department believe that by deepening students' learning through the use of mathematical ways of observing and reasoning, students can approach the essence of mathematics. We also believe that contents being learned in this unit will allow students to examine geometrical figures such as parallelograms and rhombuses from diverse perspectives while focusing on the size of angles. Also, when students learn about scaled drawing, they may also focus on the size of angles in the drawings.

(2) About strategies necessary to "approach the essence of mathematics"

① Devise lessons that are centered around questions that must be asked

The Department of Mathematics value lessons that are centered around "questions." In this unit, we try to design lessons centered around "questions," so that "questions about prior learning," "questions on similarities and differences," and "questions about merits" will naturally arise during the lessons.

② Devise lessons that are based on mathematical ways of observing and reasoning

The types of mathematical ways of observing and reasoning involved in this unit are as follows: like length, liquid volume, and area, we can quantify the size of angles using a unit, for example, if we use a right angle as a unit, a full turn will be expressed as 4 right angles; also like length, liquid volume and area, angle measurements are additive.

③ Investigate the nature of activity that promote students' reflection on their own learning

We want to examine carefully students' learning processes such as while they are grasping the main learning task, devising a plan on how to tackle a problem, solving a problem independently, comparing and contrasting various solution approaches, and reflecting on their own learning.

4 Unit plan (Total of 9 lessons)

	Goal	Learning Task	Ways of observing and reasoning	Evaluation Standards
1	Students will understand that they can form many different angles by rotating a ray.	• Investigate how the size of angles change • Express the size of angles using a right angle as a unit	Just like length, liquid volume, and weight, we can quantify the size of angles by selecting a unit and express the size in terms of	• Students can grasp the size of a half turn and a whole turn using a right angle as an informal unit. [C]

2	Through the examination of a protractor, students will learn the unit of angle measurement, “degree (°).”	• Examine the structure of a protractor • Know that the unit of angle measurement, degree, and the relationship 1 right angle = 90°	the number of units. “If an angles is the same as ○ right angles together, we can say the size of the angle is ○ right angles.	• Students understand the structure of a protractor and the relationship, 1 right angle = 90°. [KU] • Students will be interested in the size of 1 degree, and they investigate the structure of a protractor. They try to express the size of angles using a degree as a unit. [D]
3 4	Students can measure angles using a protractor.	• Know how to measure angles using a protractor • Students will measure angles by first estimating if they are greater/less than 90°		• Students have a sense of angle measurement such as judging if an angle is greater/less than 90°. [KU] • Students can measure angles using a protractor. [KU]
5	Students will understand how to measure angles greater than 180°.	• Understand how to measure angles greater than 180° • Investigate the sizes of vertical angles.	Express the size of angles flexibly and measure angles based on angles that they have learned previously. “measure based on 180°” “measuring based on 360°”	• Students think about and devise ways to measure angles greater than 180°. [C]
6 7	Students can draw angles and triangles using a protractor.	• Think about ways of drawing triangles • Know ways to draw triangles using a protractor • Draw angles of many different sizes • Draw equilateral triangles using a compass, then measure their angles and verify that the angles are congruent		• Students understand how to draw angles and triangles using a protractor. [KU] • Students can draw angles and triangles using a protractor. [KU]

8	Today's Lesson Students can make a variety of angles by putting together the angles on set squares. Students can interpret the ways to make angles by putting together the angles on set squares.	• Make a variety of angles by putting together the angles of set squares, and think about angles created by others • Interpret the way others made angles and explain how they were made using diagrams and equations	By focusing on the angles on the set squares, express various angles that can be made by putting together the angles of set squares. "If we put together these angles, you can make a ○° angle." "These angles are getting bigger by 15°."	Students are trying to make a variety of angles by putting together the angles on set squares. [D] Given angles created by others, students can figure out and explain how set squares were put together using diagrams and equations. [C]
9	Verify the mastery of the unit contents and consolidate their understanding.	• Tackle application problems		Students are making use of what they learned in the unit and engaged in a variety of activities.

Evaluation domains:
[KU] Knowledge and understanding
[C] Capacity to reason, judge, and express themselves
[D] Disposition toward learning, personal characters

5 Today's lesson

(1) Date: Saturday, June 22 (10:00 – 10:45)
(2) Location: Yamanashi University Dept. of Education Attached Elementary School
Grade 4 Classroom 2
(3) Goals of the lesson
- o Students can make a variety of angles by thinking about different ways of putting together the angles of set squares.
- o Students interpret how angles were created by putting together the angles of set squares.

(4) Rationale of lesson design
Students have already learned about the measures of the angles in set squares (30°, 60° 90°) and (45°, 45°, 90°). In today's lesson, students will engage in creating angles by using the angles from a pair of set squares, such as 30° + 45° or 45° – 30°. The angles you can make by putting together the angles from a pair of set of set squares are: 15°, 30°, 45°, 60°, 75°, (90°), 105°, 120°, 135°, 150°, (165°), and 180°. These angles may be created s either the sum or the difference of the angles on a pair of set squares.

Sum	30°	60°	90°
45°	75°	105°	135°
90°	120°	150°	180°

Diff.	30°	60°	90°
45°	15°	15°	45°
90°	60°	30°	0°

The table above does not show how a 90° angle can be made. However, one can be made outside of set square pieces as shown below (Fig. 1). In addition, a 165° angle can be made if we use 3 pieces of set squares (Fig. 2). A 165° angle cannot be made by using only a pair of set squares, however, if you can draw an auxiliary line, it is possible to create a 165° angle.

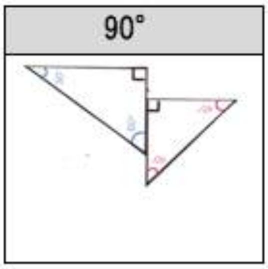


Fig. 1

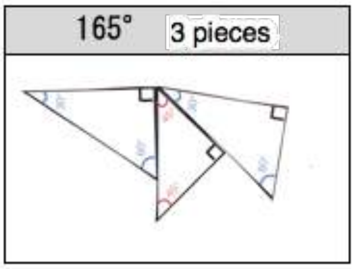


Fig. 2

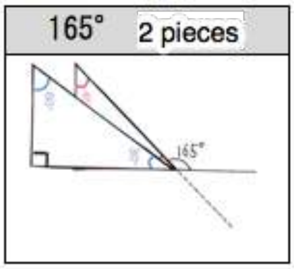


Fig. 3

During the independent problem solving time, students will express the angles they made using words, diagrams, and equations.

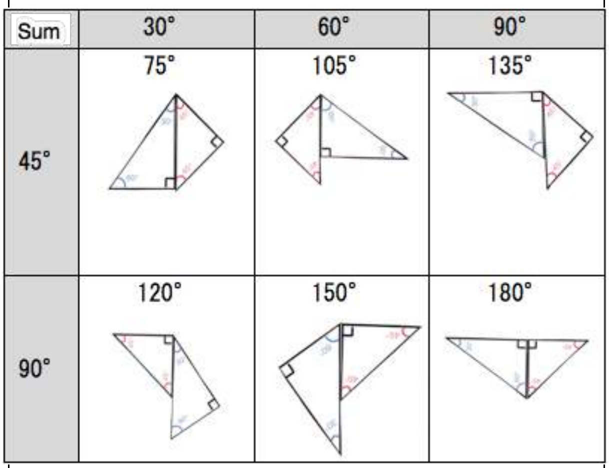
During the whole class discussion, we will start with those angles that can be made by adding two angles (75°, 105°, 120°, 135°, 150°, and 180°). Then, the teachers will ask, "I wonder if it is possible to make an angle that is less than 75°?" This question will lead students to consider angles that can be made by looking at the difference of two angles on a pair of set squares. For both types of angles, we will represent the angles using words, diagrams, and equations. In this way, students will try to interpret others' ideas and deepen their own understanding.

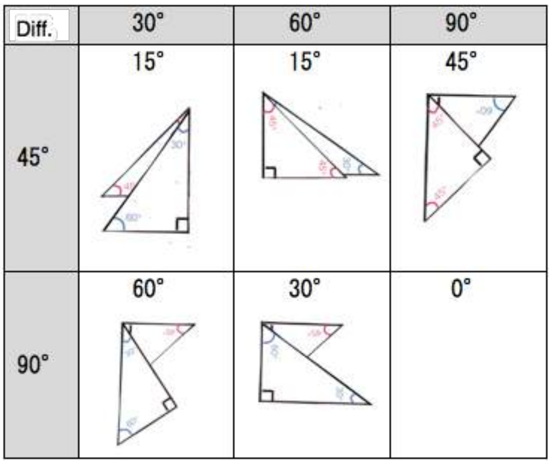
When we summarize the angles created in a table (and ordered from the smallest to the greatest angles), they realize that the angles are getting bigger by 15°. By organizing the angles in a table and examining it from a function perspective, students will realize that a 165° angle is missing. Students will then naturally be asking, "is it possible to create a 165° by combining set squares?" Based on that question, they may realize that 165° = 180° - 15°, but there is no 15° angle on a set squares. Another possibility is 90° + 45° + 30° = 165, thus, they realize that we can make a 165° only if we can use 3 pieces of set squares. We would like students to extend their learning by asking, "Is it possible to make an angle that is greater than 180°?"

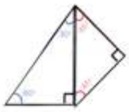
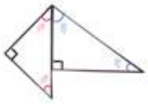
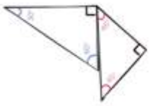
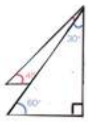
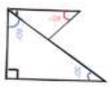
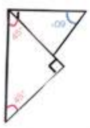
We want to extend students' capacity to reason and express themselves by engaging them in activities to communicate their problem solution processes and results using words, diagrams, and equations and to interpret other people's ideas. Students should make use of these capacities in the study of other units.

(5) Flow of the lesson

Min.	• Main learning activity • Content ○ Anticipated students' responses	• Instructional consideration ○ Strategies to "approach the essence"
5	1. Grasp today's problem • Verify the angle measures on a pair of set squares. ○ 30°, 60°, and 90° ○ 45°, 45°, and 90° Let's make different angles by putting together the angles from your set squares. • Verify that the students understand what it means to put together the angles from set squares.	• Verify the angle measures on a pair of set squares. ○ Select a task that have a variety of solutions or a variety of solution processes. • Discuss an example of putting together the angles from a pair of set squares, help students have some ideas on how to approach the task.
5	2. Independent problem solving • Make angles by putting together the angles from a pair of set squares.	• Grasp students' ideas while circulating around the classroom. • Have students express their ideas in words, diagrams, and equations. • Provide students with small set squares so that students can possibly paste them in their notebooks to show how they created angles.





30	3. Whole class discussion • Examine the angles that can be made by adding two angles. ○75°　30° +45° =75°  ○105°　45° +60° =105°  ○135°　45° +90° =135°  • Look back on the angles students have created. **“ I wonder if we can make angles less than 75°.”** • Confirm that angles can be made by using the differences of the angles on the set squares. ○15°　45° −30° =15°  ○30°　90° −60° =30°  ○45°　90° −45° =45°  ○60°　90° −30° =60° 	• Start with those angles that can be made by adding two angles as they are easier to understand. • Select the angle that is most common first. • Although the same angle can be made in many ways, select one. • Express own ideas using words, diagrams, and equations, and try to figure out other students’ thinking. • Think about commonalities and differences between own ideas and other people’s ideas. ○ Students focus on the variety of angles that can be made using the angles on a pair of set squares and represent them. [Ways of observing and reasoning] • If no students make an angle by looking at the difference of angles during the independent problem solving time, ask if it is possible to make an angle less than 75○. • If a student creates an angle by looking at the difference of the angles, ask the student to share the angle. • Ask if other angles can be made. • Verify where the angle created by the difference of two angles by using diagrams.

	• Organize the angles they have made in a table. **“Let’s order all of the angles you have created so that it is easy to see them.”** 15°, 30°, 45°, 60°, 75°, (90°), 105°, 120°, 135°, 150°, (165°), 180° ○ It’s increasing by 15 °.	
	• Verify if the angle measures are indeed increasing by 15°. **“Are the angles really increasing by 15°?”** ○ 45° - 30° = 15°, 60° - 45° = 15° ○ There is no 165°. (There is no 90°.)	○ By looking at the angle measurements from a function perspective (looking at how the measurements are changing), students will try to make an angle that is not in the table. [Ways of observing and reasoning]
	• Explore if it is possible to make a 165° angle. **“How can we make a 165° angle?”** ○ 180° - 15° = 165°, but there is no 15° angle on a set square. So, we can’t make 165°. ○ 90° + 45° + 30° = 165°, so we can make a 165° if we can use 3 set squares.	• Build this exploration on students’ desires to create a 165° angle, which is not in the table. • Verify what combinations of angle measurements can make 165° using words and equations.
	• Think about if it is possible to make other angles. **Are there other things you want to try?”** ○ I want to make angles that is greater than 180°. ○ I want to use 3 pieces of set squares. ○ I want to make angles using 2 pairs of set squares.	○ Pose the question so that students can extend their reasoning. • Ask if we can make other angles, for example, by changing the number of set squares.

5	4. Looking back • Write the summary of the lesson. • Write the learning reflection. ○ The measurements of the angles we can make with a pair of set squares increases by 15°. ○ I want to make angles using 3 set squares. ○ I wander if we can make angles greater than 180°. ○ When we organized the angles in a table, we could see that the measurements were increasing by 15 °, and we can also find an angle that was not in the table.	• Look back based on the board writing. • Assess the lesson by observing students' learning reflections.

(6) Assessment of the lesson

- ○ Students can make a variety of angles by thinking about different ways of putting together the angles of set squares.
- ○ Students interpret how angles were created by putting together the angles of set squares.

  - Were we able to pull out the ways of observing and reasoning we wanted in this lesson through questions that must be asked?
  - Were students using words that related to mathematical ways of observing and reasoning on their own?
  - Were the reflections conducted during the lesson effective?

(7) References

Omitted

Grade 9 Mathematics Lesson Plan

Date: Tuesday, June 25, 2019
Koganei Lower Secondary School
Attached to Tokyo Gakugei University
Grade 9 Classroom C (40 students)
Teacher: SHIBATA, Sho

1 Name of the unit: Variables and equations/expressions
[This unit includes the discussion on functions that are proportional to x^2, quadratic equations, and square roots]

2 Goals of the unit

- Students will understand the basic concepts and theorems/properties of square roots of numbers, polynomials, quadratic equations, functions proportional to x^2, etc. At the same time, they will master skills to mathematatze phenomena, interpreting things mathematically, processing and representing ideas mathematically, etc.
- While paying attention to the range of numbers, students will develop and nurture the capacity to examine the properties and calculations of numbers, to investigate relationships among numbers and quantities and their properties, to represent those relationships and properties, and to examine properties of functional relationships by relating tables, equations and graphs.
- Students will realize joy and merits of mathematical activities and develop the disposition to think persistently and make use of mathematics in everyday life, to reflect on their problem solving processes and try to evaluate and improve them, and to recognize diverse ideas and seek better ways to solve problems.

3 About the unit

(1) Flow of the unit

In elementary schools, students used the symbols such as □ and △ in equations such as 5 + □ = 8 and 3 x △ = 24, to grasp the relationship between addition and subtraction or multiplication and division. They also learned to express and interpret relationships among numbers and quantities using equations with words, such as (speed) x (time) = (distance). Furthermore, as the foundation for the study of algebraic expressions and equations in lower secondary school, they learned to use letters such as *a* and *x* in place of □ and △ in equations, and used equations to grasp and represent direct and inverse proportional relationships. They also used the idea of quasi-variables as they thought about ways to calculate division by fractions. The idea of quasi-variables is also utilized to represent properties and patterns among numbers. They have many experiences of representing a relationship between two quantities using a single number and identifying characteristics and patterns of two co-varying quantities.

Even in our daily life, there are many situations where we control (or make judgment) one of two quantities that are changing simultaneously (or they are predicted to be changing simultaneously). For examples, based on the cost of a train ticket, we might think “we’ve come a long way,” or we might hear a news story that “today’s youths have lower physical capacity” based on the data about students’ softball toss as an indicator for students’ “physical capacity,” which cannot be seen.

In Grade 7, based on students' learning in elementary school, students learned about the role of letters as variables, and explored the ways to manipulate and calculate with algebraic expressions and equations. In addition, instead of simply determining an unknown number, starting with the examination of quasi-variables (numbers that are treated like a variable), students learned to interpret the relationship that is represented by an equation or to represent and generalize the relationship using algebraic equations. Then, based on the examinations of everyday phenomena, students were introduced to the concept of functions, and re-examined direct and indirect proportional situations as examples of functions and investigated the relationships among equations, tables and graphs.

In Grade 8, students learned to use more letters in algebraic equations, which allowed them to examine a wider variety of phenomena. At the same time, they learned that they must think carefully about the relationship among quantities when 2 or more variables are being considered. For example, when trying to explain and justify the statement, "the sum of two consecutive even numbers is an even number," they must think about how to represent the two even numbers. They must decide whether to represent the two even numbers by using an integer n, as ($2n$, $2n + 2$), or using 2 integers n and m, ($2n$, $2m$). A model response would be ($2n$, $2n + 2$), but since the representation ($2m$, $2n$) involves less restrictions, justification with this representation does actually prove the given statement. However, the fact that the sum of any two consecutive even numbers is double of the odd number in between the two even numbers can only be see from the representation, ($2n$, $2n + 2$) – because the sum can be expressed as $2(n + 1)$. This is an example of how the advance in students' capacity to use algebraic expressions and equations leads to their capacity to reason at a higher level. It is also a good opportunity to illustrate how reasoning and representations are mutually beneficial. Students then examined everyday phenomena using the idea of linear functions.

Although the discussion above focused on topics in the domains of expressions/equations and functions, we try to pay attention to reasoning with functions even in the area of geometry. A typical example may be when students examine the quadrilaterals obtained by connecting the mid-points of the sides of any quadrilaterals. Determining what conditions relate to the special conclusion and how is indeed an application of reasoning with functions. In this way, we have been teaching students to reason with functions in many different units.

In Grade 9, this study continues with the topics such as factoring, polynomials, quadratic and cubic functions and equations. As we designed the unit which deals with these topics, factoring, polynomials, quadratic equations and quadratic functions (only proportional relationship to squares of a quantity), we paid particular attention to the following.

(2) Instructional considerations

① Understanding the meaning of letters

The letter a is used as a proportional constant in Grade 7. However, even though the phrase "proportional constant" is being used, when students must determine the value of a from the graph of the proportional relationship, it is being considered as an unknown. Moreover, while examining how the change in the proportional constant influences the graph of the proportional relationship, it is being used as a variable. On the other hand, when it is used in an identify such as an equation showing the distributive property of multiplication, it is used as a generalized number. Although the same letter, a, is being used, its meaning changes depending on the context. Therefore, it is important for the teacher to be aware that there are multiple meaning of letters and help students understand these meanings in a variety of situations.

Moreover, in elementary schools, often times the expression on the right side of an equation is the answer of calculations and the left side is the calculation problem. However, in the study of algebraic expressions, students need to look at an algebraic expression such as $3(a + b)$ shows both the process of calculation and the result of the calculation (Process-Product-Dilemma). Thus, to promote students' understanding, we need to engage them in rich activities that require students to interpret algebraic expressions and equations, and encourage them to think carefully about whether they are being used for representing the calculation processes or the results of calculations.

② Application of letters in problem solving

We want students to be able to deepen their exploration of relationships among quantities by representing the relationships in algebraic equations with letters and clarifying the structures of the relationship. For example, the sums of a 2-digit number and the second 2-digit number obtained by reversing the digits in the original 2-digit number are always multiples of 11. We can extend this relationship further without necessarily proving it. For example, we can focus on the number of digits, and try to examine what happens if we had a 3-digit number. Or, we can focus on the operation, and investigate what happens if we found the difference between those 2-digit numbers instead of the sum.

	2-digit #	3-digit #	4-digit #	5-digit #
Subtraction	Multiples of 9	Multiples of 99	~~Multiples of 999~~	- - -
Addition	Multiples of 11	~~Multiples of 111~~	- - -	

If we summarize the extensions in a table, it is as shown in the table above. Thus, we can see that it is possible to extend the original observation to the subtraction, and to the difference of two 3-digit numbers. However, the pattern cannot be extended any further. On the other hand, reflecting on a proof and investigate the conditions that produce these patterns based on the proof, we could discover the essence of this problem, and we can not only figure out the cases for 3- and 4-digit situations, but also we could understand the meaning of "switching digits" in the 2-digit number. We could say that this is also an example of reasoning with functions. We have been providing these opportunities across grade levels. Students need to be fluent in manipulating algebraic expressions appropriately.

Therefore, we believe our instruction should not just focus on developing skills to manipulating algebraic expressions or formal study of functions based on mathematical definition. Rather, we want to teach our students in such a manner that they can think about and understand the merits of reasoning based on experiences.

4 About students

Students have learned about calculations with algebraic equations, simultaneous linear equations, and linear functions in previous grades. In their study, they engaged in activities to investigate the nature of changes using algebraic expressions and equations, generalizing observed patterns, representing the patterns as functions and determining unknown numbers. During lessons, we encouraged them to be conscious of their own problem solving processes and reflect on "things that need to be reasoned," and "perspective for reasoning." This year, they have learned about factoring, various patterns of numbers, and quadratic equations. We tried to teach these ideas so that students can sense mathematical necessity.

Students do not necessarily feel that they are weak in mathematics, but there are some students who find it difficult to explain their own ideas. However, students have had experiences of thinking about and resolving challenges other students felt, and the classroom atmosphere is such that a student can openly share things they do not understand. Many students are willing to share their own ideas, and simple ideas often arise from the class.

5 Unit plan

Section 1 Introduction: Graphs of quadratic functions (3 lessons)
Section 2 Expressions of sums and graphs of quadratic functions (5 lessons)
Section 3 Expressions of products and quadratic equations (6 lessons)
Section 4 Need for square roots and quadratic equations (6 lessons)
Section 5 Application of expressions of sums and products to proofs (3 lessons)
(Today's lesson is Lesson 1 of 3)
Section 6 Quadratic equations and quadratic functions (10 lessons)

6 Today's lesson

(1) Goals of the lesson

Through the examination of a calculation technique, students will understand the merits of expressions of sums and products and the base-10 numeration systems. Students can investigate the essence of the calculation technique and try to extend the idea.

(2) About mathematics in today's lesson

Today's lesson will open by sharing some of the following calculations.

$15 \times 15 = 225$
$25 \times 25 = 625$
$35 \times 35 = 1225$
$45 \times 45 = 2025$
$55 \times 55 = 3025$
$65 \times 65 = 4225$

What are common in these calculations are:

- These calculations are all squaring of numbers whose ones digit is 5
- The last 2 digits in the products are all 25
- The digits in the hundreds place and above may be calculated by (digit in the tens place) × (digits in the tens place + 1)

If we simply consider these calculations as squaring of 2-digit number, students might try to prove this pattern by using algebraic equations,

$$(10a + b)^2 = 100a^2 + 20ab + b^2.$$

But, this equation does not really explain the patterns we observed.

If we represent the original number as $10a + 5$, then square, we get

$$(10a + 5)^2 = 100a^2 + 100a + 25.$$

But, this alone cannot explain the patterns either. If a student simply focuses on calculations, he or she might try to factor out 25 or other meaningless calculations.

This problem requires students to constantly reflecting on the original observations and identify the conditions necessary for the pattern. Therefore, this is an ideal problem for Grade 9 students who have learned about equivalent algebraic expressions through the study of factoring and expanding products of algebraic expressions.

The original calculations are special instances of the fact that the product of $10a + b$ and $10a + c$ can be expressed as $100a(a + 1) + bc$, when $b + c = 10$. The calculations will be as shown below:

$(10a+b)(10a+c)$
$= 100a^2 + 10a(b+c) + bc$
$= 100a^2 + 100a + bc$
$= 100a(a+1) + bc$

(3) Flow of the lesson

Time	Learning activity	Anticipated responses	※ Points of consideration ○ Assessment
5 min.	[Introduction] • Write on the board: 15 × 15 = 225 45 × 45 = 2025 35 × 35 = 1225 • I have not memorized these. I'm just calculating really fast.	• You are really fast! • Did you memorize them?	
7 min.	[Step 1] Let's find the rule for the quick calculation. Independent problem solving (1)	• Calculate others 55 × 55 = 3025 95 × 95 = 9025 • Organize 15 × 15 = 225 25 × 25 = 625 35 × 35 = 1225 45 × 45 = 2025 55 × 55 = 3025 • Use algebraic expressions $(10a+5)^2$ $= 100a^2 + 100a + 25$ (Inductively reason) 5 × 5 = 0 25 15 × 15 = 2 25 25 × 25 = 6 25 35 × 35 = 12 25 45 × 45 = 20 25 55 × 55 = 30 25 ○ The last 2 digits are 25. ○ The numbers formed by the digits in the hundreds place and above are increasing by 2, 4, 6, 8, 10, …	※ Make sure students understand the merits of organizing for discovering patterns. ※ If there is any student who is considering 5 x 5 as the case for the tens digit being a 0, make sure to discuss that idea. (This idea might be more common among those students who take an inductive approach.)

		(Reason to generalize) 5 × 5 = 0 25 15 × 15 = 2 25 25 × 25 = 6 25 35 × 35 = 12 25 45 × 45 = 20 25 55 × 55 = 30 25 ○ The last 2 digits are 25. ○ The numbers formed by the digits in the hundreds place and above are (tens digit) × (tens digit + 1)	
5 min.	Sharing of ideas from independent problem solving (1)		※ Share how they considered the numbers on the left hand side of the equation. ※ It is possible that students discover 2 different patterns (from the inductive reasoning and generalization). However, because the proof for the latter is easier, if no student comes identify the pattern, ask, "I wonder if we need to start calculating with 1 in order." (It is hoped that students will seek for the generalization pattern because the original calculations were not presented in order.)
8 min.	[Step 2] Let's prove that when we square a 2-digit number ending in a 5, the last 2-digit of the product is 25 and the number formed by the digits in the hundreds place and above will be (tens digit) × (tens digit + 1).		
	Independent problem solving (2)	• Cannot go beyond $(10a+5)^2 = 100a^2 + 100a + 25$. • Can go as far as $(10a+5)^2 = 100a^2 + 100a + 25 = 25(4a^2+4a+1) = 25(2a+1)^2$.	※ The task will be set up based on the problems students develop in independent problem solving (1).

		• Cannot figure out the conditions for *b* and stop after calculating $(10a+b)^2 = 100a^2 + 20ab + b^2$. • $(10a+5)^2$ $= 100a^2 + 100a + 25$ $= 100(a^2 + a) + 25$ $= 100a(a+1) + 25.$ • Calculate $(10a+b)^2 = 100a^2 + 20ab + b^2$, then continue the calculation by substituting *b* = 5: $100a^2 + 20a \times 5 + 25$ $= 100a^2 + 100a + 25$ $= 100(a^2 + a) + 25$ $= 100a(a+1) + 25.$	※ When there are many students who used the method on the left, during the sharing ideas from independent problem solving (2), have students compare and contrast different solutions so that students might think about the condition for *b*.
10 min.			※ Encourage students who were stuck to share. (If students do not volunteer, the teacher will share the idea and ask if anyone who had a similar problem.) Develop a shared understanding of the challenge. Ideally, we want students to verbalize, "I don't know how to proceed with the calculation" or "I don't know what to do next." ※ As students share in response to the above, ask them "what their goal was." 〇 Students will understand the merits of expressions of sums and products. ※ Make sure students understand the meaning of factoring out 100. 〇 Students will understand the merits of the base-10 numeration systems.

15 min.	[Summary] • What do we need to pay attention to when we are manipulating algebraic expressions? • What if the ones digit isn't 5?	• We need to have a clear goal for manipulation. • We need to manipulate algebraic expressions with an understanding if the expression is an expression of sums or products. • If the ones digit is not 5, for example $23 \times 23 = 529$, there is no pattern. • If the ones digit is not 5, the term $20ab$ gets in the way to have a simple technique for calculation.	※ Students have learned that factoring and expanding products of polynomials are ways to manipulate algebraic expressions. Therefore, we will try to make sure students understand what the goal of manipulations is. ※ After students understand that we needed the term $100a$, depending on the availability of time, the teacher will suggest ideas like: • if $b + c = 10$, then for example, $23 \times 27 = 621$ and $34 \times 36 = 1$ • $(10a + b)(10a + c)$ $= 100a^2 + 10a(b + c) + bc$ $= 100a^2 + 100a + bc$ $= 100a(a + 1) + bc$ ○ Students can investigate the essence of the calculation technique and try to extend the idea.

June 26

Grade 4 Mathematics Lesson Plan

Date: June 26, 2019
Denenchofu Elem. School, Ohta Ward, Tokyo
Grade 4 Cherry Blossom Team[1]
Location: Gymnasium
Teacher: SATOH, Akira

2019 Research Theme:
Elementary Mathematics Department of Ohta Ward Research Group

Designing lessons in which students will make use of mathematical ways of observing and reasoning and deepen their learning.

1 Name of the unit: Let's explore quadrilaterals

2 Goals of the unit

Through activities to examine the positional relationships among lines and the structures of quadrilaterals, students will understand perpendicular and parallel lines and definitions of trapezoids, parallelograms and rhombuses. They will also enrich their ways to observe geometrical figures and spatial sense.

[1] The Cherry Blossom team is one of 4 teams for this unit. It is an advanced group.

3 Assessment standards

	A. Interest, Eagerness, and Attitude	B. Mathematical Way of Thinking	C. Mathematical Skills	D. Knowledge and Understanding
Standards for the Unit	Students can identify perpendicular lines, trapezoids, parallelograms, rhombuses, etc. in their surroundings and actively thinking about the situations where those figures are being used.	Students can identify properties of various quadrilaterals by focusing on the positional relationships of their sides and other structural characteristics. They can grasp the properties of diagonals, integrating their understandings.	Students can draw perpendicular lines, trapezoids, parallelograms and rhombuses.	Students understand the definitions and properties of perpendicular and parallel lines, trapezoids, parallelograms, and rhombuses. Students enrich their spatial sense.
	1. Students are investigating how lines are intersecting by focusing on the angles formed by the lines. 2. Students are trying to classify quadrilaterals by focusing on the number of pairs of parallel sides. 3. Students are attempting tiling activities while making use of what they have learned.	1. Students are thinking about and able to explain how to draw perpendicular lines by focusing on the right angle on set squares. 2. Students are thinking about and able to explain how to draw parallel lines by focusing on the property of the congruence of corresponding angles. 3. Students identify and explain properties of parallelograms by focusing on the positional relationships and lengths of sides and angle measurements. 4. Students are thinking about and able to explain how to draw a parallelogram by making use of the definition and properties of parallelograms. 5. Students identify and explain properties of rhombuses by focusing on the positional relationships and lengths of sides and angle measurements. 6. Students are thinking about and grasping the relationships among quadrilaterals by focusing on the characteristics of diagonals.	1. Students can draw perpendicular lines by using set squares. 2. Students can identify and verify parallel lines. 3. Students can draw parallel lines using set squares. 4. Students can draw parallelograms. 5. Students can draw rhombuses. 6. Students can make various quadrilaterals by putting together two congruent triangles. 7. Students can solve problems by applying what they learned in the unit.	1. Students understand the meaning of perpendicularity. 2. Students understand the meaning of parallism. 3. Students understand that parallel lines will intersect another line forming the angles of equal measurements and the width between a pair of parallel lines is constant. 4. Students understand how to identify and verify perpendicular or parallel lines using a grid. 5. Students understand the definitions of parallelograms and trapezoids. 6. Students understand the properties of parallelograms. 7. Students understand the definition of diagonals and the characteristics of diagonals in various quadrilaterals. 8. Students understand that the 2 triangles obtained by splitting a parallelogram by a diagonal are congruent.

4 About the Unit

(1) About the topic

According to the new Course of Study (to be implemented starting in the 2020 school year), the contents of this unit are described as follows.

> **Grade 4 B Geometrical Figures**
>
> (1) To provide instruction so that pupils acquire the following items through mathematical activities on plane figures.
>
> A. Acquire the following knowledge and skills.
>
> (a) To understand the relationships such as parallelism and perpendicularity of straight lines.
>
> (b) To get to know parallelograms, rhombuses and trapezoids.
>
> B. Acquire the following abilities to think, make judgments and express themselves.
>
> (a) To examine the way geometrical figures are composed and identify their properties by paying attention to the constituent parts of geometrical figures and their positional relationships, and to reinterpret the previously studied geometrical figures based on those properties.

[Knowledge and skills to be learned in this unit]

(a) Perpendicular and parallel lines

Students are expected to understand the following definitions of perpendicularity and parallelism:

- When 2 lines intersect to form right angles, the two lines are perpendicular to each other.
- When 2 lines are perpendicular to a 3rd line, the 2 lines are parallel to each other.

They will develop this understanding through activities to draw perpendicular and parallel lines using set squares and to investigate perpendicular and parallel relationships in rectangles and squares they have previously learned.

In addition, through activities to investigate the characteristics of parallel lines, they will discover the following properties of parallel lines:

- A pair of parallel lines will never intersect each other.
- The width between two parallel lines is constant no matter where they are measured.

Moreover, through activities to investigate perpendicular lines, students will recognize the difference between right angles and perpendicularity. The aim of instruction is for students to understand that perpendicularity and parallelism are about positional relationships between 2 lines through mathematical activities.

(b) Parallelograms, rhombuses and trapezoids

Previously, students have learned to examine geometrical figures by using the length of sides and angle measurements as the lens for observation. In this unit, students will learn "parallelism" and "perpendicularity" as new lens to examine geometrical figures. They will learn that when a pair of opposite sides of a quadrilateral are parallel, it is a trapezoid, and when there are 2 pairs of parallel sides in a quadrilateral, it is a parallelogram. Through the activity to classify quadrilaterals obtained by overlapping 2 geometrical figures, they will develop the capacity to sort quadrilaterals without being influenced by their orientations and sizes.

By using the length of sides as a lens to observe quadrilaterals, students realize that rhombuses form a class of quadrilaterals. By comparing and contrasting rhombuses to parallelograms, squares, and rectangles, they will discover similarities and differences among them and deepen their understanding of geometrical figures.

Moreover, through activities to examine the characteristics of diagonals in various quadrilaterals and through tiling activities, students will discover characteristics involving the size of angles.

[Ability to reason, judge, and express oneself to be learned in this unit]

Through activities to examine relationships between two segments (sides) in quadrilaterals, we want to help students understand the special relationships between two lines, perpendicularity and parallelism. We want students will deepen their understanding by engaging in concrete activities such as classifying geometrical figures using pairs of parallel sides as a lens for observation and drawing parallelograms and rhombuses using their properties that have been identified.

In particular, we consider the activity in today's lesson where students create and classify quadrilaterals by overlapping familiar figures as a key experience. We want students to experience activities so that they can reason and judge that infinitely many different geometrical figures can be made by changing the way two geometrical figures are overlapped, and that they can classify quadrilaterals by using parallel sides as a lens for observation. We want them to be able to express those ideas as well.

In addition, we want students to realize that rectangles, squares and rhombuses are all special types of parallelogram when we use the parallel sides as a lens for observation. In this way, students can deepen their understanding of geometrical figures and begin to develop a unified view of quadrilaterals.

Moreover, through the activities to examine the length and positional relationships of diagonals in various quadrilaterals, we want students to be able to identify common characteristics. In this way, students will enhance their capacity to focus on the way quadrilaterals are structured and relationships among the constituent parts of quadrilaterals.

(2) About the students

Students have learned about geometrical figures in previous grades: "rectangles, squares and right triangles" in Grade 2; "isosceles and equilateral triangles" in Grade 3, and "angle measurements" in Grade 4. As structural features of geometrical figures, students have learned about "the number of sides and vertices," "right angles," "length of sides" and "size of angles." Students have also classified triangles and quadrilaterals using a particular viewpoint. In addition, they have learned the definitions of geometrical figures and how to draw them using their definitions and properties.

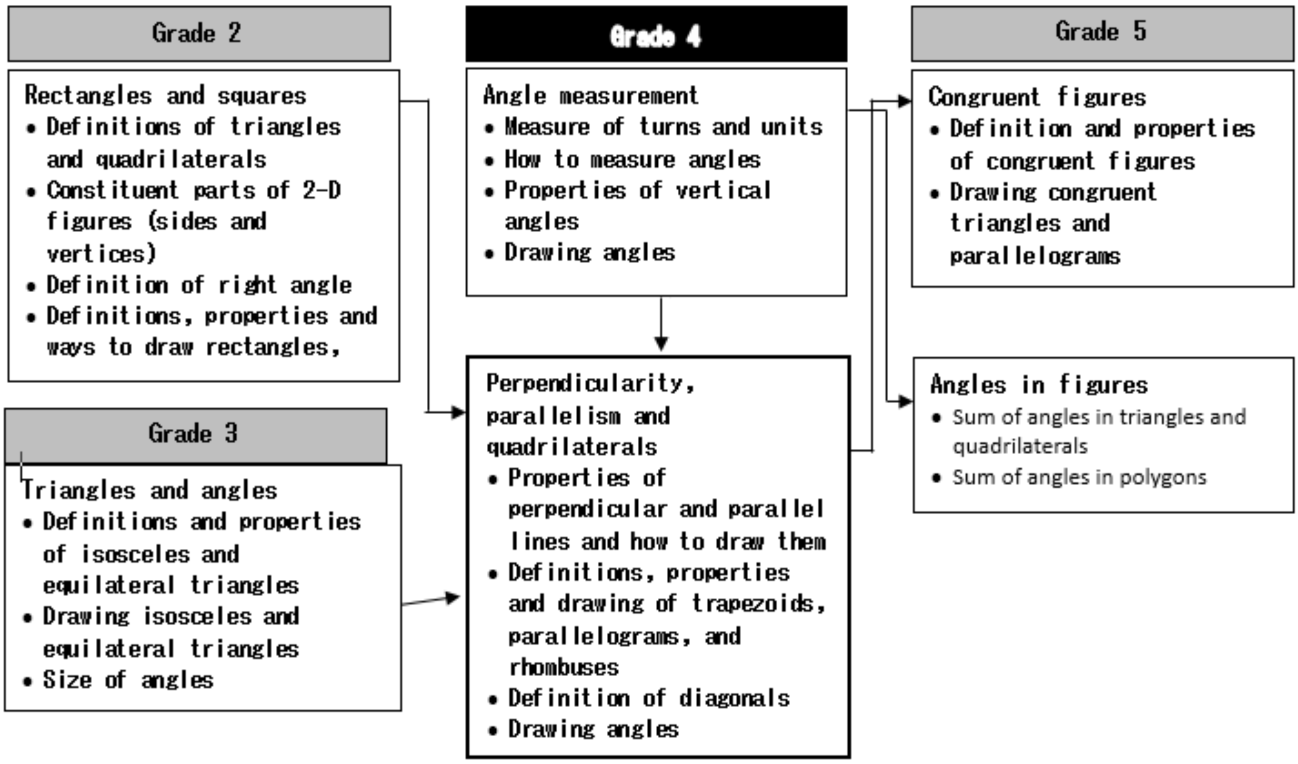
At our school, we administer a readiness test before each unit. Based on the results of the readiness test, and also considering each student's own desire, we organize teams for each unit. The results of the readiness test for the current unit is as follows.

<table>
<tr><td></td><td colspan="3">Purpose of the question</td><td>Success rate</td></tr>
<tr><td>①</td><td colspan="3">Students can draw isosceles triangles</td><td>79 %</td></tr>
<tr><td>②</td><td colspan="3">Students can measure angles using right angle as a unit</td><td>90 %</td></tr>
<tr><td rowspan="5">③</td><td colspan="3">Students know the names and the definitions of rectangles, squares, isosceles triangles and equilateral triangles.</td><td rowspan="5"></td></tr>
<tr><td>Rectangles</td><td>Name 91 %</td><td>Definition 26 %</td></tr>
<tr><td>Squares</td><td>Name 75 %</td><td>Definition 25 %</td></tr>
<tr><td>Isosceles triangle</td><td>Name 91 %</td><td>Definition 81 %</td></tr>
<tr><td>Equilateral triangle</td><td>Name 91 %</td><td>Definition 80 %</td></tr>
<tr><td>④</td><td colspan="3">Students can identify the triangles they can make by using 2 set squares (equilateral triangle and isosceles triangle).</td><td>81 %</td></tr>
<tr><td>⑤</td><td colspan="3">Students understand the congruence of vertical angles.</td><td>89 %</td></tr>
</table>

From the readiness test, we can see that many students can visually identify rectangles and squares, but not many students understand their definitions. In addition, students who indicated that they enjoyed the study of geometrical figures gave the reasons such as "I enjoy drawing and making figures myself," and "geometrical figures are composed of many figures and I enjoy thinking about them." On the other hand, students who indicated that they did not like the study of geometrical figures gave the reasons such as "there are many different ways of reasoning, and I can't keep them straight," and "I don't understand how to draw specific figures."

Based on the results of the readiness test, it is decided to design the lessons in this unit so that students can first understand the definitions of geometrical figures based on mathematical activities that allow them to experience the definitions. Then, based on the definitions they understood, they will think about ways to draw those figures. Through these activities, even those students who do not like the study of geometrical figures may discover commonalities among various ways of reasoning, and they can enjoy drawing activities in which the rationale for each step of drawing is made clear.

5 Scope and sequence



6 Organization of the unit and evaluation plan

		Cherry Blossom	Sunflower	Cosmos	
	Goals	Learning activity			Evaluation standards
1	Motivate students to examine quadrilaterals by focusing on structural components of the figures.	Let's make different quadrilaterals and find similarities and differences among them. • Draw quadrilaterals by connecting dots. • Discuss different ways lines are intersecting each other and different quadrilaterals formed by intersecting lines. Students will become interested in plane figures. • Investigate different ways two lines may intersect each other. • Know the definition of perpendicularity.			[A] In addition to the length of sides and the size of angles, students are examining quadrilaterals using the relationships of sides as a lens. [A-1] Students are examining the ways lines are intersecting by focusing on the angles formed. [D-1] Students understand the definition of perpendicularity.
2	Through the activities to examine the ways 2 lines intersect, students will know the meaning of perpendicularity and be able to identify and justify perpendicular lines. Students will be able to draw perpendicular lines using set squares.	Let's think about ways to draw perpendicular lines using set squares.			
		• Think about ways to draw perpendicular lines using set squares based on the definition of perpendicular lines. • Draw perpendicular lines.	• Think about ways to draw perpendicular lines using set squares based on the definition of perpendicular lines. • Draw perpendicular lines.	• Given a line, think about ways to draw a line that will be perpendicular to the given. • Think about ways to draw perpendicular lines using set squares. • Draw perpendicular lines.	[B-1] Students are thinking about and able to explain how to draw perpendicular lines by focusing on the right angle on set squares. [C-1] Students can draw perpendicular lines by using set squares.
3	Through the activities to examine the ways 2 lines intersect, students will know the meaning of parallelism and be able to identify and justify parallel lines.	Let's think about ways to identify parallel lines.			
		• Examine the way lines are arranged. • Know the definition of parallelism. • Identify and justify parallel lines. • Look for perpendicular and parallel sides in rectangles. • Deepen the understanding of parallelism by comparing and contrasting various lines, including curves that are equally spaced from each other.	• Examine the way lines are arranged. • Know the definition of parallelism. • Identify and justify parallel lines. • Look for perpendicular and parallel sides in rectangles.	• Examine the way lines are arranged. • Know the definition of parallelism. • Using a given pair of parallel lines as the point of reference, distinguish and justify parallel lines from those that are not. • Look for perpendicular and parallel sides in rectangles.	[C-2] Students can identify and verify parallel lines. [D-2] Students understand the meaning of parallism.

4	Students will understand properties of parallel lines such as they will intersect another line forming congruent angles and their width is constant.	Let's examine properties of parallel lines. • Explain that parallel lines will intersect a line forming congruent angles based on their knowledge of the congruence of vertical angles and congruence of corresponding angles. They can also explain that parallel lines will not intersect each other no matter how far they are extended. • Examine angles formed by parallel lines and another line. • Examine the width of parallel lines. • Summarize that the distance between a pair of parallel lines is constant. • Deepen their understanding of parallelism by knowing we do not call curves parallel even if the distance between them is constant.	• Examine angles formed by parallel lines and another line. • Examine the width of parallel lines. • Summarize that the distance between a pair of parallel lines is constant. • Deepen their understanding of parallelism by knowing we do not call curves parallel even if the distance between them is constant.	• Using parallel and perpendicular lines found in the lines and grids in heir notebooks, examine angles formed by lines and the width of parallel lines.. • Summarize that the distance between a pair of parallel lines is constant. • Deepen their understanding of parallelism by knowing we do not call curves parallel even if the distance between them is constant.	[D-3] Students understand that parallel lines will intersect another line forming the angles of equal measurements and the width between a pair of parallel lines is constant.
5	Students can draw parallel lines using set squares.	Let's think about ways to draw parallel lines using set squares • Explain the way to draw parallel lines based on the congruence of corresponding angles. • Think about ways to draw parallel lines using set squares. • Draw parallel lines. • Examine the relationships of sides in rectangles and squares and identify that the opposite sides are parallel and adjacent sides are perpendicular.	• Explain the way to draw parallel lines based on the congruence of corresponding angles. • Think about ways to draw parallel lines using set squares. • Draw parallel lines. • Examine the relationships of sides in rectangles and squares and identify that the opposite sides are parallel and adjacent sides are perpendicular.	• Given a line, think about ways to draw a second line that will be parallel to the given. • Think about ways to draw parallel lines using set squares. • Draw parallel lines. • Examine the relationships of sides in rectangles and squares and identify that the opposite sides are parallel and adjacent sides are perpendicular.	[B-2] Students are thinking about and able to explain how to draw parallel lines by focusing on the property of the congruence of corresponding angles. [C-3] Students can draw parallel lines using set squares.

6	Students will understand perpendicular and parallel lines in on grid papers.	Let's think about ways to identify perpendicular and parallel lines when they are drawn on a grid.			
		• Think about ways to identify perpendicular and parallel lines on a grid based on the fact that you can draw a line with a specific slant when you move ○ spaces vertically and □ spaces horizontally.	• Think about ways to identify perpendicular and parallel lines on a grid.	• Think about ways to identify perpendicular and parallel lines on a grid.	[D-4] Students understand how to identify and verify perpendicular or parallel lines using a grid.
7	[Today's Lesson] Through the activity of classifying quadrilaterals, students will understand the definitions of trapezoids and parallelograms.	Let's examine how many different kinds of quadrilaterals we can make by overlapping two figures.			
		• Given various figures classify quadrilaterals. • Know the definitions of trapezoids and parallelograms. • Deepen their understanding of parallelograms by identifying common features among rectangles, squares and parallelograms.	• Given various figures classify quadrilaterals. • Know the definitions of trapezoids and parallelograms. • Deepen their understanding of parallelograms by identifying common features among rectangles, squares and parallelograms.	• After confirming that we are classifying figures using parallel sides as a lens, classify quadrilaterals. • Know the definitions of trapezoids and parallelograms. • Deepen their understanding of parallelograms by identifying common features among rectangles, squares and parallelograms.	[A-2] Students are trying to classify quadrilaterals by focusing on the number of pairs of parallel sides. [D-5] Students understand the definitions of parallelograms and trapezoids.
8	Students will understand the properties of parallelograms.	Let's examine properties of parallelograms.			
		• Draw trapezoids and parallelograms using grid lines or given parallel lines. • Look for the properties of parallelograms by investigating lengths of sides and angle measurements.	• Draw trapezoids and parallelograms using grid lines or given parallel lines. • Look for the properties of parallelograms by investigating lengths of sides and angle measurements.	• Draw trapezoids and parallelograms using grid lines or given parallel lines. • Look for the properties of parallelograms by investigating lengths of sides and angle measurements.	[B-3] Students identify and explain properties of parallelograms by focusing on the positional relationships and lengths of sides and angle measurements. [D-6] Students understand the properties of parallelograms.

9	Students can draw parallelograms.	Let's think about ways to draw parallelograms.			
		• Think about ways to draw parallelograms. • Draw parallelograms by making use of the definition and the properties of parallelograms.	• Think about ways to draw parallelograms. • Draw parallelograms by making use of the definition and the properties of parallelograms.	• Think about ways to draw parallelograms. • Draw parallelograms by making use of the definition and the properties of parallelograms.	[B-4] Students are thinking about and able to explain how to draw a parallelogram by making use of the definition and properties of parallelograms.
10	Students can draw the parallelogram whose length of sides and an angle measurement are given.	Let's draw a particular parallelogram.			
		• Tackle an application problem.			[C-4] Students can draw parallelograms.
11	Students will understand the definition and properties of rhombuses. They will be able to draw rhombuses.	Let's think about ways to draw a rhombus using the properties of rhombuses.			
		learning on drawing various geometrical figures, realize that to draw a particular quadrilateral, we need to make use of its properties. • Know the definition of rhombuses. • Summarize the properties of rhombuses. • Draw rhombuses. • Deepen the understanding of rhombuses by examining common characteristics between rhombuses and squares.	definition of rhombuses. • Summarize the properties of rhombuses. • Draw rhombuses. Deepen the understanding of rhombuses by examining common characteristics between rhombuses and squares.	definition of rhombuses. • Summarize the properties of rhombuses. • Draw rhombuses. Deepen the understanding of rhombuses by examining common characteristics between rhombuses and squares.	[B-5] Students identify and explain properties of rhombuses by focusing on the positional relationships and lengths of sides and angle measurements. [C-5] 8. Students can draw rhombuses.
12	Students will deepen their understanding of the contents in the unit through mathematical activities, and they become more interested in quadrilaterals.	Let's create tiling patterns using quadrilaterals and find patterns.			
		• Deepen their understanding of 2-D figures through tiling activities using quadrilaterals. • Investigate if it is possible to tile the plane using quadrilaterals other than parallelograms. Think about why it is possible to tile the plance using any quadrilaterals.	• Deepen their understanding of 2-D figures through tiling activities using quadrilaterals.	• Deepen their understanding of 2-D figures through tiling activities using quadrilaterals.	[A-3] Students are attempting tiling activities while making use of what they have learned.

13	Students will understand the definition of diagonals and characteristics of diagonals of various quadrilaterals.	Let's examine diagonals of various quadrilaterals and find patterns.			
		• Examine the characteristics of segments connecting 2 vertices of various quadrilaterals. • Understand the definition of diagonals. • Summarize the characteristics of diagonals of various quadrilaterals. • Deepen their understanding of diagonals by examining the characteristics of diagonals in isosceles trapezoids and kites.	• Examine the characteristics of segments connecting 2 vertices of various quadrilaterals. • Understand the definition of diagonals. • Summarize the characteristics of diagonals of various quadrilaterals. • Deepen their understanding of diagonals by examining the characteristics of diagonals in isosceles trapezoids and kites.	• Examine the characteristics of segments connecting 2 vertices of various quadrilaterals. • Understand the definition of diagonals. • Summarize the characteristics of diagonals of various quadrilaterals. • Deepen their understanding of diagonals by examining the characteristics of diagonals in isosceles trapezoids and kites.	[B-6] Students are thinking about and grasping the relationships among quadrilaterals by focusing on the characteristics of diagonals. [D-7] Students understand the definition of diagonals and the characteristics of diagonals in various quadrilaterals.
14	Students will know that triangles obtained by cutting a rectangle, parallelogram, and rhombus are congruent. They will be able to make various quadrilaterals using this knowledge.	Let's make various figures by cutting quadrilaterals along a diagonal.			
		• Examine the two triangles obtained by cutting a rectangle, parallelogram, and rhombus along a diagonal. • Make various quadrilaterals combining the these triangles. • Compare and contrast quadrilaterals they created to think about what properties of the quadrilaterals are being used and share their observations.	• Examine the two triangles obtained by cutting a rectangle, parallelogram, and rhombus along a diagonal. • Make various quadrilaterals combining the these triangles.	• Examine the two triangles obtained by cutting a rectangle, parallelogram, and rhombus along a diagonal. • Make various quadrilaterals combining the these triangles.	[C-6] Students can make various quadrilaterals by putting together two congruent triangles. [D-8] Students understand that the 2 triangles obtained by splitting a parallelogram by a diagonal are congruent.
15	Students will be able to solve problems by making use of what they learned.	• Complete problems in "Power Builder" and "Mastery Problems."			[C-7] Students can solve problems by applying what they learned in the unit.
16	Students will make sure they have mastered skills learned in the unit and consolidate their understanding.	• Tackle problems in a worksheet.			

7 About the lesson (Lesson #7 of 16)

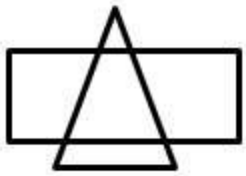
(1) Goal of the lesson

Through the activity of classifying quadrilaterals, students will understand the definitions of trapezoids and parallelograms.

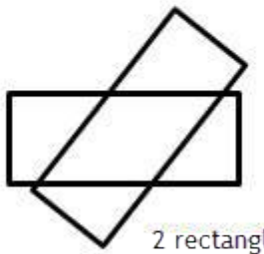
(2) Strategies to address research theme

1 Ideas related to the design of the instructional materials

We want students to make use of the structures of the basic geometric figures and their properties they have previously learned as they deepen their learning processes. To support that aim, we decided to set up an activity in which students will manipulate geometric figures that they have already learned in today's lesson. When students generate and classify new geometric figures on their own while paying attention to the constituent parts of the new figures, they are likely to notice that some quadrilaterals are members of the same group when they are viewed using parallel sides as a lens even if the lengths of sides or angle measurements are different.



Rectangle and triangle



2 rectangles

2 triangles

2 Students who are using mathematical ways of observing and reasoning in this lesson

[Mathematical ways of observation] --- Students are trying to classify quadrilaterals by focusing on one of the structural components of geometrical figures, positional relationships of sides.

[Mathematical ways of reasoning] --- Students are classifying quadrilaterals using previously learned knowledge of parallelism and perpendicularity, and they are able to integrate their knowledge and understand that rectangles and squares are special types of parallelogram.

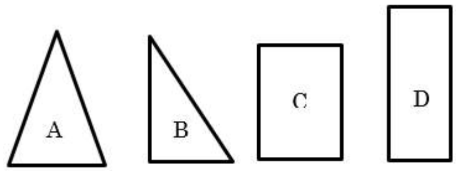
3 Stratgies to deepen students' learning

[Whole class discussion] --- To help students deepen their understanding, groups will be asked to share only a part of their ideas so that other students can explain how those groups might have completed their solution.

[Summarizing] --- By looking back on various lenses through which we classified quadrilaterals, students can define parallelograms and trapezoids using the new lens of parallel sides.

[Reflection] --- By having students post the quadrilaterals they created on the whiteboard based on the classification criterion, help students able to classify quadrilaterals based on the positional relationships of sides without being distracted by the orientations and sizes of the figures.

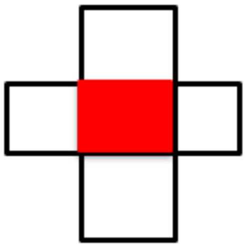
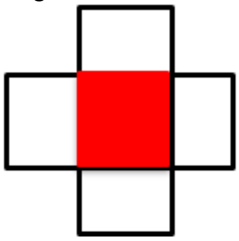
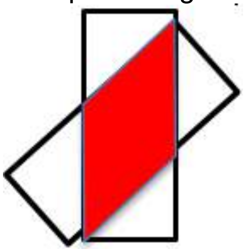
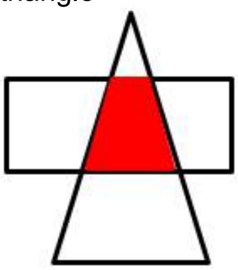
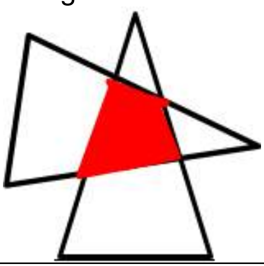
(3) Flow of the lesson

	Learning activity/Content	Instructional points of consideration ○ Support ◆ Evaluation
Grasping the problem/Plan 5 minutes	1 Reflecting on the previous lesson T: What are these shapes? (Show A and B) C: Isosceles triangle. T: How do you know it is an isosceles triangle? C: There are 2 sides that are equal length. C: B is a right triangle because there is a right angle. T: Even though they have different characteristics, they are both triangles, aren't they? T: What are these shapes? (Show C and D) C: Rectangle. C: We can't decide unless we can measure. C: If all 4 angles are right angles, it is a rectangle. C: Opposite sides are parallel and adjacent sides are perpendicular, aren't they? T: I'm going to overlap a rectangle and a triangle. What kind of figures do you think we will get? C: I think it will be a quadrilateral. T: OK, let me show you. C: It's a quadrilateral. C: I think we can make other figures if use different combinations of figures. C: I think we can get different figures even with the same set of figures if we change their angles.	○ Reflecting on the definitions and properties of perpendicular and parallel lines students learned in prior lessons. ○ Show 2 non-congruent triangles and 2 non-congruent rectangles.  ○ Teacher will show that the angles are right angles and confirm they are rectangles. ○ Remind students that there are 2 pairs of parallel sides in a rectangle so that they may be able to use the characteristics as they sort figures they will create. ○ Emphasize that "to classify" means to organize figures using one specific characteristics. There are parallel sides → Yes or No!

[Goal]

Let's make different quadrilaterals by overlapping 2 geometric figures.

<table>
<tr>
<td>Independent problem solving 7 minutes</td>
<td>2 Investigate what quadrilaterals can be made by overlapping geometric figures, and record the findings in own notebooks

C: A rectangle by overlapping a small rectangle with a large rectangle

C: A square by overlapping 2 rectangles (both large or both small)

C: A parallelogram by overlapping 2 rectangles

C: A trapezoid by overlapping a rectangle and a triangle

C: A general quadrilateral by overlapping 2 triangles
</td>
<td>○ Distribute small and large rectangles and triangles (each with 2 copies, one made with laminated colored paper and the other with laminated tracing paper.

○ Instruct students to use the one made with the trancing paper on top to make quadrilaterals.

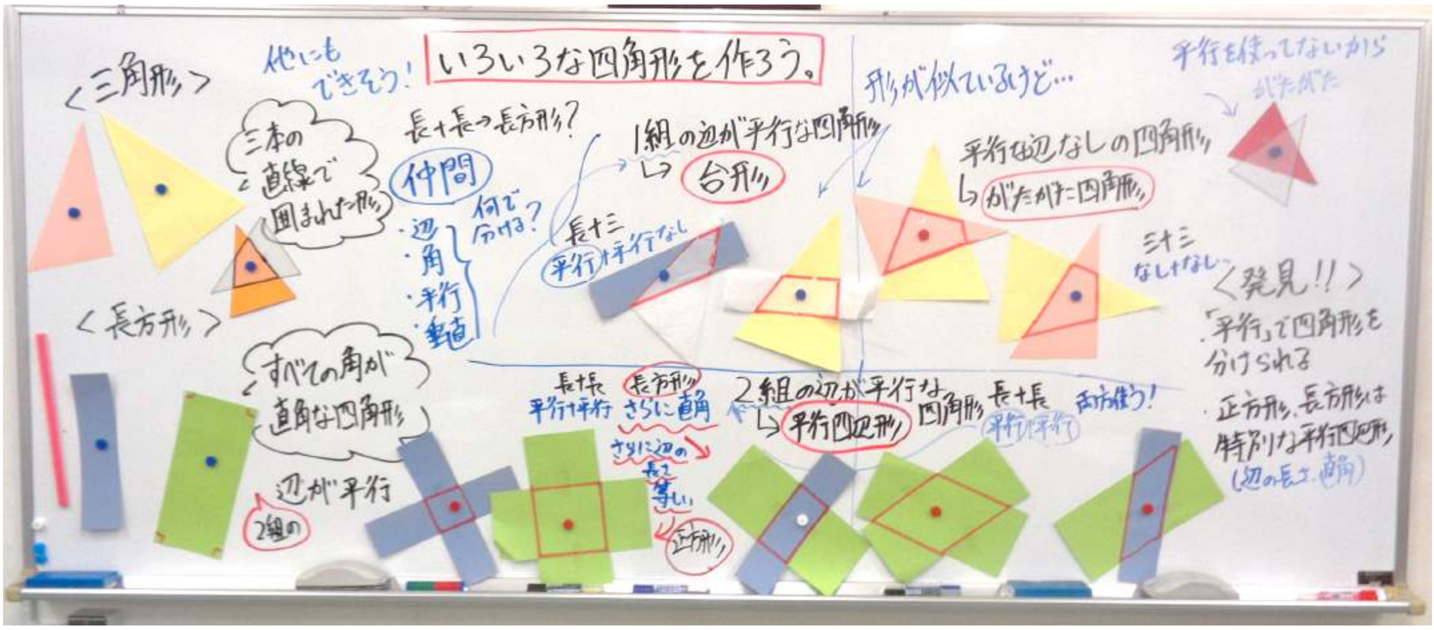
○ Have students write their name on the quadrilaterals they created.</td>
</tr>
</table>

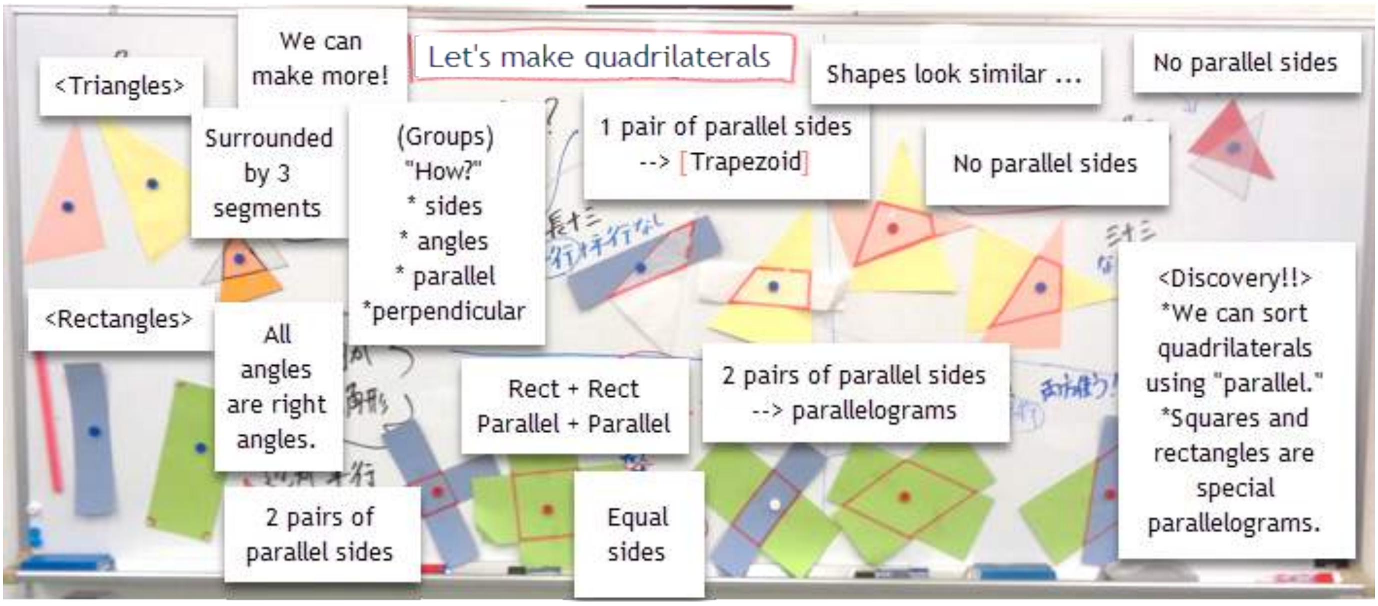
Sharing and discussion 23 minutes	3 Think about ways to classify in groups (10 minutes) T: What kinds of quadrilaterals did you make? Let's share your quadrilaterals in groups. C: I made a rectangle using a small rectangle and a large rectangle. C: I made a square using 2 small rectangles. C: Using 2 large rectangles will also make a square. C: The length of sides are different, they are in the same group. T: I heard some groups are saying figures are in "the same group." Did you all find some figures that appear to be in the same group? C: I think there are different ways to groups these figures. T: To classify figures, we need to have a theme, don't we? What kind of characteristics have we used to classify figures? C: Length of sides. C: We also use the size of angles. C: We learned about right triangles and isosceles triangles. I think the rectangles are another example. C: We also learned about perpendicular and parallel lines. T: Let's classify the figures you made by using some of the characteristics of geometrical figures. C: It is difficult to find the figures with the same length sides. C: Some of them have right angles and others don't. C: If you turn one of the figures a bit, we get a slanted quadrilateral (parallelogram). C: With a triangle and a rectangle, you get a shape like a foot stool. C: When you overlap two triangles, it is just a quadrilateral. C: Even if the size of figures we use ae different, if we use the same kinds of figures, the quadrilaterals we get look like each other. C: How can we classify them? C: Length of sides and the overall sizes are all different, aren't they? C: I wonder if we can use perpendicular or parallel sides. C: There are 2 pairs of parallel sides in rectangles, squares and parallelograms. C: In rectangles and squares, there are right angles. C: The figure that looks like a foot stool has only a pair of parallel sides. C: When we overlap two triangles, we get a quadrilateral with no pair of parallel sides. C: I think we can make 5 different kinds of quadrilaterals.	○ By using students' own idea of "the same group," we encourage students to classify figures with their own initiative. ○ Have students classify figures using the structural components they have learned previously: length of sides, size of angles, parallelism, and perpendicularity. ○ If no student raises the possibility of using perpendicular and parallel sides, stop the class, and confirm that length of sides and angle sizes are not appropriate lens to use because we have quadrilaterals of with different sizes. ○ Have students record what they used as the lens to classify and what they notice in their notebooks. ◆ Students are trying to classify quadrilaterals by focusing on the number of pairs of parallel sides. [A-2] (From students' comments and their notebooks)

	4 Whole class discussion (15 minutes) T: What kinds of figures did you get by overlapping two figures? C: We made rectangles. C: We made 3 different rectangles. C: We also made squares and a slanted quadrilateral (parallelogram). T: Could you actually show us how you made a slanted quadrilateral? C: (Just demonstrate) Overlap two rectangles, then turn one of them. C: I got it. It was at first a rectangle, but as one rectangle is turned, it became a slanted quadrilateral (parallelogram). C: That's because the size of angles change. C: You get a square only if we overlap two rectangles that are the same. C: That's because all four sides must be equal. T: There is something common among the three quadrilaterals you just shared with us. Some groups used it to classify their quadrilaterals. What is it? C: There are 2 pairs of parallel sides. C: Even when one rectangle is turned, there are always 2 pairs of parallel sides. C: I think rectangles, squares and slanted quadrilaterals (parallelograms) are all in the same group. C: We have to use two rectangles. C: I wonder why we cannot make them using other combinations. C: I think the important point is how many pairs of parallel sides the original figures have. T: Did anyone make other types of quadrilaterals? C: We made a figure that looked like a step stool (trapezoid). T: Can you show us how you made it? C: (Demonstrate) This part is the quadrilateral that looks like a step stool. C: Even when we turn one of the figures, the quadrilateral looks similar. C: This figure has only one pair of parallel side. C: We made another kind. C: We made an irregular quadrilateral. C: We overlapped two triangles. T: Can you show us? C: There is no parallel sides even when we turn one of the figures. C: Even though the figures look all different, we made 5 kinds of quadrilaterals. T: Even though they looked different, when we classify them using parallel and perpendicular sides, we made 5 different quadrilaterals.	○ Allow different students to share instead of one student sharing all types he/she made. This way, help all students develop an understanding. ○ If time allows, discuss classifications that used the existence of right angles or equal length sides. ○ General quadrilaterals obtained by two triangles will be discussed last. ○ If students say ~ and ~ are in the same group, acknowledge the observation. (For example, rectangles and parallelograms are in the same group.) Developing a unified perspective.

	5 Students will learn the names, parallelogram and trapezoid T: We found many different quadrilaterals today. We call quadrilaterals with a pair of parallel sides "trapezoids," and quadrilaterals with 2 pairs of parallel sides "parallelograms." Please pick a quadrilateral you made and post it in the group it belongs.	○ Have students record the definitions of trapezoids and parallelograms in their notebooks. ○ Have each student pick one of the quadrilaterals they made and post it in the categories shown on the whiteboard. Have students explain why they put their quadrilaterals in a particular group to their neighbors so that they can explain the classification based on parallel sides. ◆ Students understand the definitions of parallelograms and trapezoids. [A-2] (From students' comments)
	6 Write reflections and share with the class T: We made many different quadrilaterals and classified them, but what is that we used to classify them? Also, what did you learn in today's lesson? Look back on the lesson and write your reflection in your notebook. C: We were able to classify figures using a new idea, parallel sides. C: If we focus on the number of pairs of parallel sides, I learned that rectangles and squares are also parallelograms.	○ Have students use drawings and words to summarize today's learning. (Note taking, 5 minutes)

8 Board writing plan





Lesson Report

Report created by: Heather Dallas, Michelle Sidwell, Helen Chan, Julie McGough

Name of Lesson: Let's Investigate the Way Quantities Change

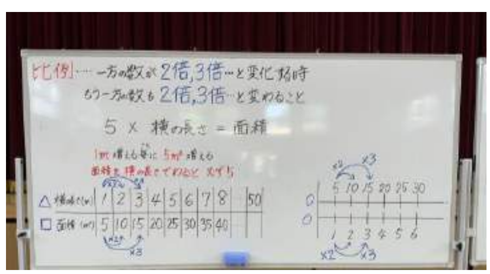
Date of Lesson: June 19, 2019

What are the primary lesson goals? Students can examine two co-varying quantities using proportional relationship as a viewpoint.

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?
This unit includes the following learning goals:

- Students will understand the relationship between the number of busses and the maximum number of passengers (total). They will understand the term "proportional relationship."
- Through activities to examine the relationship between two co-varying quantities, students can identify and verify a proportional relationship.
- *Through the activity to examine the relationship between two co-varying quantities in a concrete situation, students can solve problems based on the fact that the two quantities are in proportional relationship.*

Summary of Lesson

Start/End Time	Lesson Phase	Notes
1:21	**Introduction, Posing Task**	**Strategies to build interest and to connect to prior knowledge** The teacher reviewed the previous day's lesson, including the definition of a proportional relationship and the context of the previous day's problem, which was the relationship between length and area in their classroom. He reviewed the unit rate.  After the review, the teacher turned the board around. He wrote the date on the board.

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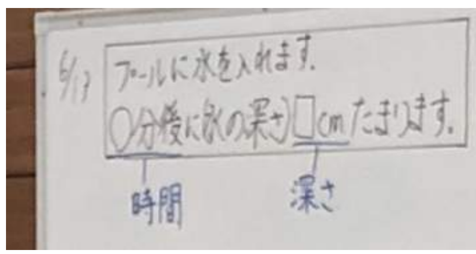
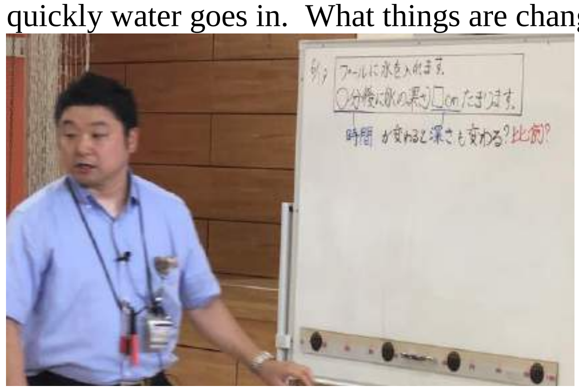
To build interest in this lesson, the teacher connected a context (a pool) that was related to these students' everyday lives (because there is a pool at the school and children take swimming lessons there). This lesson was also during the warm weather season.

T: We're going to pour water into the pool. What changes?
S: Amount of water (many students responded this way)
T: What else changes?
S: It gets deeper
S: Liquid volume
S: Depth of the water
S: Weight
S: Air
T: How? Something else changes (teacher looks at watch).
S: Time!
Teacher wrote on the board that ◯ represents minutes and ☐ represents the depth of the water in cm.



The teacher then went on to acknowledge the fact that pools can come in different shapes.
T: For today, we will assume the pool is a rectangular prism. We will also assume the rate in which the water goes in is the same. We are not changing how quickly water goes in. What things are changing?



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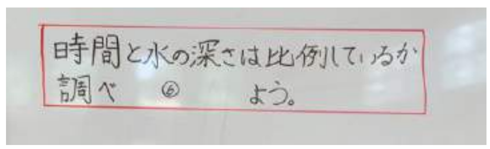
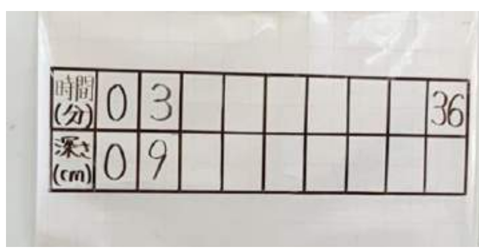
1:40

S: Depth and time (or duration)
T: How are they changing?   Turn and talk with a neighbor for 25 seconds.
The pair talk time increased interest because it provided an opportunity for individual engagement and provided students who may not have known where to start with ideas.
T: How do the duration and depth change?
S: After 5 minutes, maybe the depth will be 5 cm. After 10 minutes maybe the depth will change 10 cm
Teacher writes when time changes, depth changes also.
T: What does it mean to change the same way?
S: Quantities change in proportional relationship
Teacher writes today's goal using a different colors to highlight the different parts.



After that he provided agency for the students by asking them how they wanted to see the data.
T: How would you like to see the data?
S: We want a table.
Teacher reveals a pre-constructed table after the students said table.



Students copy the table into their notebooks. Teacher walks around also making sure they use color. Teacher also ensures that students leave spaces in their table.

T: There are many empty cells. What do you think the depth of the water will be after 36 minutes? Who wants more information? How many of you can figure this out with the information?   I will tell you

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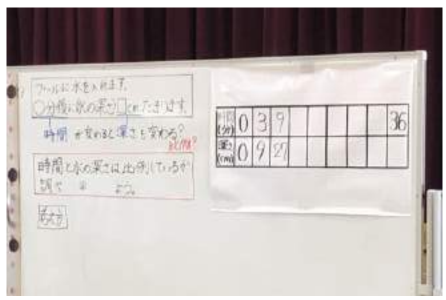
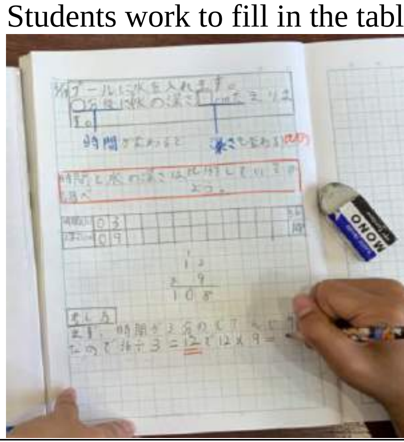
		one thing. What do you want to know? Talk with your neighbors. After a few seconds of turn and talk, the teacher continues asking questions. T: What do you want to know? S: I think it's a proportional relationship. T: How do you know? If it's a proportional relationship, can you figure it out? S: Yes. T: How many of you understand? S: Teacher earlier said that the water is poured at the same rate, so I think it's proportional. T: Are we ready to move into independent problem solving? Who's not ready yet? What else do you want to know? S: I want to know what else comes after 9. T: I'll give you more info, but you can go ahead if you think you can figure out.  Teacher provided one more set of data (9, 27). S: Now I know.
1:45	**Independent Problem Solving**	**Individual, pairs, group, or combination of strategies** T: OK. I'll give you 6 minutes Students work to fill in the table. 

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		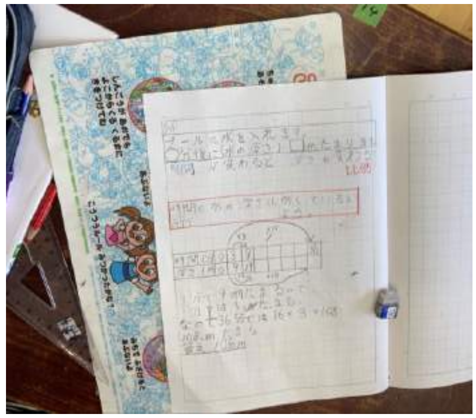 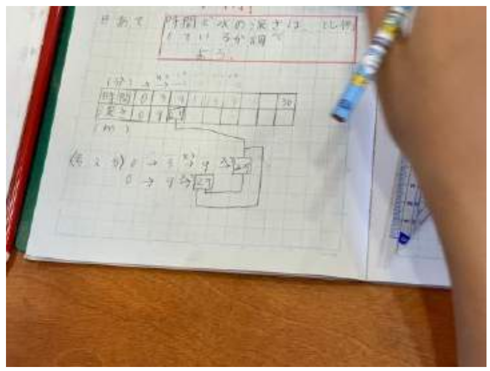 T: I’ll give you 3 more minutes
1:54	**Presentation of Students’ Thinking, Class Discussion**	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses** Students share their ideas. S: I think that since 3 x 12 = 36 then I can multiply 9 x 12. S: 36 divided by 3 is 12 so 3 x 12 = 36 S: 3 x 12 = 36 so 9 x 12 = 108 S: Because duration and depth is a proportional relationship, 36 is 12 times as much as 3. I made 9 twelve times as much to find the depth after 36 minutes.

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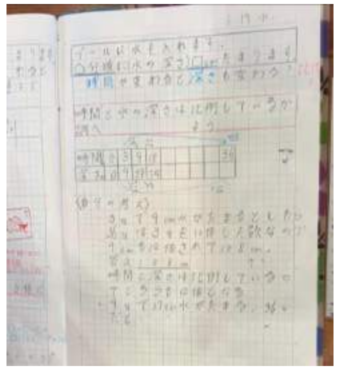
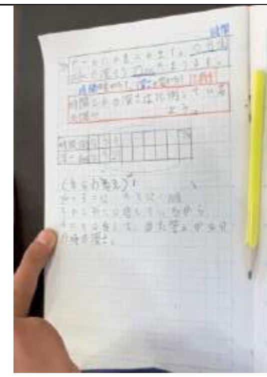
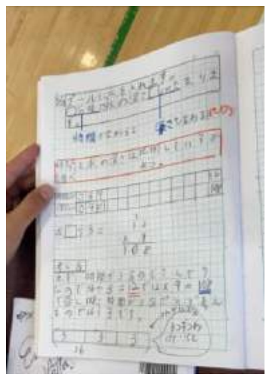
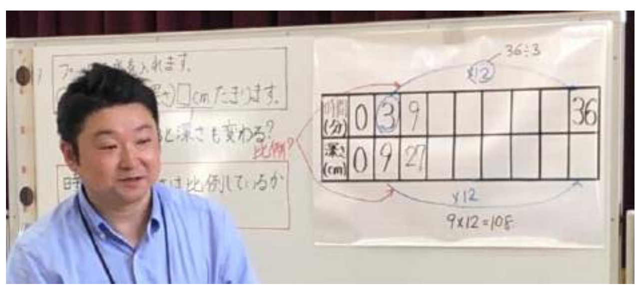
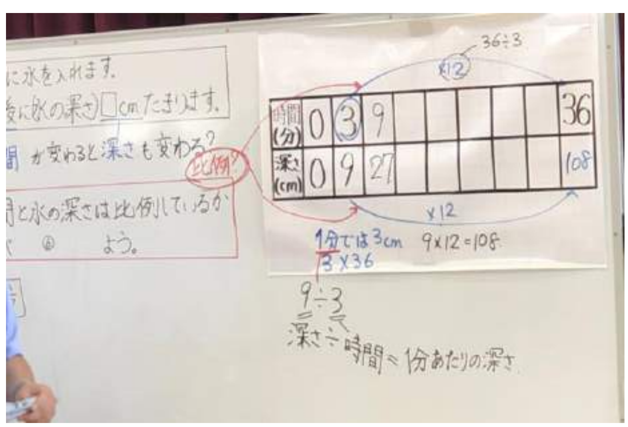




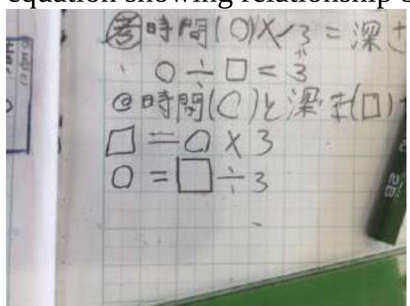
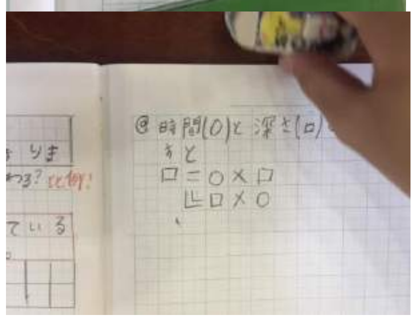


Teacher annotates the table on the board.





		T: Do you understand what she said? Do you want another explanation? S: The cells in the table could be 3 times, 4 times, 5 times, but 36 is 12 times 3 and I don’t think I have enough space. Some other students are confused about the number of empty spaces on the table. Teacher says they don’t have to go in order.  Student shares about 9 divided by 3 and the multiplying by 36. Teacher asks 9 divided by 3 (9 represents depth, 3 represents duration). T: I am going to jump and add 20 to the table. Can we still figure this out if it is not a multiple of 3? After 1 minute, depth changes 3 inches. Depth divided by duration is equal to the depth per minute so we can figure it out from that. Teacher takes out pink magnetic strips to label depth and duration. 

		Figure out 10 minutes. S: 20 divided by 10 is 2 so 30 x 2 = 60, so 60 cm S: ½ of 20 is 10. 60/2 = depth at 10 minutes T: 20/2 = 10. 60/2 = 30. It is the same relationship even with division as the operation.
	Summary/Consolidation of Knowledge	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals** T: Duration is ◯ . ☐ is depth. Can you write an equation showing relationship between ◯ and ☐ ?   Some students have correct answers, some have incorrect answers, and a large percentage did not write anything until they copied the answer from the board in the group discussion. T: Writes ◯ = ☐ x 3. We are running out of time. We will finish tomorrow. Sit straight. Open notebooks. Pass notebooks to the front.

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What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion?

During the post lesson discussion, a number of mathematical and pedagogical ideas were discussed:

1) Number choice, specifically the inclusion of (0, 0) in the table. Additionally, the choice to use 3 as the multiplier and 3 minutes created potential for confusion;

2) Clarification of appropriateness of goal in light of the 5th grade learning standard. The goal seemed to be more appropriate for the 6th grade standard;

3) The group wondered if there were ways in which the teacher could have further drawn out the voices of the other students;

4) How much data should be provided in the table as well as the number of spaces provided in the table;

5) The number of new elements that were introduced in one lesson;

6) The decision to make the goal to find volume at 36 minutes vs making the goal to find out when the pool will be full;

7) The choice of the scenario. Just stating that the pool would be considered a rectangular prism for this lesson probably did not provide enough clarification for students. The Knowledgeable Other pointed out that it is possible to have a swimming pool with a sloped bottom. It seemed that some students struggled with this scenario without any visual image of a pool or a video of a pool being filled;

8) In Japan, they utilize a scaling definition of proportional relationship for 5th grade so that they can connect to the multiplication work the students had previously completed. This impacts the mathematical representation that they use with 5th graders. The fact that they have selected this scaling definition makes the inclusion of (0, 0) inappropriate for 5th grade; and

9) The use of circle and square was an accessible way to introduce variables.

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

It was powerful to have administrators participating in every part of the lesson study process. The principal's commitment to being an instructional leader sets the stage for their staff to commit to the process of being lifelong learners and taking risks in front of their peers in teaching a lesson study lesson. The administrator invited the Knowledgeable Other to support the professional learning of all of the staff.

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The administrator also set the stage for the meeting to be conducted with the highest level of professionalism. Teachers all listened to one another, provided respectful insights about the lesson, and also treated students with respect in their discussions. The choice to participate in research as an elementary school elevates teaching as a profession.

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

- The choice to focus an entire lesson around one problem has a significant impact on the ability to develop concepts deeply and to take the time to listen to student ideas.

- Students were asked to speak and defend their reasoning which helped all of the students further develop their understandings. Because students regularly defend their reasoning, they are confident to present their ideas.

- The use of the notebook was a powerful tool for students to record their thinking. Students referenced previous learning in their notebooks.

- The organized board work provided a powerful learning tool for students. They were able to reference the questions and the important data throughout the lesson.

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Lesson Report

(Annotate with pictures, quotes, student work examples, board work etc.)

Report created by: Yekaterina Milvidskaia, Nancy Sirois, Kim Hollowell, Henk Logtenberg
Name of Lesson: Let's Think about the Division of Decimal Numbers (Tokyo Shoseki Textbook)
Grade 5, Basic Group C

Date of Lesson: June 20, 2019

What are the primary lesson goals?

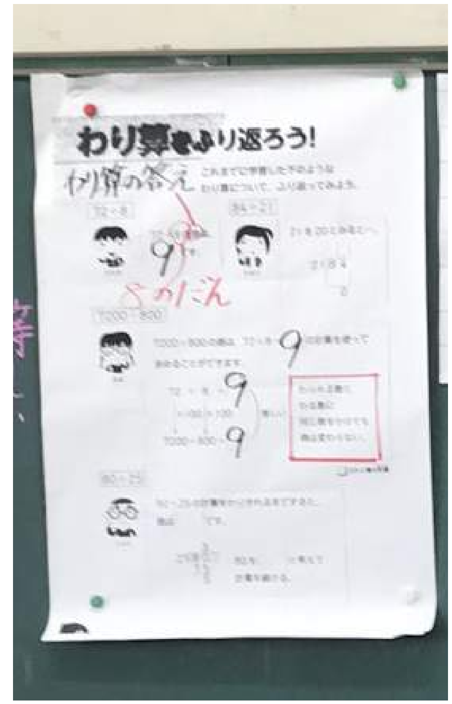
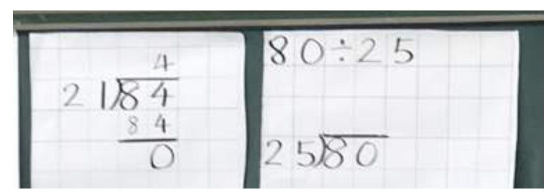
Students understand the meaning and method for division calculations in which the divisor is a decimal number.

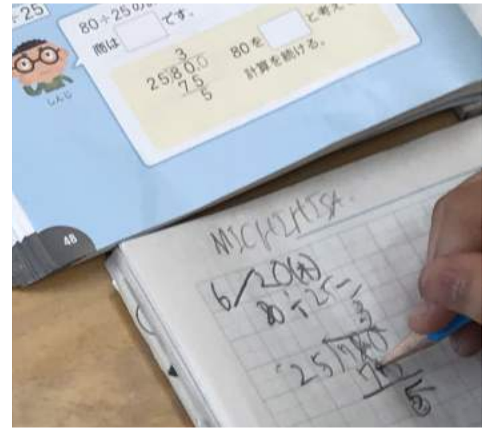
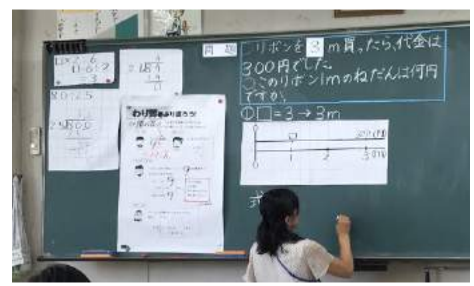
Interest, Motivation, and Disposition	Students use calculations of whole numbers and the base-ten numeration system as the basis for thinking about and generalizing division to calculations when the divisor is a decimal number.
Mathematical Reasoning	Students can apply number line representations and the properties of division to think about, explain, and summarize the meaning and method of division calculations in which the divisor is a decimal number.
Mathematical Reasoning Skills and Procedures	Students perform division calculations in which the divisor is a decimal number.
Knowledge and Understanding	Students understand the meaning and method of division calculations in which the divisor is a decimal number.

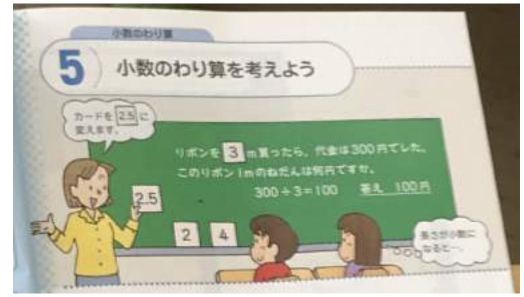
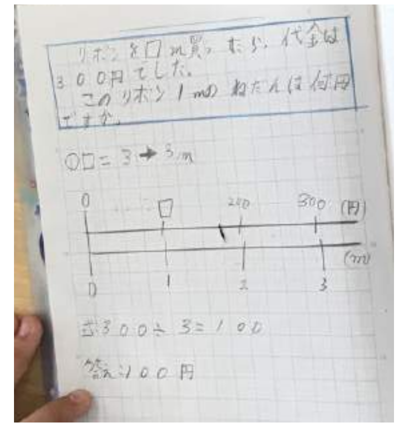
Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

Lesson 1 of 14 Lessons	Goals: • Understand the meaning of dividing by a decimal number and think about how to calculate whole number ÷ decimal number.	Learning Activities: • Establish a math sentence on their own. • Think and explain using number lines and word math sentences. • Think about how to calculate 300 ÷ 2.5.

Summary of Lesson
C Basic Class: 14 girls, 7 boys

Start & End Time	**Lesson Phase**	**Notes**	**Photos**
1:36	**Introduction, Posing Task** "Let's look back at what we have done before in grades 3 and 4. Let's look back at the different division we have done previously. What does the word quotient mean? Reviewed the terms: Sum Difference Product Quotient Had students read the problems: 72÷8 = 9 Modeled 84÷21 on graph paper using the algorithm	**Strategies to build interest and to connect to prior knowledge** Used a poster with different examples of division they have done in the past (grades 3 and 4). Had class read the problems together.	  At this point in the lesson only approximately 50% of students could solve these problems and get the correct

1:58 Done intro 2:00 Began Posing Task	72÷8 helps you solve 7200÷800 Asked 80÷25 □x2=6 - Can you guess what goes into this box? What calculations would you do to solve this problem? I know many of you know this but what would you have to do to solve this? The student answered 3 and she asked her what the calculation was to get there. "I bought __ meters of ribbon. The price was 300 yen. How much is the price of one meter of ribbon."	Teacher walked around to check notebooks. "I see some of you are not quite sure what do write in the box." She modeled the division problem: 6 ÷2 = 3 "You can do 6÷2 equals…." "What if we multiplied the dividend and the divisor by 10? 60÷20 "So what is the answer? What do you notice?" So use this to answer the 7200÷800. "If you solved it, circle it. If you were incorrect, mark it so you can go back to complete it." Student came up to solve 80÷25 on board with a decimal using the traditional algorithm. Students copied problem in their notebooks with a box around it. She had them read it aloud together. Teacher: "Now solve the problem. (wait time) If	answer. Many just copied from textbook.  

		you can’t solve it, why can’t you solve it?” Student: “We don’t know how many meters we bought?” She changed the amount to 3 meters. Brought out graph paper to draw a double number line to solve the problem. “We will draw this double line together but next time you will have to do it yourself so think about it as you draw.” Teacher: “What always goes here (beginning)?” Students: “Zero” Teacher: “What goes at the end? Please write it in yourself.” Top is cost bottom is meter. **Teacher:** Who can solve the problem? When only 2 students raised their hands to answer, “Only 2?” Who needs more time? Several hands went up so she gave them more time and they could work together to figure out the answer. After 2 minutes…”How about now?” More hands went up to answer the problem. “How many of you had 300 ÷ 3? (several hands went up) “When I was walking around I saw 3÷300. Which one is it?” - Student come up to explain:	  

<table>
<tr>
<td>2:18</td>
<td>□x3 = 300

□= 300÷3

= 100

Posed problem:

2.5 meters for 300 yen</td>
<td>“Since the problem is asking the price for 1 meter, I did 300 divided by 3 because we are finding the price for 1 meter.” Can someone else come up to explain?

“We studied a proportional relationship right? What do we see here? What do these arrows show?” image

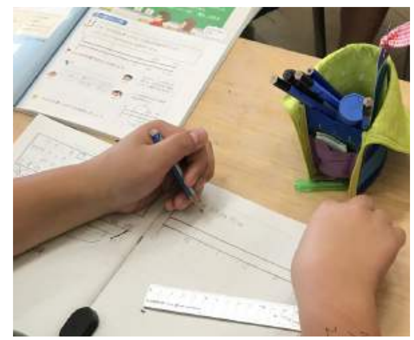
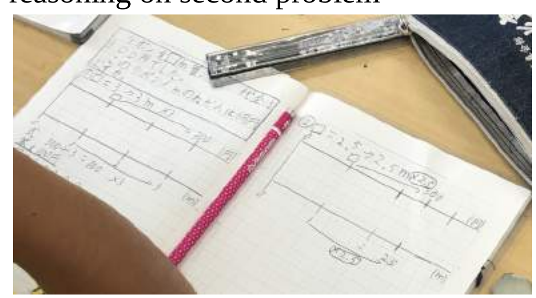
Are you sure you can answer this using division? So 300÷3=100

Used a meter stick to model 3 meters so students could visualize how much. “We can’t draw the actual size but if you can picture it in your head, it will help you.”

Modeled the length of 2.5 meters.

Asked for clarification of the problem then asked them to draw a double number line for this problem.

After 3 minutes she began drawing a double number line with no numbers. “We are close to the end of the period so I’m going to draw the number line. How many of you have a box above 1? How many have the correct labels? What</td>
<td>

⅓ of students do not write the number sentence but only write the double number line.
<hr>
Same student as above shows Additive reasoning on second problem
</td>
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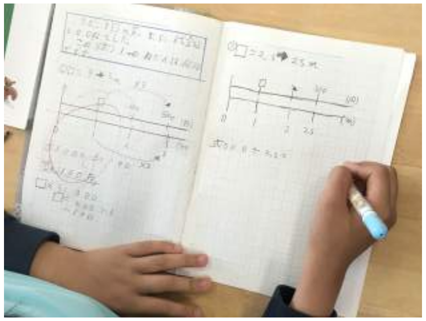
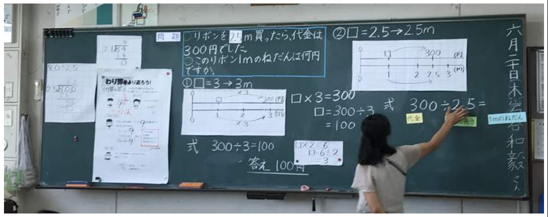
2:30 end		calculation will we need to do? Can you write down the math sentence? You don't have to solve it but can you write down the sentence?" You don't need to solve it. That is what we are doing next? She wrote down 300÷2.5. Who had this? "Tomorrow we will begin by checking if this math sentence is right and then we will try to solve it?" She labeled the problem on the board asking students what each number represented in the number sentence. Tomorrow we will see if this is a proportional relationship and will do the work of dividing with decimals.	Correctly shows x2.5 but does not write a number sentence.   300 ÷2.5=

			
	Independent Problem Solving This was an introductory lesson so the problem was introduced at the end and there was no independent problem solving other than the work described above.	**Individual, pairs, group, or combination of strategies** • **experience of diverse learners** • **teacher's activities**	
	Presentation of Students' Thinking, Class Discussion Modeled 84÷21 on graph paper - algorithm. Asked a student to come up to solve 84÷21 "I bought __ meters of ribbon. The price was 300 yen. How much is the price of one meter of	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses** **Teacher:** "Why did you think of 21 as 20? Why did that help?" **Student 1:** "It is easier to estimate the quotient." **Student 2:** "You can see there are four 20's in 84 so easier to estimate the quotient."	

	ribbon."	**Teacher:** Now solve the problem. (wait time) If you can't solve it, why can't you solve it? **Student:** We don't know how many meters we bought? After working on a double number line to solve the problem with 3 in the box. **Teacher:** Can someone come up to share the double number line? Can you explain? **Student:** We know that 3 meters is 300 yen so the problem is asking us to find the answer to how much is one meter of ribbon? **Teacher:** How many of you had 300 ÷ 3? (several hands went up) When I was walking around I saw 3÷300. Which one is it? **Student:** Since the problem is asking the price for 1 meter, I did 300 divided by 3 because we are finding the price for 1 meter."	
	Summary/Consolidation of Knowledge	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals**	

	The teacher had students record a possible equation for the situation and asked them to think about if it was truly the equation that modeled the situation for today. She didn't want them to calculate the expression but rather think if it modeled the situation.	On the blackboard she wrote the expression 300 divided by 2.5	

What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion?

During the discussion we mainly focused on the 3 separate classes at the school. We wondered about the impact on the students' mindsets and their identity as mathematical learners.

We are still wondering if the double number line is viewed by the students as an actual mathematical tool that helps them visualize division or is it the only strategy being expected at this time.

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

It was interesting for us to note that during our post discussion the administrator spoke more on behalf of the teachers, especially when speaking to the content. In our experience it would be rare for the admin to speak on behalf of the teachers and their instruction. We are wondering how much he is involved in the day to day planning process of mathematics instruction.

We appreciated the support and engagement on the part of the admin. We observed that he approached the teacher at the end of the lesson to discuss what we presume would be the next steps of teaching this lesson.

One of the struggles we face in the US is having admin understand the value of lesson study and to provide structural support to make lesson study a viable part of PD for teachers.

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

The board work was well thought out and showed the progression of learning throughout the lesson. The teacher had clearly anticipated scaffolds that might be needed by the students and had them ready just in case. The teacher was completely prepared - all materials were at her fingertips.

She adjusted the timing of the lesson based on student understanding and gave them extra time to work on the double number line. She walked around to monitor their progressions. She had students talk and share their thinking at one point during the lesson to check what number they had put into the double number line.

3rd Grade 6/21/19 Lesson Report

Report created by: Justin Stoddard, Denise Kleckner, Katerina Palomares, Maira Lopez
Name of Lesson: 3rd Grade Let's Think About Division (Division with Remainders)
Date of Lesson: June 21, 2019

What are the primary lesson goals?

Interest, Motivation, and Disposition	Using cases of division when there is no remainder (divisible division), students try to understand the meaning of and how to calculate division when there is a remainder (indivisible division), by connecting division to their understanding of multiplication and representing and modeling indivisible division with concrete objects.
Mathematical Reasoning	Students see that division with divisible cases and indivisible cases both represent unified division cases. They express the meaning of division and division calculations using concrete objects, diagrams, and math sentences.
Mathematical Reasoning Skills and Procedures	Students perform indivisible division calculations and find solutions that are quotients with remainders.
Knowledge and Understanding	Students know what remainders represent and understand the size relationships between remainders and divisors, as their understanding of division increases.

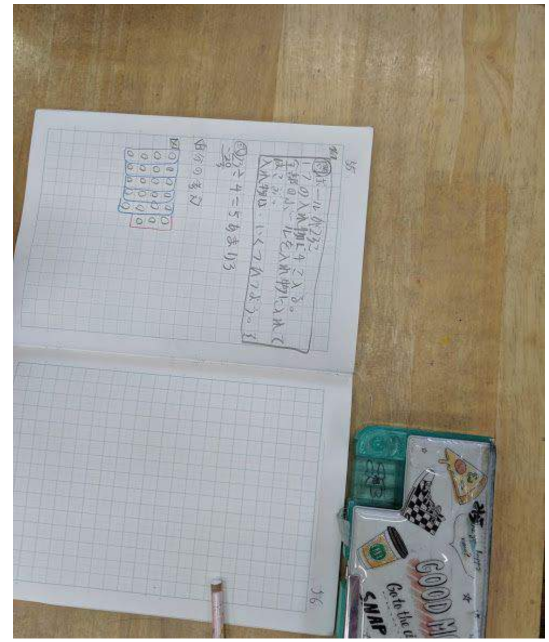
Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?

Lesson 7 of 10 Lessons	Goals: Students think about how to process remainders based on problem situations and be able to explain the process. (Problem situation: quotient plus 1).	Learning Activities: Students grasp the problem situation, establish a math sentence, 23 ÷ 4. • The calculation shows the quotient is 5 and remainder is 3. Students discuss if the answer should be 5 or not. • Students summarize why the answer will be the quotient plus 1.

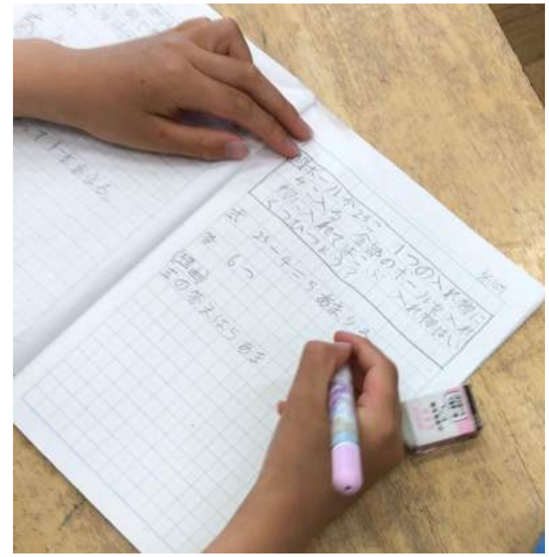
Summary of Lesson

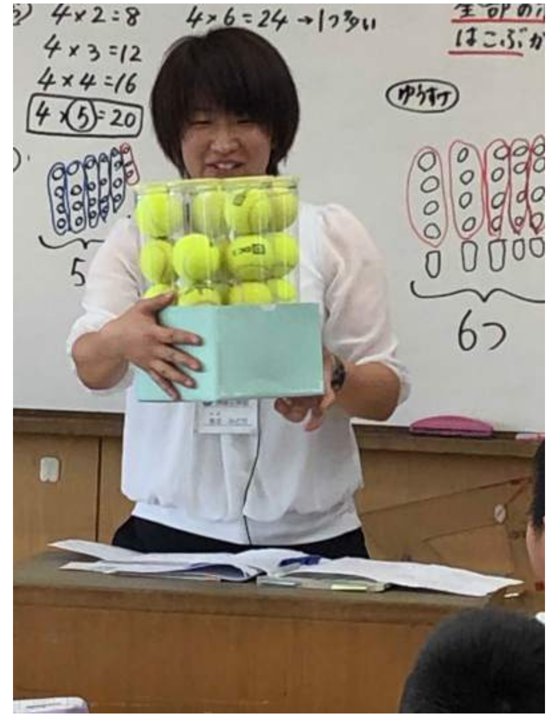
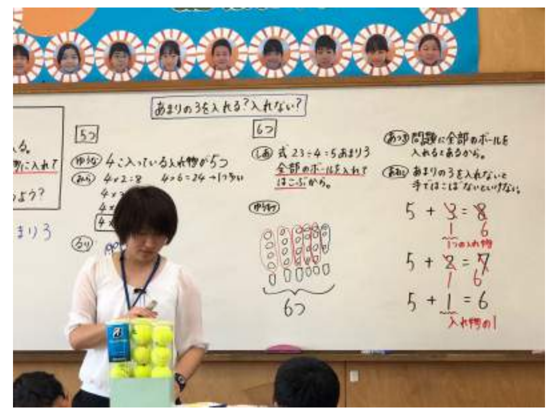
Start & End Time	Lesson Phase	Notes	Photos

1:55	**Introduction, Posing Task** 1. Grasp Today's task. ○1 Grasp the problem situation ○2 Think about the math sentence 23 ÷ 4 ○ 3 Grasp Today's task	**Strategies to build interest and to connect to prior knowledge** Teacher showed them the tennis balls overflowing out of a box which ignited their excitement and helped set the context of the problem to be solved. **T-** How can I bring these to another location in a better way? **S1:** Maybe another box. **S2-**Maybe we can make a container to hold 3. (T goes to grab the tennis ball container out of cabinet that was hiding and the students were very interested.) **T**-What is this? I want you to think about what you have already been learning. **T-** Have you noticed something related to it before? How many do you think fit in? We want to think about how many containers we need. (T has class chorally count as they fit 4 balls into the container and chorally counts that there are 23 tennis balls.) **T-** Do you think you are ready to solve the problem? Ok, let's make the problem. **<Problem> There are 23 balls. One can fit 4 balls. To put all of the balls into containers, how many containers do we need?**	

		T- Do you think you can write the number sentence for this one? **S**-Yes! Students generate the equation: 23 ÷ 4	
2:03	**Independent Problem Solving** Think: 2. Write your own idea in notebook. A: 23 ÷ 4 = 5 R3 Answer: We need 5 containers and 3 balls are left The answer to the calculation is 5 R3, so we need 5 containers and 3 balls will be left. B: 23 ÷ 4 = 5 R3 Answer: 5 containers The 3 balls left over cannot be in the container, so the answer is 5 containers. C: 23 ÷ 4 = 5 R3 Answer: 6 containers We need to put the 3 balls in a container also. So, we need one more container. The answer is 6 containers. (If we show it with a diagram) Some students checked their answers with the equation with 4x5+3=23 20+3=23	**Individual, pairs, group, or combination of strategies** • **experience of diverse learners** • **teacher's activities** **T-** Now that we know our equation, please solve. Students begin to work independently to solve the problem. **S-** If we know how, do we need to explain it? **T-** Yes, if you are able, please explain how and why you solved it the way you did. **The teacher reminded the students that the question is how many containers you need, so make sure that your answer explains this, how many containers you need.	

			
2:10	**Presentation of Students' Thinking, Class Discussion** 3. Discuss the solution (whole class). ○1 Explain your solution. A: The answer to the calculation is "5 R3," so we need 5 containers and 3 balls are left. There are only 3 balls left, so we can't put them in the container. I think we need only 5 containers. We don't need to think about the remainder. B: 5 containers and 3	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses** **Teacher:** What calculation should we see? **Student 1:** 23 ÷ 4 = 5 R3 Answer: We need 5 containers. **T-** How many of you have 5? (11 people raised their hands) **Student 2:** I think 6. **T-** How many of you have 6? (10 people raised their hands)	

	balls left, so 5 containers. C: We need to put the 3 balls in a container, so we need 6 containers. We need to put all the balls in the containers, so we need to put the 3 balls in a container. We need 5 containers to put all the balls away. If we draw a diagram, we can see that we need another container. If we write it in a math sentence, 5 + 1 = 6. ○2 Compare each solution and relate the solutions to each other: There are answers that show the remainder and add one more container to include the remainder. There is an answer that does not think about the remainder. If we don't use another container, we need to carry the 3 balls by themselves. The problem says, "all the balls in the containers," so we need to put the three balls in a container also. 6 of the 6 containers means 5 + 1. ○3 Summarize the discussion I thought I needed to find the remainder at first, but I understand that I need one more	T writes tally vote of how many had the answer 5 and how many had the answer 6. **(S1(Yuri) came up to the board to display her strategy.)** Student drew 5 groups of 4 in an array with each group circled in blue and circled a group of 3 in red. **T -** asked "How many of you did the same kind of drawing? Then she asked the meaning of each blue group of 4 and the meaning of the group of 3. **(S2 (Yuna) came up to the board to show their solution.)** S- I used multiplication to solve. Student wrote the multiplication facts for 4x2 through 4x6, then said "So 24 is 1 more than 23 so 4x5 is the best one. T-Which one is showing that there's 5 containers. T- asks the class, "So what do you think?" (Some students have the same idea.	 

	container to carry all the balls. I thought I didn’t need to think about the remainder, but now I understand that I need to add one more container. ○4 Think about if the remainder is 1 or 2 (instead of 3) We need to use another container to put in the remaining balls, even when there are only 1 or 2 balls.	Ss replied to teacher questioning about the meaning for the multiplication equations that the 4x5 is representing the containers. **Student 3 (Shia) comes up to the board to show her work.** 23 ÷ 4 = 5 R3 But we have to put all the balls into a container to carry them. **T-** Why do you say that? **S3-** Because it is mentioned in the problem.	
	Summary/Consolidation of Knowledge Summarize how to process quotient and remainder If we have 3 or 2 left, we need another container. Even if there are only 2 or 1 left, there are cases when we will need to add 1 to the quotient.	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals** **T:** So what did we do about the remainder? Do we need to put the reminder in a container? **S:** If you have a remainder you still need to put it into a container.	

T: What if the reminder was 2 or 1?

Teacher extends students' understanding of how to handle the remainder by giving them 2 different situations where would have to add 1 to the answer. She kept asking students to label to units to ensure that they turned the balls (remainder) into containers.

S:

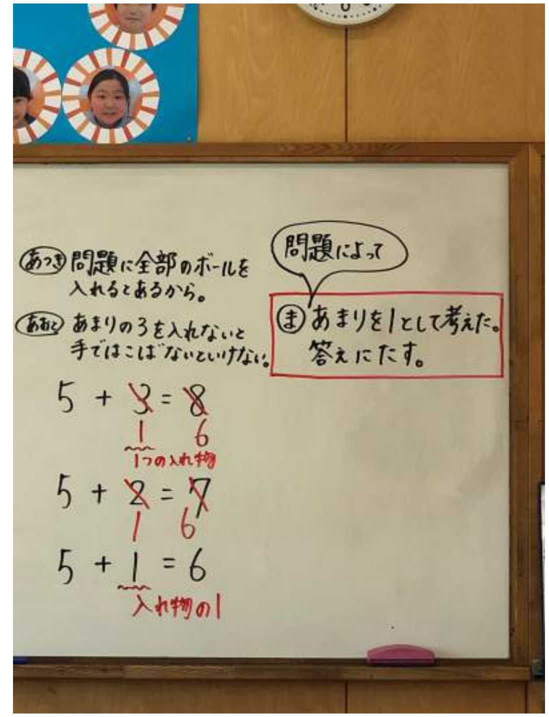
T: when there is a remainder, you might have to add 1 to the answer.

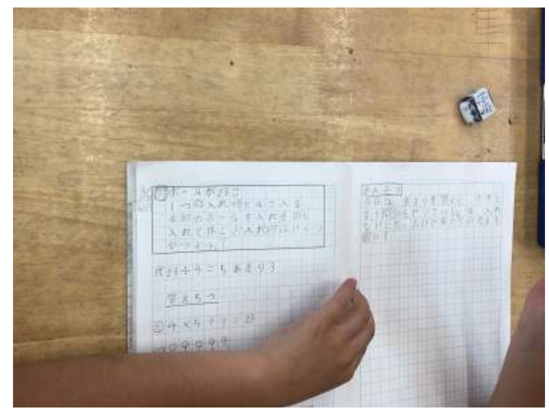
Teacher writes summary on the board and boxes it. Students copy summary into their notebooks.

T asked students to write their own reflection or what they learned from a friend.

S: Finally saw that 6 is the answer. We need 6 containers.

S: Because I didn't read the problem carefully, I made a mistake. After listening to others, I learned.





What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion?

Appreciated Professor Kasai for pointing out the Yamanashi handout with the list of 8 bullet points or reminders of key components to keep in mind in preparation for the facilitation of a lesson. There is a constant reminder of the importance of the students' voices to be heard by the teacher AND their peers. Additionally, the teacher's (and the team's) preparation of the types of facilitative questions to engage students in interactive learning is a key reflection of the teacher moves to demonstrate.

One thing that stood out for me was the way that the teacher didn't rush through the problem and discussion of boardwork to get through all components of the TTP lesson, instead she was very responsive to the needs of the students so they could make sense of each others' thinking and grasp the problem. In addition, I really appreciate how the teacher had established the context for the problem in a very engaging way and invited the students to collectively co-create the problem to be solved. When asked by the principal why she didn't explicitly give the goal for the lesson at the beginning, she explained that she held that back in order for the students to have a greater opportunity to grapple with the problem in order to discover what to do with the remainder. This reminded me of the importance of being mindful of setting the context and not giving too much support during a TTP problem in order for students to engage in productive struggle in a way that enables them to deepen their understanding of the math involved in the problem.

I learned how important the launch of a problem is to lend to students being able to problem solve and not just calculate. The context has to provide a need for students to problem solve. I valued that she didn't just give them a picture but she also used tangible objects to manipulate so that the students interest was sparked. Also, during the discussion someone asked , "What teacher moves helped change students thinking?" which really helped me reflect on how I am capturing the ways students are changing their thinking during the class discussion and if I'm asking the right kinds of questions to promote the conversation amongst students so that they debate their ideas and try to persuade one another.

What new insights did you gain about how administrators can support teachers to do lesson study?
Administrators can support teachers by taking the time to sit in with the presenting team during their planning sessions so that the administrator is able to have the perspective of the team's wonderings or ideas of the anticipated student interactions or responses. Administrators can additionally support by knowing the students' academic strengths & needs prior, so that the administrators can also provide thoughtful feedback for the team or teacher presenting the lesson.

Administrators can also research and connect with internal district resources (i.e. district math department) to additionally invite as guests, expert commentators or additional coaching support. This could also lead to finding any additional written resources (books, articles) that could help support teachers' understanding of lesson study or their research lesson planning.

I really appreciated how involved the principal and other administrators have been in the post lesson discussions. The administrators seem to have a solid understanding of the math being taught, what is happening in the classroom, and what the gaps and struggles of the students are. Therefore, like stated above administrators can be more involved with the full planning process of a lesson study team. Each team could have an admin assigned to them as an objective part of their team so they can offer constructive criticism as the team goes through the planning process.

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

The lesson provided us the opportunity to see the benefit of establishing the context for a problem directly connected to a real world issue and giving the students an opportunity to create a problem to solve based on that context. In addition, she made sure to come back to the context regularly throughout the discussion and made that come to life even more when she had the students collectively put the balls into the cannisters and back into the original box to demonstrate the ease of carrying all of those tennis balls. I also agreed with the comment during the post-lesson discussion where someone mentioned that it would have been more helpful if the teacher had labeled the 5 or 6 containers so that the students could explicitly understand the meaning behind the numbers. The teacher's use of a tally vote to create an exciting amount of tension in the class propelled them to want to make sense of the problem and which answer made the most sense as it relates to the original question/problem. However, as the expert commentator mentioned, it would have been helpful to revisit that tally vote and do an additional one after the lesson to see how many students changed their thinking as a result of the discussion of the boardwork.The design of this lesson was well thought out because it caused the students to grapple with whether the calculation answers the question or not. Finally, our expert commentator also mentioned the importance of going through a mock version of the lesson with the planning team in order to determine where students might get stuck and fully flush out all potential anticipated student responses in order for the teachers on the planning team to think about advantageous strategic questioning in order to help guide the direction of the conversation.

The context also made it necessary to deal with the remainder in a meaningful way so that the goal of the lesson stayed in tact so once they calculated the problem they were still left with the question of what to do with the remainder.

Notes:

Lesson Report

(Annotate with pictures, quotes, student work examples, board work etc.)

Report created by: Elisa Szeto, Maiya Coilton, Malia Vitousek, Francisco, Jacqueline Smith
Name of Lesson: What is Left and What is the Difference?
Date of Lesson: June 22, 2019

Goals of the Unit:

- Students recognize and know the problem situations that use subtraction, such as take from, take apart, and compare; and students understand the meaning of subtraction. (knowledge and skill)
- Students are able to perform subtraction with minuends up to and including 10. (knowledge and skill) Students recognize that the ideas underlying take from, take apart, and compare situations are all connected as kinds of subtraction. (thinking, justification, expression, etc.)
- Students are able to think about how to calculate subtraction with minuends up to and including 10 by paying attention to the structure (composition & decomposition) of the 1- digit number and are able to manipulate concrete materials to represent and express the calculation process. (thinking, justification, expression, etc.)
- Students are able to identify the take from, take apart, and compare problem situations in daily life phenomena. They understand the merit of expressing these situations using math sentences and are eager to recognize and use subtraction in daily life. (attitude for learning, human nature, etc.)

Primary Lesson Goals:

The primary goal of this lesson is to help students understand that subtraction can be used in solving compare situations problems. Students are recognizing how to represent and express in a math sentence a compare problem situation. The lesson is using a problem situation in a context that is familiar to students. The lesson intends to develop a conceptual understanding of the meaning of operations. Students are using manipulatives, diagrams, and pictures to work independently first and then engage in a whole class discussion to learn that compare problems can be solved using subtraction. The engaged discussion is helping students expressing their mathematical reasoning logically presented.

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

In Lesson 6 from the current subtraction unit, students start with recognizing the difference between take from/take apart situations, which students learned previously, and compare problem situations. The subtraction the students learned prior to this lesson pertained to the problem situation that deals with one (whole) set that is split into two subsets (parts), and subtraction is used to solve and find one of the subsets. However, in this compare lesson, the problem involves two distinct sets and students need to find the difference between the two sets. In the previous lessons, it was easier for students to identify "what is left" when they manipulated concrete materials. The big difference for students in today's subtraction situation is that they will need to think about the number of objects that cannot be aligned to make a one-to-one correspondence when objects in the two sets are compared. In a compare situation, manipulation of concrete objects is different from the take from and take apart situations; however, I would like to help students understand that - even though the problem is a compare situation - they can use the subtraction operation just as they used subtraction for take from and take apart situations.

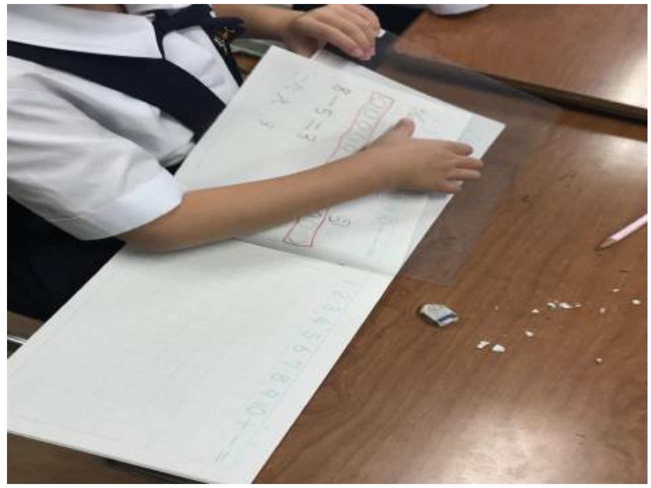
Summary of Lesson

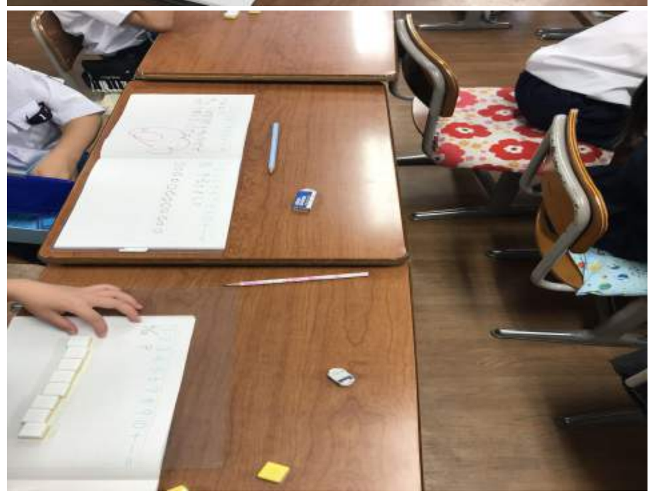
Start & End Time	**Lesson Phase**	**Notes**

7	Deepen understanding of the meaning of the *compare* subtraction situation by solving word problems.	• From word problems and pictures of situations, think about how to answer questions, such as "Which one has more, how many more?" and "What is the difference between ○ and △?" • Confirm the problem situation is a *compare* situation using manipulation of concrete materials or diagrams and expressing the situation in a math sentence.		☒ Identify the problem situation from the written problem as *compare* situation, represent the situation with math sentence, and be able to solve the problem.

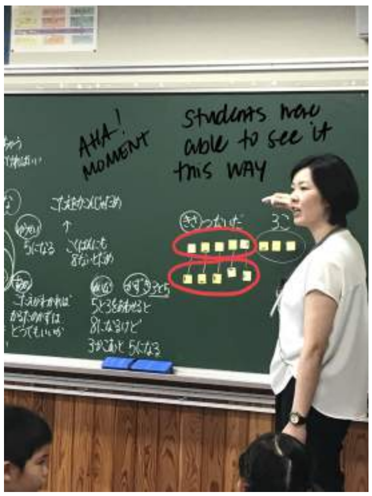
8:50- 9:06	**Introduction, Posing Task** Teachers played karuta, a Japanese card game. Mr. Noboyuki took 8 cards. Mr. Yunikaro took 5 cards. How many more cards did Mr. Noboyuki get than Mr. Yunikaro?  	**Strategies to build interest and to connect to prior knowledge** Teacher begins lesson with a song and finger game (helps to activate brain)- kids are super engaged, children who are focused are more successful. This game helps students engage with each other and begin getting their brains ready to focus and get started. Teacher introduces a card game that the kids know from Japanese language class. Teacher has photos of card game and of two teachers who won cards. The students count how many each has, and notice right away that the second teacher has fewer cards. Students are enthusiastic and the pictures help engage the students, as well as the well-liked game. Throughout the lesson, the teacher uses guiding questions such as “So what does that mean?”, “Can you show me?”, “I don’t know, can you explain?”, “So what do we do?”. She is engaging the students and encouraging them to speak to each other during the whole class discussion. When a student realizes the numbers are a comparison, the teacher encourages the students to explore further, and recommends they reflect back on what they have learned in past lessons. **T:** “So when we look for something more, what do we do? Who remembers from what we’ve learned before?” **S:** “We connect” **T:** “What do we connect?” **S1:** “We connects the blocks and then see what’s left!” **S2:** “If you connect the 5 and 5, we can understand that 3 is not connected.” **S3:** “The part that’s not connected is the answer!” This opportunity created a dialogue and connection between the students and their thoughts.

		Students are engaged and excited to learn and the teacher is inviting in guiding this debate and discovery. The teacher called on many students and recorded their voices on the blackboard. She did a great job at constructing the lesson based on students' voices.
9:06- 9:10	**Independent Problem Solving**	Individual, pairs, group, or combination of strategies ● experience of diverse learners ● teacher's activities "Let's think about how many more" What do we use? (students said the different tools they could use) SS: blocks, marks, dashes, fingers, drawings Students worked independently, Teachers stood at the front of the classroom while students were working independently Most students used blocks, observed a few students making drawings Some students set the problem up where you could see the difference clearly. Others just put out 8 blocks in a straight line. Some drew pictures of 8 circles in a straight line. Some students didn't get started.





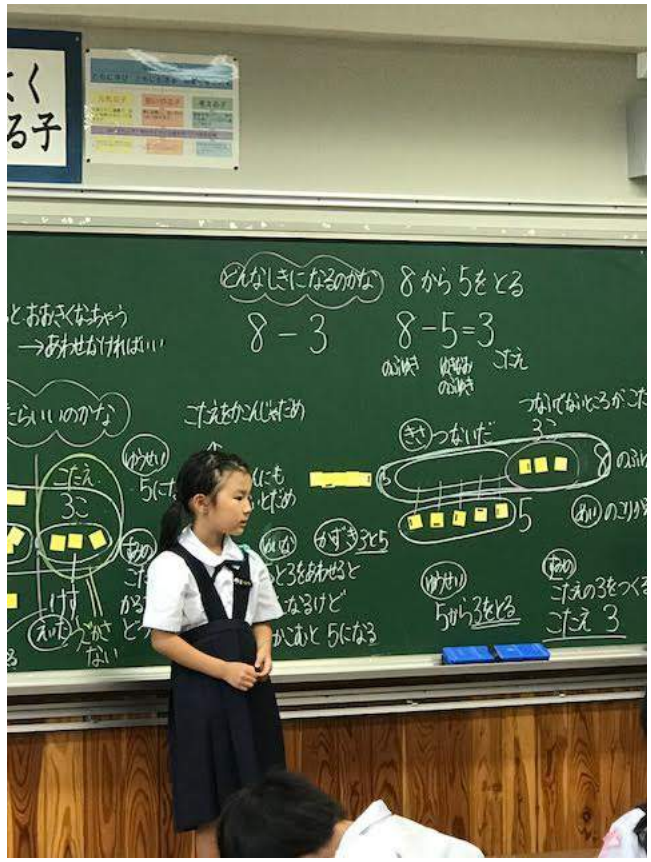
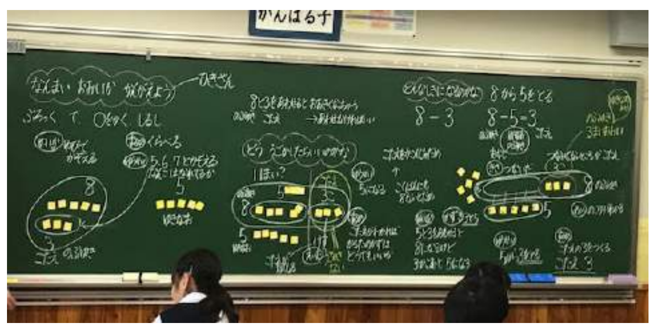
		 
9:10- 9:44	**Presentation of Students' Thinking, Class Discussion** 	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses** **Student 1:** **S1 used two sets of cubes. She took 8 cubes from one set and 5 cubes from the other set. She lined up the two sets of cubes horizontally, one stacked upon the other. She counted all blocks. Then counted the 3 three blocks that consist of the difference.**



Student 2: A students stand up by his desk as says "if you count 5,6,7,8 and I found the distance in between those numbers. The teacher then says "I don't know can you up and explain" "If you count you'll be able to find…… Then the student says "you'll be able to find how many numbers in between" Then another student stands up and says "I show 6,7,8 with my fingers (holding up 3 to

		show the difference) **Student 3:** Student 3 takes out a set of blocks and counts 5 blocks and then 3 blocks. He then takes out another set of blocks and takes out 5 more blocks. He stacks the blocks on top of one another using one-to-to correspondence by counting them and sees the difference of 3.  
	 	**Student 4:** This student suggests to splits the 8 blocks that represent Mr. Noboyuki's cards in 5 and 3; then it can be compared with the 5 blocks that represent Mr. Yumiko's, cards. other student suggests drawing a vertical line to see clearly that 5 is a common number in both sets of cards and 3 is the difference.

		**Student 5** This student shows on the board that using previous practiced one to one correspondence, she can connect with a line 5 blocks on the top row with 5 blocks on the second row. “If you do the connecting; the connected part is the same; 3 are not connected. The not connected part is the answer.”
9:44- 9:51	**Summary/Consolidation of Knowledge** 	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals** Teacher asked many questions to guide understanding after presenting multiple student strategies. While sharing student ideas, the teacher encouraged students to refer back to the problem by asking: “what is the 8?”, “what is the 5?”. After presenting all student ideas, the teacher asked, “What is important?” “What are we thinking about today?” “What is the answer today?” Teacher wrote on the board: “Mr. Noboyuki had 3 more cards.” Then asked did he have 3 cards? This question encouraged students to contemplate the difference, rather than just the number of cards. She then asked “What equation should we write?” One student was able to shout out, “subtraction.” Teacher wrote on the board 8-3. Then she wrote 8-5 =3 labeling 8, Mr. Noboyuki’s cards; 5, Mr. Yumikos’ card removing the 5 blocks; the answer 3. Finally, the teacher said, “we are still confused and we will think more about this tomorrow.

		  During her final moves teacher removed the 5 blocks from the one to one correspondence set by the student; it might be confusing to students since the objective of the lesson was not to solve a simple take away subtraction problem; but understanding that a compare problem can be solved by using subtraction.

What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion?

- Students cannot understand without teacher questions. Teachers need to be prepared and focused in order to prompt learning. Teachers need to think about how the students think and how they can connect with each other. When creating a lesson, teachers need to focus and plan independently during lesson, and they need to be walking around and seeing students in order to continue the lesson. It is also extremely vital to pay attention to the students who are **not** listening.

- During the lesson debrief, the knowledgeable other discussed how students gradually move from representation through concrete materials (like blocks or counters), to more abstract representations (like drawing circles). It is important to pay attention to the “phases of change” and facilitate students development of mathematical understanding by strategically supporting the transition to more abstract representations. It is critically important, however, to acknowledge and honor that not all students will make that transition at the same speed.
- The post lesson discussion highlighted several important key points/takeaways that I will be sure to keep in mind while planning, doing and reflecting on math lessons. The commentator said “In the lesson plan be sure to note what you want the class to discuss during the neriage. This stood out to me because as I have sat on 2 different lesson study teams I realize how important planning the discussion portion can be in helping students have an aha moment. It’s a great way to make sure the lesson will benefit those who have yet to see and understand the new learning. This involves teachers carefully observing and taking good notes and then analyzing them to see which students will be important key players in the discussion.

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

- Administrators can support teachers by facilitating opportunities to observe and engage in public lessons at individual school sites and beyond. At this lesson, there were observers from schools across the district. That opportunity to learn from other professionals, is incredibly valuable. Administrators can be a part of lesson study teams to help construct and plan lessons. They can also serve as host for the visitor and inform the visitors about our school and what we’ve been working on as a school site (mission statement, population/demographics info, go over the goals of the lesson etc). Provide teachers with time outside and during the school day to collaborate with other team members.

- Administrators can help cultivate a positive and effective work environment where teachers feel safe to make mistakes, take risks and ask for help. By creating a safe work environment where teachers feel respected in their roles, it will help contribute not only to their improvement, but allow a positive and safe work environment for everyone to be a part of lesson study. Lesson study allows teachers to develop their profession and create lessons and part of the process is being open to receive feedback, making mistakes and validating teacher uncertainty. Just as teachers have to be role models for students, administrators can model the kinds of behavior that create positive relationships amongst the staff.

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

- It was evident throughout the lesson that the teacher created much of the discussion so that students' voices were heard and recorded. It is really important to help students come up with a conflict as this adds to students' questions. In this lesson students needed more opportunity to debate and discuss. Students were talking, but it was unsure if their debates were enough to resolve and satisfy any conflict. The teacher, however, consistently utilized a myriad of guiding questions to help engage the students and encourage them to participate in whole-group discussion and truly delve into the problem.
- This teacher did a great job at not telling students how to solve the problem. She acted as the slowest student at times throughout the lesson, telling students "I couldn't understand can someone explain what he said to me? What number sentence should we make? She encouraged her students to be independent problem solvers and help facilitate a discussion that helped uncover a very difficult task. I feel as though high impact practices involve making sure all students are engaged and if students are not as a teacher it's our responsibility to get them back on track by involving them in the lesson in some way.
- It's critical for not just teachers to give knowledge to students, but giving students opportunities to build their own knowledge. By giving students opportunities to explore using pictures, diagrams or blocks, you're giving them experiences to build an understanding of the mathematical content. If students are not able to experience something, they may not be able to understand the concept or skill. The teacher in the lesson gave students independent time to think about how to solve the problem with a plethora of strategies e.g., blocks, picture, diagram, draw lines for one-to-one correspondence, etc before comparing and having a discussion as a whole class. It's helpful to observe how students interact with a task before coming together and discussing students' work which is evident from this lesson where the teacher provided students to build their own knowledge using prior learning that was taught. Students may show different strategies during the independent time so it's helpful for the teacher to give students ample time to build their own knowledge as independent problem solvers.

Lesson Report

Report created by: Berenice Heinlein, Anthea Oppong-Kwarteng , Christina Isles, and
Name of Lesson: Let's Think About Ways to Express the Size of Angles
Date of Lesson: 6/22/2019

What are the primary lesson goals?
As outlined by the lesson plan there are two main goals of the lesson.

1. Students can make a variety of angles by thinking about different ways of putting together the angles of set squares.
2. Students interpret how angles were created by putting together the angles of set squares.

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

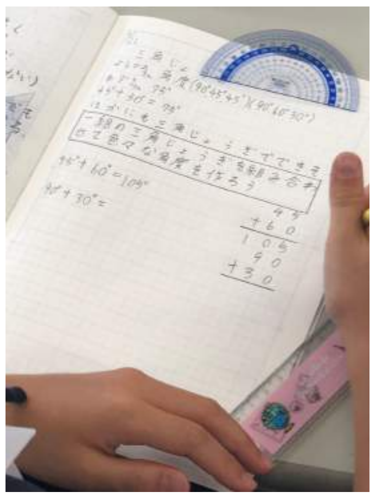
This is the 8th lesson and is the second to last lesson of the unit. The next lesson goal is to "verify the mastery of unit contents and consolidate [student] understanding". Since the next lesson's learning task is planned as a series of application problems, this lesson is the last problem solving lesson of the unit.

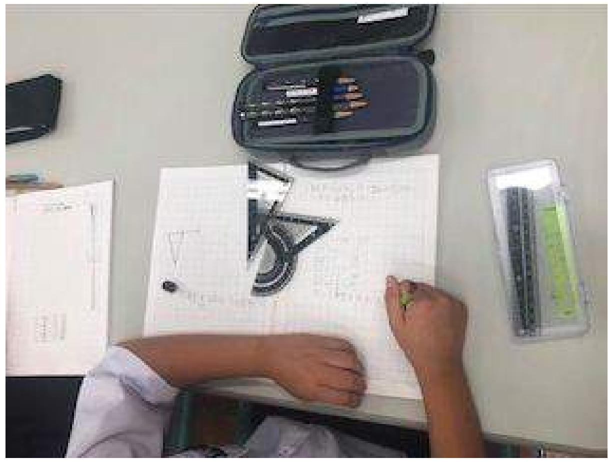
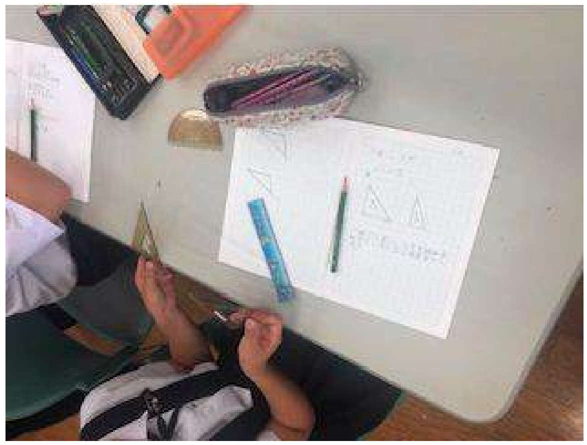
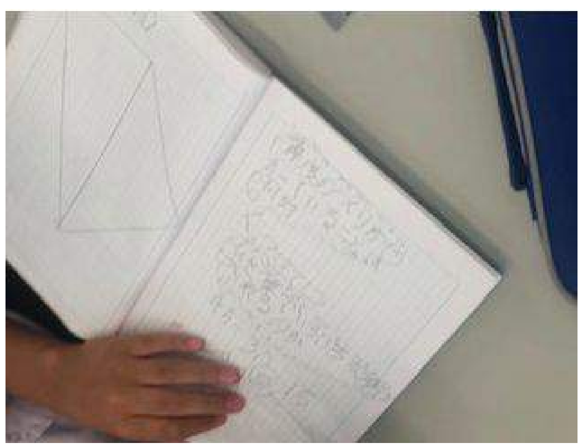
Within this unit, students have learned about diverse angles using rays by extending understanding to see angles represented as the amount and measurement of openings created by turns. They also learned to measure angles by utilizing a protractor with the unit "degree". By lesson 5 students are familiar with angles under 180°. Students then learn about angles greater than 180°. In the lesson prior to this one, students were expected to measure or draw angles to 360°. Set squares are used throughout the unit, therefore students are familiar with angles and the use of set squares prior to this lesson.

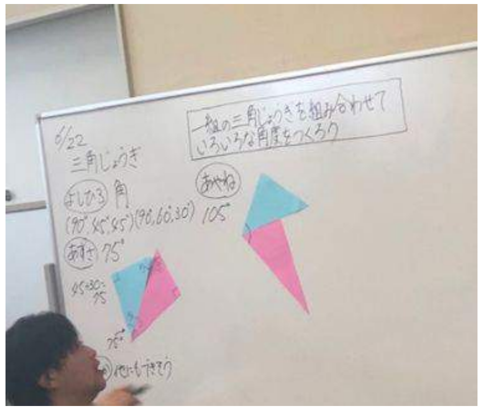
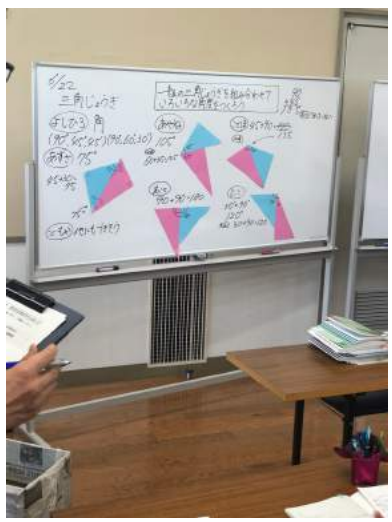
Summary of Lesson

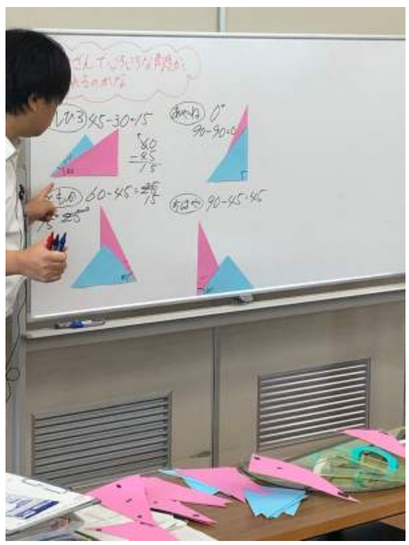
10:00 10:53	**Lesson Phase**	**Notes**
10:00 - 10:07	**Introduction, Posing Task** -Review of set squares -Setting the task	**Strategies to build interest and to connect to prior knowledge** **Introduction** T: What do you use set squares for? S: Angles with 30, 45, 65, 90, degrees T: These are the angles. Can we make more angles? S: You can put them together. T: Can you show us. S: 30 + 45 = 75 S: We can make others too.

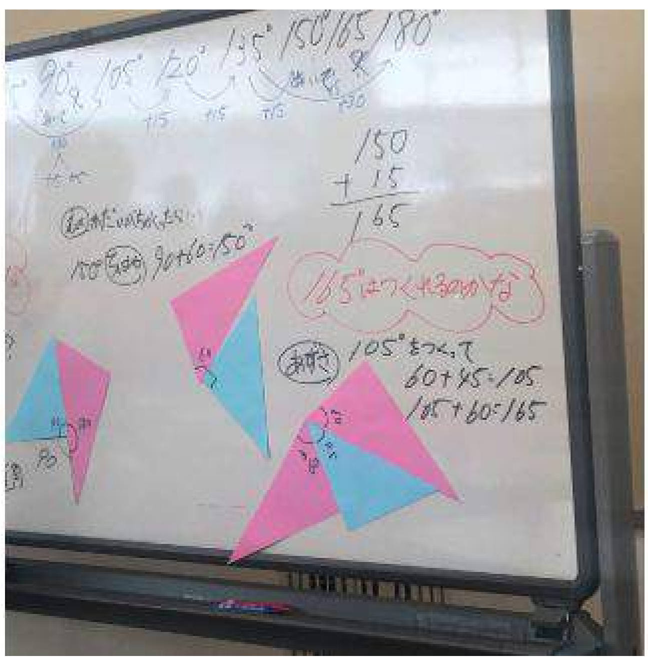
		Posing the Task T: Let's make different angles pairing set squares. You can draw pictures and write an addition sentence. [Anecdotal Notes: Students in the center were engaged and eager to try, students on the left and right sections were not trying to solve.]
10:07 - 10:10	**Independent Problem Solving** -Make angles by putting together the angles from a pair of set squares *There were 3 minutes of exclusive independent work time. At 10:10, T: It is time. Students asked for more time. T:I know you want more time, but let's share what we have. Many students did not have more than one idea at this time. *Nonetheless, many students	**Individual, pairs, group, or combination of strategies** *Students used setsquares, some correctly, and some attempted to use the center triangles of the set squares. *Some students utilized partners to express work and to correct one another in the use of set squares. *Some students used addition statements as a supplement, and others exclusively utilized math sentences. *Students work individually with the option to work with classmates. **During work time teacher clarifies by stating:** "By one pair, I mean two differnt shapes. It can be any shape, not just these two", in reference to the several set squares that students have. **Here is the layout of student work at the time discussion began:** **Left side: 9 Students 4 Boys, 5 Girls** Front row students, a boy and a girl, were both unsure how to use the tool. They were writing down what the teacher said and waiting for their peers to answer the questions for them. The girl attempted to use the protractor but was unsure how to use the math tool. 

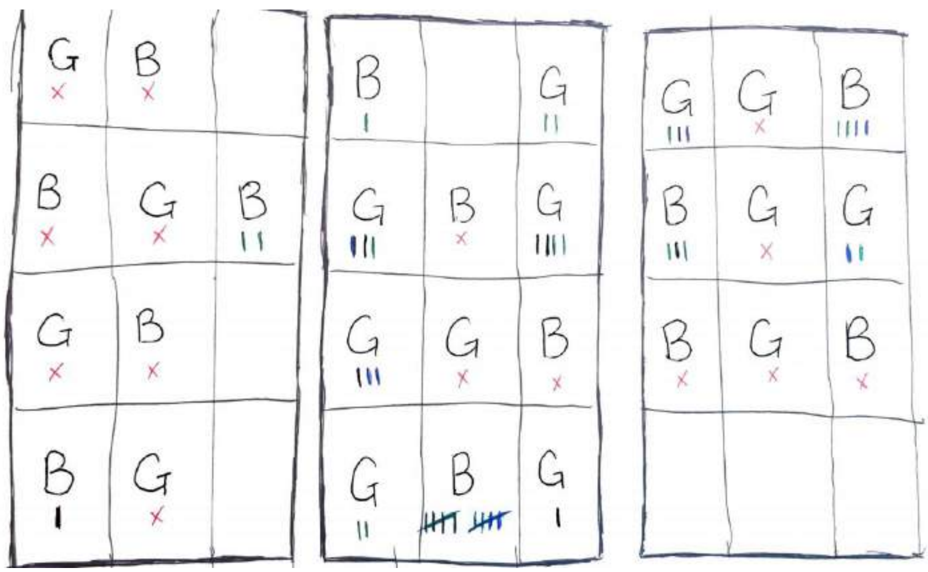
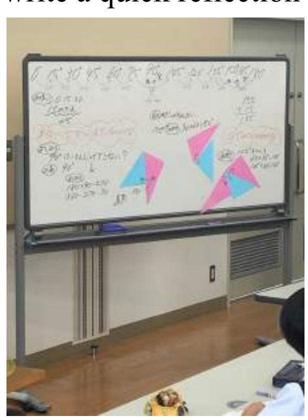
	continued working independently throughout the lesson. *Left and right is defined by what observers were seeing, facing the teacher.	One boy, who was the first that I saw on the time that I was on, was the first student that I saw us were using the set triangles correctly and was making the made a 45* + 30= 75* Another boy on the left side did not understand the task, and was drawing 2 triangles, not together and not a pair of triangles. **Center: 11 students, 4 Boys, 7 Girls** Of the 11 students, 2 had two examples, 5 had one example, and the rest were still grappling with the problem.  **Right Side: 9 students - 5 girls, 4 boys,** One boy was incorrectly 90+90=180 correctly using the inside of his set squares and writing math sentences. One girl had used the set squares to draw one pair of set squares, but did not manage to write the math sentence. One boy at the front only wrote the number sentences but could not draw the angles.

		  This student was confused about how to use set squares, she later received clarification from her partner. 

10:10 - 10:52	**Presentation of Students' Thinking, Class Discussion** -Board work models students set squares with blue and pink paper cut like the set squares placed with magnets. When students showed work, students commented on the accuracy of calculations. Many times, a different student explained the thoughts of the student who showed the work. We identify this discussion as having 3distinct "phases" as seen though board work and focus of discussion. 1. Addition 2.Subtraction 3.Patterns	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses** **(Phase 1: 10:10)** **Student 1:** 60+45=105  **Student 2:** 90+90=120 **Student 3:** 45+90=135 **Student 4:** 30+90=120  **Teacher:** "What is similar about the angles, or the way they were made? What do you notice?" S: All use these angles. S: All are put together to make and measure one angle. S: We put them together. T: All use addition. Anything else? S: What do you mean?

	*The question on subtraction is a deviation from the plan, which would have asked “Can it [the angle] be less than 75 degrees?”	**(Phase 2: 10:25)** **Teacher:** “Can you subtract?” “Can we make angles by subtracting?” (9 Students raised their hands and said yes. Other 22 students did not answer.) **Student 5:** Yes, 45-30=15 **Teacher** “What do you mean? Where are those angles?” **Student 5:** “ The part in between(the overlap) is 15” **Student 6:** 90-45=45 **Student 7:** 90 - 30=60 **Student 8:** 90-60=30 
	This phase addresses the increasing pattern going by multiples of 15. It also tackles: -Using inverse angles. -Using 3 set squares	**(Phase 3 10:37) Teacher:** “What angle measurements did we make? Put it in order.” **Many students:** 60, 75, ____, 105, 120, 135, ___, ____, 180 **Teacher:** What do you notice? **Student 9:** There are missing spaces. **Student 10:**They are multiples of 15. **Teacher:** “What is happening?” **Student 11:**The way the teacher puts it on the board gives a hint. **Student 12:**You are adding 15 each time. **Student 13:** I see blank spaces too. Are these angles really increasing by 15?

		Student 14: There is a 0 or 5 in the ones place value column. **Teacher:** “What do you notice about the missing numbers?” **Student 15:** Its 30, we can split it 15 and 15. **Teacher:** “How can you make 90 with the set squares?” (Student shows how to make 90.) S:180+90=270 360-270=90 **Teacher:** What about 150? **Student 16** 90+60=150 **Student 17:** “Can we make 165?” **Teacher:** “Do you think we can?” (Student shows 60+45=145, 145+60=165) (This student used 3 set squares.) (Students protest that she used 3 set squares, and the problem specifically stated pairs.) **Teacher: “**We have to change the problem because it originally said pair.” 

	It is color coded to show the nature of the contribution. **Green:** Student came up to the board to show work or explain work. **Blue:** Student provides a comment with a new idea or discussion topic. **Black**: Student restates, agrees, or adds on to a prior point.	**Student Voice:** The following image tracks each student and the number of times he or she made a vocal contribution to the class as an individual. It excludes comments shouted by several students, or answers where the teacher asked for a whole class simultaneous answer. There is a G for girl or B for boy to make the nameless anecdotals easier to envision. Unfortunately, preferred pronouns of students are unknown, and therefore not used. 
10:52 - 10:54	**Summary/ Consolidation of Knowledge**	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals** **Teacher:** “Let’s summarize. If we use a pair of set squares, we can make a bunch of angles, increasing by 15 degrees. To conclude this lesson, write a quick reflection in your notebook. You have 1 minute.” 

What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion?

A pedagogical insight that we noticed is that the teacher tried to engage as many students as possible. He would have one student share an angle they created on the board and have another student explain where the angle was. This method allowed him to hear from almost 20 students in a single lesson.

The teacher used Bruner's model CPA (concrete, pictorial then abstract) to use resources to develop the children's understanding of how to make angles. It was interesting how he used other children as the more knowledgeable other, which supports Vygotsky's model for a cumulative learning environment. Children were able to build on each others response which helped children who initially were visibly unclear on the task at hand, but by the end of the lesson were able to use the resources effectively and make pairings collectively.

Questioning placed a large role in this lesson as well. It would have been interesting to see the teacher utilize the original question "Can we make angles less than 75 dregrees?" instead of "Can we subtract?", which was leading. Students may have come up with the idea themselves. Overall, students needed more work time to engage with and participate in this problem.

When the teacher was able to explain his reasoning from the lesson in the post lesson discussion, he was also able to see his successes with the lesson and his gaps. He had the majority of the students engaged, but was unable to take their engagement to the next level in the class reflection/discussion. I do hope this is something he will go back to in the days following and do. The Japanese teachers, as well as the IMPULS teachers raised the same concerns, "where was this lesson going?' It seemed to many is was like an onion with multiple layers. While there were many engaged students, there were also those who did not even know how to properly use the math tool, and the question was floated out there, "What do we do for/with those students?

Board work is a large part of mathematical pedagogy an the board was organized by the three phases of instruction. During the post lesson discussion, someone recommended that board work could have been placed on paper so that the instructor could allow students to organize the work themselves and recognize the pattern without leading.

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

Administration can support lesson study by being a part of the discussion and an active participant in the process. The support from administration creates a culture in which the expectation is for all educators to be a part of this learning process. In this particular case, the classrooms and some students had to be available for the district to engage in high level thinking with one another. Communication between teachers within a school site and off is a high impact practice for educators amongst themselves. Teaching can feel lonely, and the lesson studies feel like continuous thought partners at a high level. The post discussion right after the lesson provided timely feedback.

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

Through this lesson we can better understand the importance of student conversation as the driving force of the lesson. This lesson illuminates the importance of hearing from students throughout a lesson. Even though the teacher ran out of time and didn't have a true summary of the lesson, students ideas and voices were heard constantly throughout the lesson. This highlights the class discussion as an essential component to every lesson. This guides student learning, which is the ultimate goal of teaching.

This lesson highlighted the importance of teacher questioning, the teacher had prepared focused questions, which he was able to use to lead children towards the desired learning goals, he was able to engage most learners by creating a disequilibrium of conflict and inspiring debate between the children. However, one point to consider is whether or not the children had enough opportunity to respond to teacher questioning, perhaps it would have been more beneficial for children to record mini reflections throughout the lesson, rather than the one minute reflection at the end.

5th Grade: Determining whether to Multiply or Divide Decimals in Story Problems

(Annotate with pictures, quotes, student work examples, board work etc.)

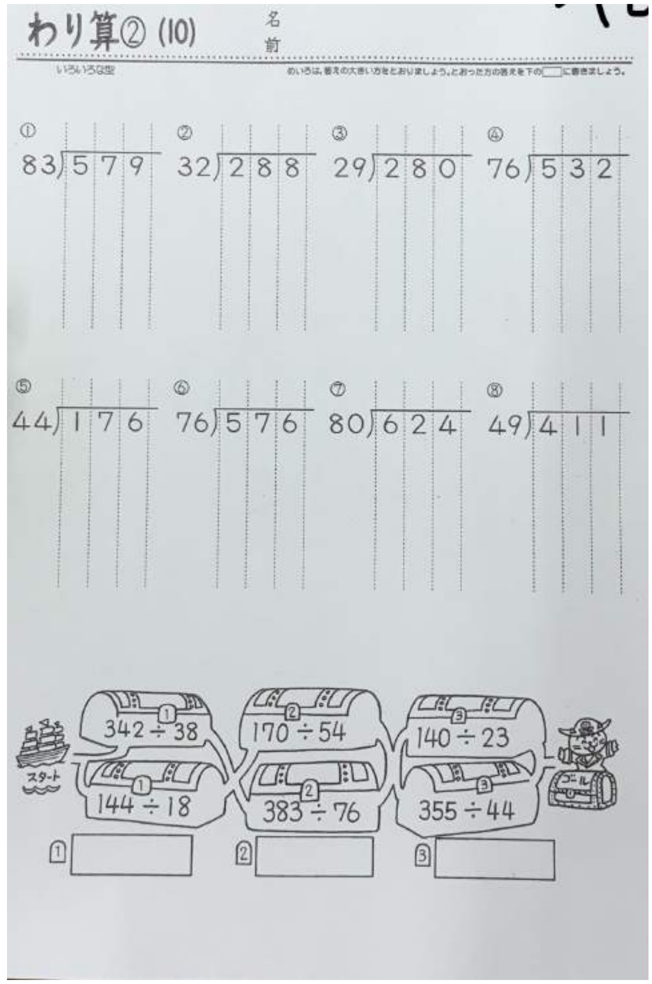
Report created by: Lucy de Anda, Cassie Kornblau, Joe Mannanino, and Wendy Ottinger
Name of Lesson: Multiplying and Dividing Decimal Word Problems
Date of Lesson: 6/24/2019

What are the primary lesson goals? To be able to determine if a decimal problem requires multiplication or division to solve. Students should be able to write an equation for the problem and use a diagram to explore which operation to use.

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)? Towards the end of the unit of division with decimals.

Summary of Lesson

Start & End Time	Lesson Phase	Notes
	Introduction, Posing Task	**Strategies to build interest and to connect to prior knowledge** Started with a whole number division practice worksheet to work on calculating more quickly. Students were given two minutes to complete the work but took more than five minutes. The teacher became involved with a student who entered class late without books and was emotionally upset. Students self-corrected their papers as the teacher read the answers. Most students got 100%.



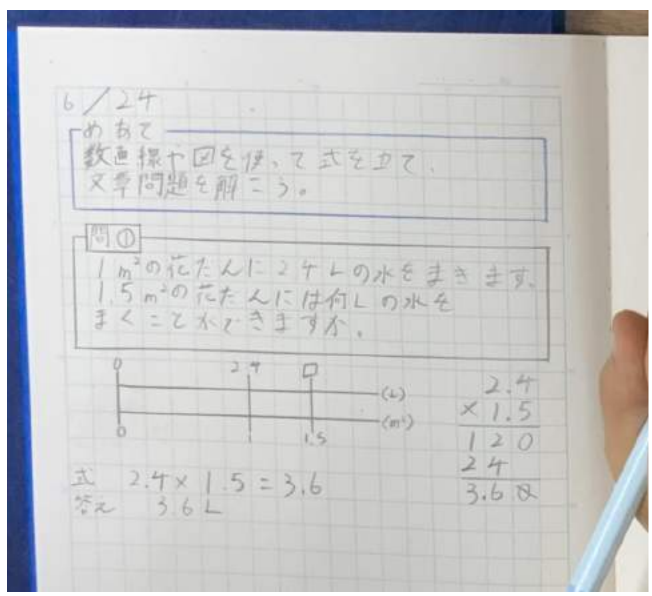
Teacher told the students that they would be looking at several word problems.

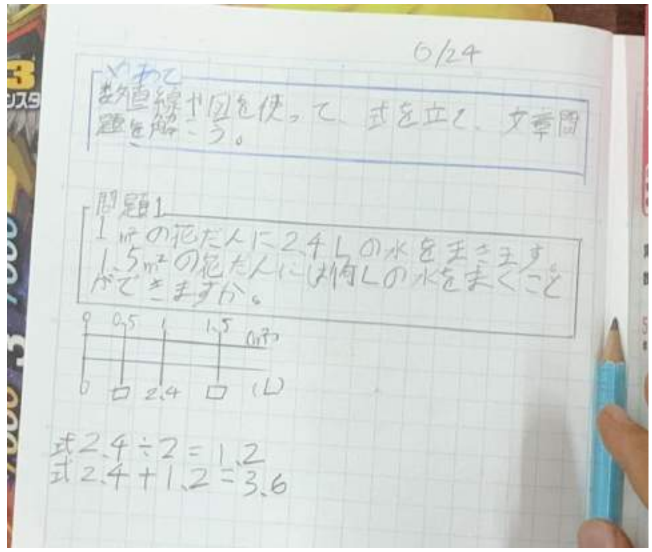
Problem: “Using number lines or diagrams, write the equation necessary and find the answer to the word problem.”

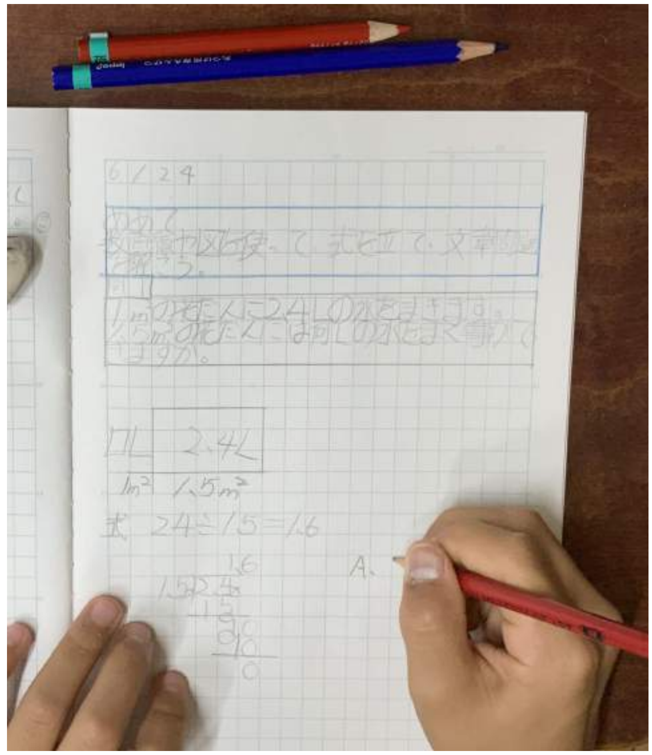
The first problem was then given: “It takes 2.4 L of water to water 1 square meter. How much water would you need for 1.5 square meters?”

T: “You can think about what calculation is needed as you are copying the problem.” She told kids not to take out their textbooks but several had them open throughout the lesson.

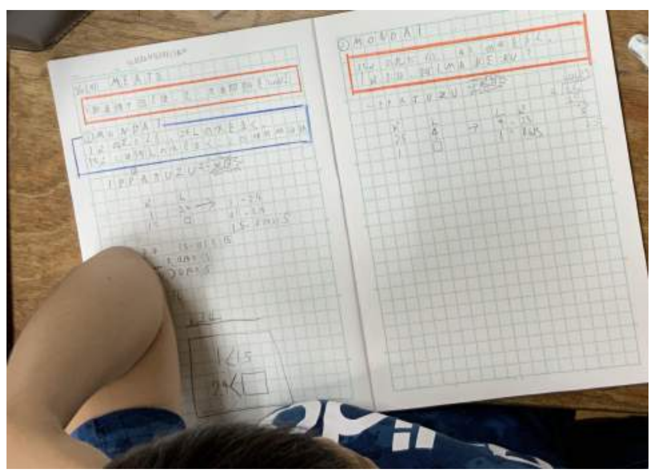
		There was some discussion about the context when a few kids recognized that 2.4 L is a lot of water. The teacher wrote both a blank number line and table labeled with units under the problem to assist the students in their solving.
	Independent Problem Solving	**Individual, pairs, group, or combination of strategies** The overall format of the lesson is that the teacher would write down a problem and the kids would solve the problem independently. When everyone was done, she would have two volunteers come up and show how to solve using a number line and a table. There would be some discussion following to clarify the answer and why it was either a multiplication or a division problem There was no partner work or group work in the lesson ● **experience of diverse learners** Even though this class was Group A which is the highest ability level, there was still a range in students' understandings.. Some kids were quickly able to solve the problems, others were using their textbook to help them even though the teacher explicitly stated that they were to close their textbook. Using the textbook to copy their work, or even copying the teacher's method from the board probably lowered the productive struggle for those students.

		 There was one student in the back that did not have a notebook or textbook and the teacher provided no assistance. ● **teacher's activities**
	Presentation of Students' Thinking, Class Discussion	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses** **Student 1:**  Copied from the board as the teacher had done to set up the problem. **Student 2:**

			 This student found half of 2.4, then added the result to 2.4 to find how much water is needed to cover 150% of $1m^2$ This method was not shared with the class in the boardwork. **Student 3:** Used “area model”, which we had not heard of before, to set up problem. Unfortunately this is not the correct set up for the problem. This method was used by several students, but was not addressed in the boardwork or discussion.

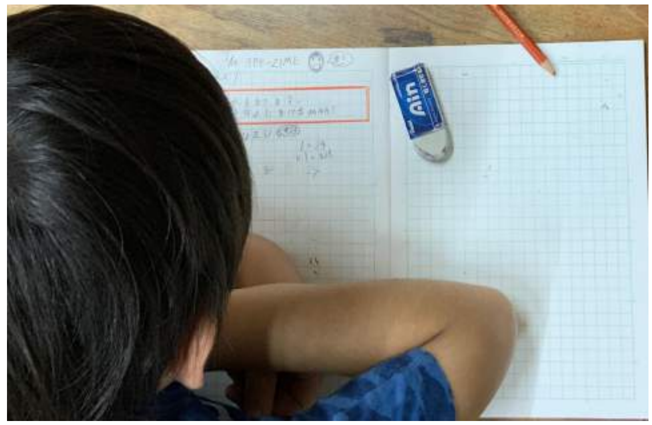


Student 4:

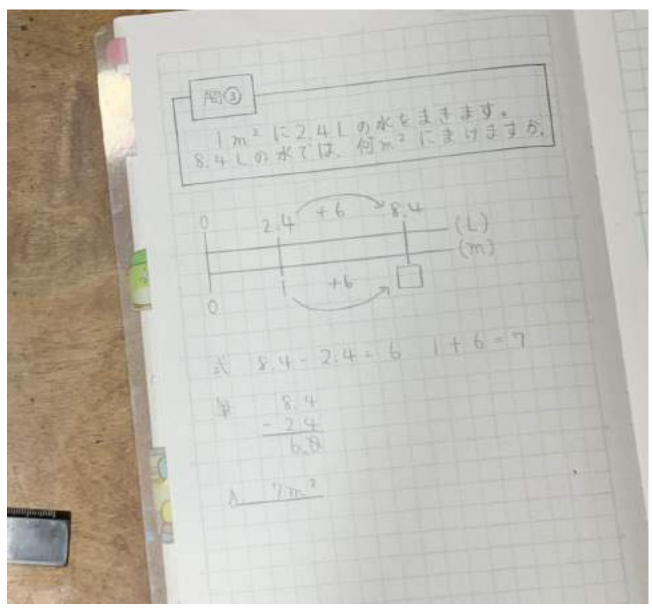


This student's strategy is to think about the problem as a ratio, or algebraically. 1 is to 2.4 as 0.1 is to 0.24. Multiplying both sides of this equality by 15 leads to 1.5=> o.24 x 15 = 3.6 He then thought about a check and wrote 1<1.5 and 2.4< ____. This method was not shared in the boardwork.

This student tried to use the same strategy for problem 3 but confused the order:
4 is to 2.5 as 1: 2.5/4 and got the result of 0.625
This student also appeared to struggle to get this method to work on #3.



Student 5:
This student was still thinking additively about ratio for problem 3, when he was working on his own. This was not addressed in the lesson.



	Summary/Consolidation of Knowledge	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals** The lesson was the last in the unit, and its intention was to give students the opportunity to interpret simple story problems for the appropriate operation, while practicing strategies learned over the course of the unit. Some problems called for division, and others for multiplication. The class did the first two problems using the 1)independent time 2) sharing strategies on the board. Students did the third problem completely on their own and individually shared their work with the teacher. They then went on to complete problem 4 on their own, but this was not checked during this lesson. By the end of the lesson, the board represented the correct way to solve each problem. Students were asked to write a reflection at the end of the final problem. This lesson did not have a formal summary.

What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion?

The post lesson discussion for us can clarify what next moves might be for us as teachers when our students present misunderstandings. We can also learn more about how students come to understand the mathematics presented by looking carefully at their work and discussing it with other knowledgeable teachers. I was impressed by my colleagues' skill at watching students and the teacher interact and noting the development of the lesson. I appreciate the opportunity to learn collaboratively by hearing my colleagues insights about student work and what teacher moves they might incorporate themselves in a similar situation.

Despite being the advanced class, there were students who would have greatly benefited from seeing multiple ways of thinking. In particular, one girl in the front row struggled to complete any problem independently. The teacher checked in with her on four occasions, from my count, and each time the student would make progress and get stuck again. She didn't make it through a single problem independently. There were others who relied on the share out to give them the correct answer. The teacher did not see their work, and they erased the incorrect strategy and wrote the board work down. This emphasized to me the importance of building the expectation that work does not get erased, but rather, that it is corrected so as to create a record of the day's learning. During the IMPULS discussion, a lot of time was spent on the problems with tracking students by achievement. This conversation further illustrated for me the importance of having diverse learners in the same space. The math we choose should be rigorous, with multiple opportunities for entry and understanding. We as teachers need to facilitate the discussion and board work so that all learners in the room, not just those with the correct answer, can understand the day's goals.

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

The idea behind this lesson was once students learned how to multiply and divide decimals, they needed an opportunity to explore different contexts that require these operations. Students' needed to determine what operation--multiplication and or division--was appropriate for the context of the various problems. Although this lesson fell at the end of the unit, I think students' still had a lot of confusion around when to multiply or divide in the context of the problems. Therefore as an administrator, I think teachers would benefit from support around how to facilitate discussion that enables a debate over when to multiply or divide decimals in the context of story problems. Similarly, I think administrators should push teachers to highlight the various mistakes students' make with their models. If students in this lesson saw their mistakes on the board and then as a class discussed why these models did not correctly support the operation needed in the problem, I think the teacher would have seen a bigger shift in student understanding from the beginning to the end of the lesson.

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

I think this lesson highlighted the importance of using two high impact practices: class discussions and highlighting student misconceptions in the board work. In this lesson, students would have benefited over a discussion around the context of the problem and the models that support that situation. Although the teacher in this lesson did not spend much of class having a discussion as to why students' should have multiplied or divided decimals in the context of the problem, the misconceptions students' had over whether to multiply or divide further emphasized why a class discussion was necessary. In addition, this lesson proved why teachers need to highlight misconceptions for the entire class to see through board work. Students who solved the problems incorrectly in this lesson often erased their errors in their journals and copied the correct answers off of the board. For these students, they never had an opportunity through discussion or through board work to look at what they did and have a chance to grapple with their misconception. As a result, they simply changed their answer by erasing their work, rather than learning from the mistake they originally made. If students' could have looked at their error along side the correct answer, they would have been able to compare and contrast the two strategies and reasoned as to why one was correct versus incorrect in the context of the problem.

Lesson Report

Report created by: Gerhardt, Rossiter, Girard, Soto
Name of Lesson:Application of expressions of sums and products to proofs
Date of Lesson: June 25th

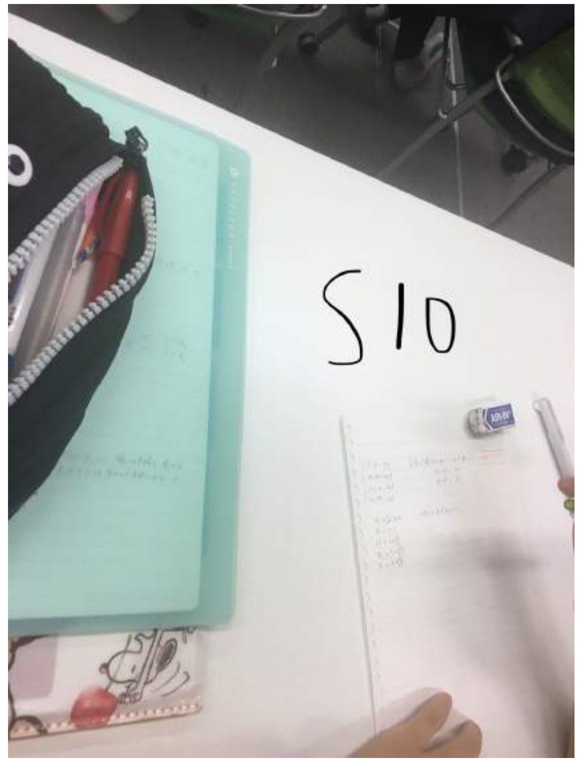
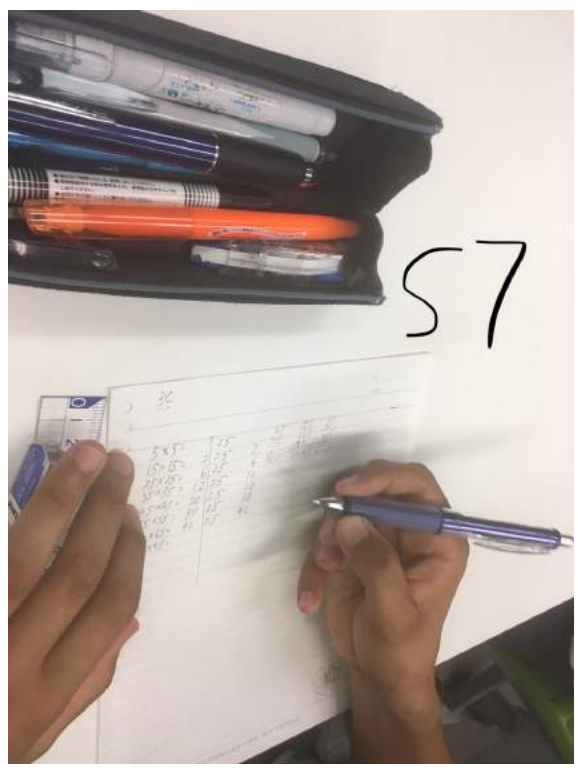
What are the primary lesson goals? Based on the lesson plan, the goals of the lesson were to:

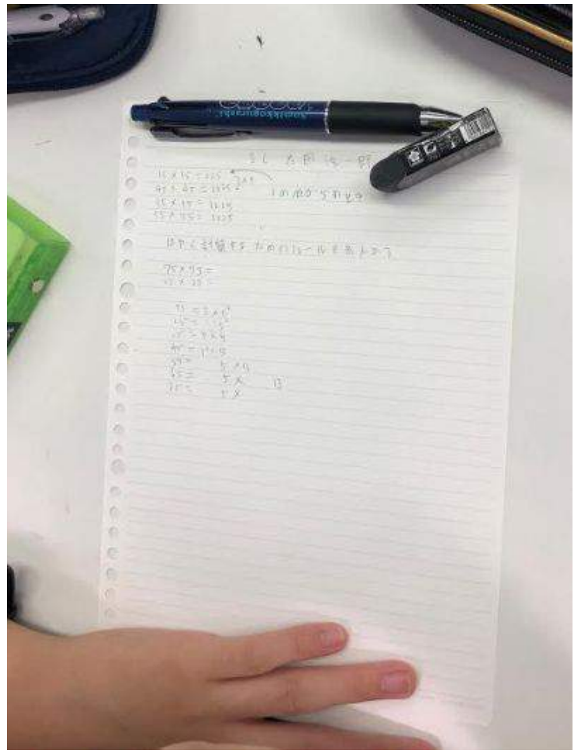
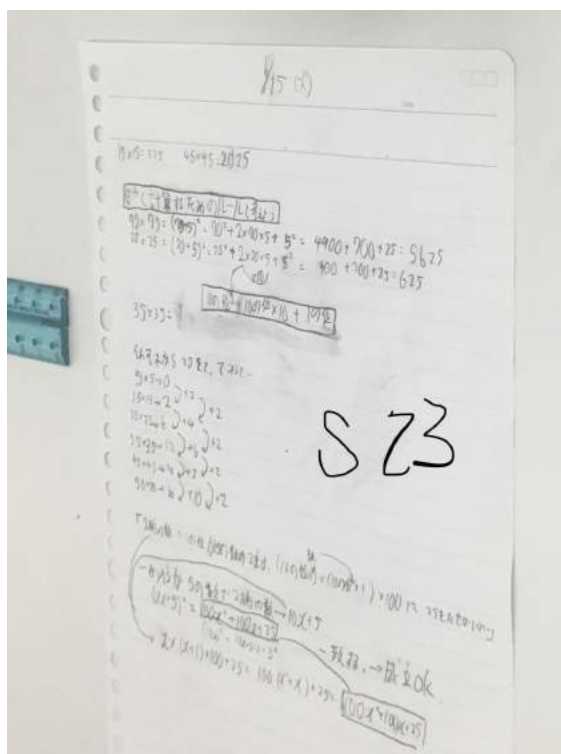
- examine a calculation technique (squaring a number whose ones digit is 5)
- explain the pattern using algebra
- apply expressions of sums and products to proofs

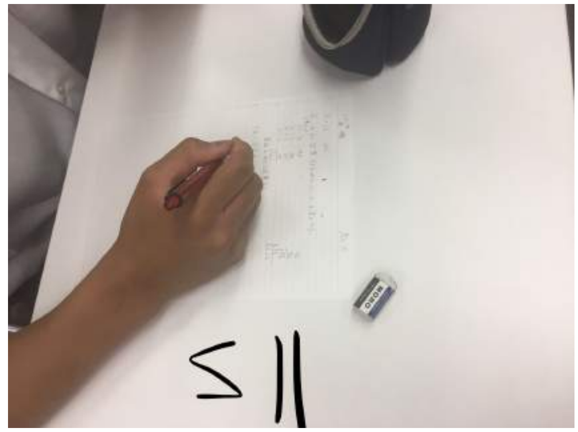
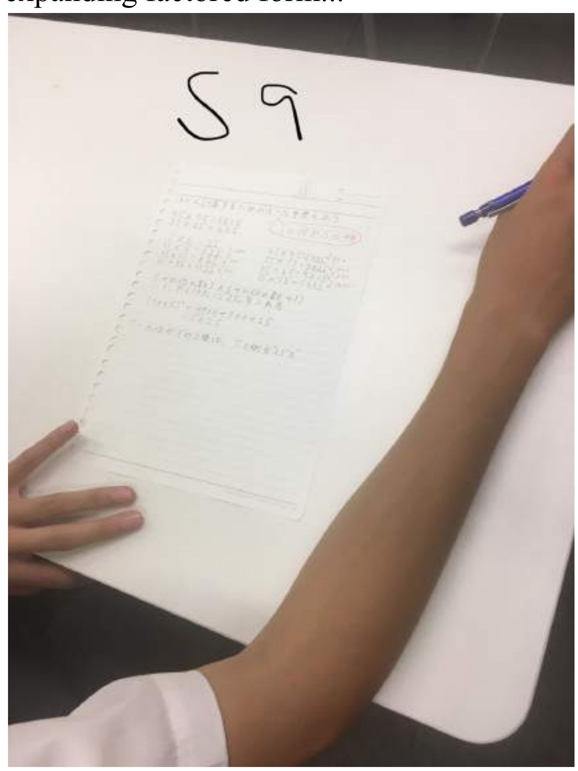
Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)?
This lesson was the launch of the fifth section of this unit on quadratics. It was lesson 1 of 3 in this section, and was lesson number 21 according to the unit plan provided. As such, students have had experience in factoring and expanding quadratic functions, as well as writing and using them in various contexts.

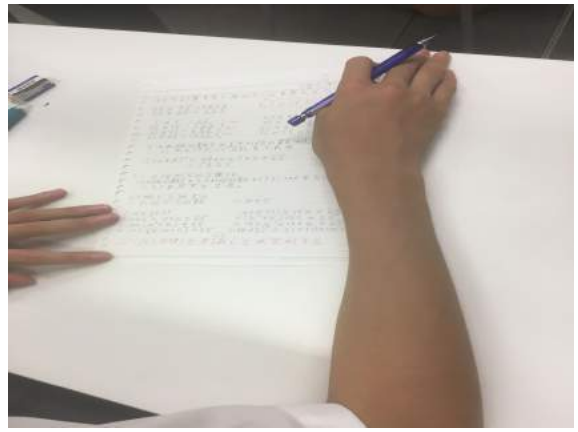
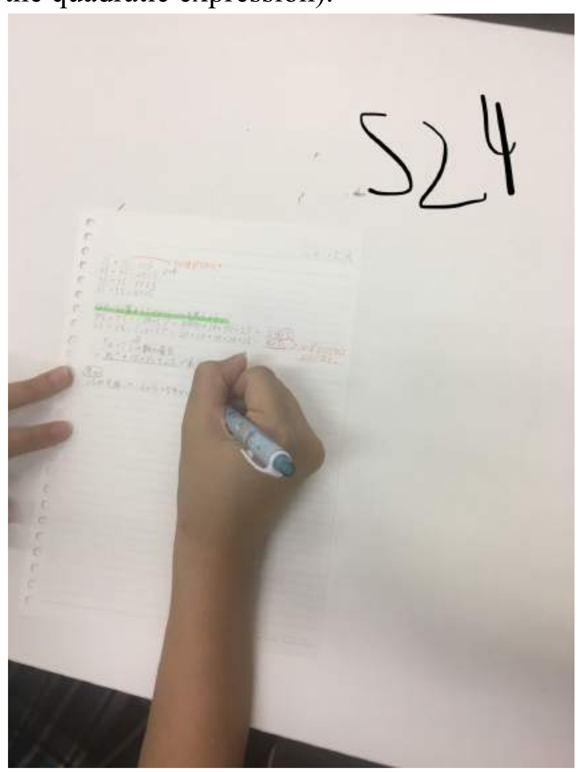
Summary of Lesson

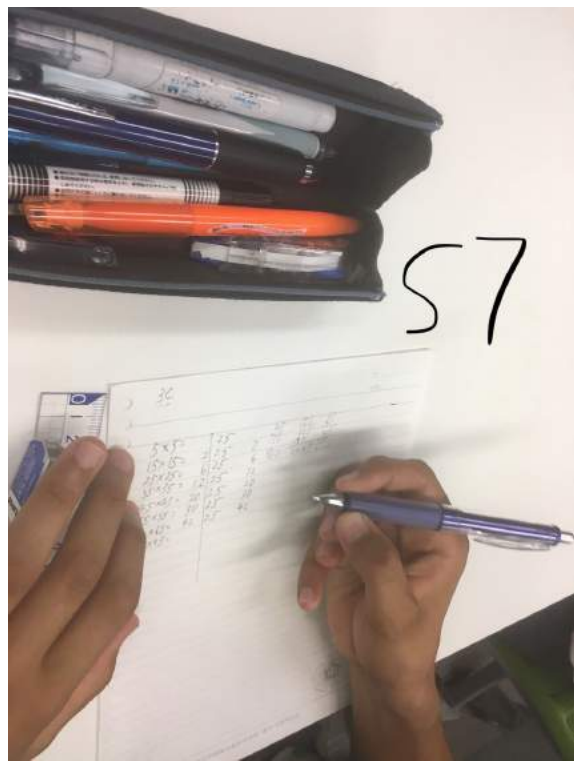
Start & End Time	**Lesson Phase**	**Notes**
Minute 1-7	**Introduction, Posing Task**	**Strategies to build interest and to connect to prior knowledge** Teacher started by quickly computing 15x15, 45x45, 35x35 and 55x55 with the students' help and checking along the way. He asked students to see if they could figure out the rules in play for the pattern.
Minute 8	**Independent Problem Solving**	**Individual, pairs, group, or combination of strategies** • **experience of diverse learners** • **teacher's activities** Students worked to continue to square numbers ending in 5 and then find a pattern. They worked independently for several minutes. Over half were still trying to identify a mathematical pattern. A number of students highlighted the numbers ending in 25 (example below, where

		Student 10 underlined the 25 and was attempting to find a pattern in prime factorization of the numbers to be squared).  Some students noted second differences, such as Student 23 and 7: 

		Student 18 found a pattern with multiplying by 5's  

		There were also students calculating partial products, such as student 11.  (he did 70*70, then 70*5, 70*5, and 5*5). During the second stage, they were trying to algebraically prove the method chosen as a class in stage 1. Student 9 initially focused on the 2nd difference, and then on using the pattern in expanding factored form...  and then eventually came to the idea of the pattern being expressed by 100(x(x+1)+25

		in the discussion. His work shows the evolution of his thinking.  Student 24 began by trying to find growth factors between products of the squares, but got stuck at that point. (She then took notes on student 7s methods during first group discussion and used this to correctly expand the quadratic expression). 

		Some students were clearly stuck at this stage and were
	Presentation of Students' Thinking, Class Discussion	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses** There were two stages of presenting students' thinking. First, after step 1, the teacher asked students to share out their methods. **Stage 1:** Student 7 focused on the second difference of the 100s place and above in his notes as well as highlighted the common feature of 25 in all numbers.  In the discussion, the teacher summarized the second difference method. He went over other methods, including "25 in ones and tens and the rest of the numbers are 10s place x 10s place plus 1" (student 19, method 2), application of Distribution (e.g. $75^2 = (70+5)^2 = 4900 + 700 + 25$ (Student 24, method 3)). The teacher's question was, "Which was the quickest?"

		He asked who liked each method. Students settled on method 2 and then got more precise wording for the method: take the product of the tens digit and 10s + 1. Multiply by 100 and add 25" The teacher asked students to prove this algebraically saying, "Think about how to explain this." (33 minutes) into the lesson, the teacher began eliciting students' ways of understanding. He asked, "What was the first expression?" Then he wrote $(10x+5)^2$ on the board and expanded to form: $(10x+5)^2 = (10x+5)(10x+5)$ $= 100x^2 +50x+50x+25$ $= 100x^2 +100x+25$ Next, he asked, "Was anyone stuck at this point?" It is not known how many were/were not or how the teacher knew. Shifting from the first elicited approach, the teacher asked, "Who started with something different?" (36 min) Teacher: "In other classes, many were stuck here". The teacher suggested factoring out 100 [to obtain $100(x^2 +x) +25$]. (37 min) The teacher shifted attention to another approach: $x(x+1)*100+25 = (x^2+x)*100+25$ $= 100x^2+100x+25$ Student 34 explained why this is a proof. T: Is this good? Okay both ways are okay. Another student in another class [wrote] $25(4x^2+4x+1) = 25(2x+1)$ and was stuck.

		Why couldn't this student complete the proof? Student 23 offered an explanation. The teacher asked, "Do you understand what they are saying?", but nobody offered a response. Next, the teacher asked, "For those who factored 100. Why?" He followed with the statement, "If you factored out 100, you were paying attention to what we want to prove." (44 min) T: Some started with x(x+1)100+25. Instead of mindlessly manipulating, track what you want. Changing forms, but there are many variations. In grade 7 and 8, you could get away with it, but not when there are many options. The class ended with reflection time (3 min)
	Summary/Consolidation of Knowledge	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals**

		 The teacher’s final remarks served to consolidate much of what had been done and why it had been done by attending to a valuable problem-solving approach. “Instead of mindlessly manipulating, track what you want. Changing forms, but there are many variations. In grade 7 and 8, you could get away with it, but not when there are many options.” When manipulating algebraic forms, one must have a target and a purpose. The teacher may have assumed students would get lost in their aimlessness while making valid, but unhelpful conclusions. It has also been documented in math education literature that without the development of this habit of mind (manipulate with a target/purpose), students come to see mathematics as a meaningless activity and symbols take on a life of their own, generating many errors because they lack referents (e.g., one might wish that $(a+b)^2=a^2+b^2$ were so, but real numbers this is not the case for all real numbers).

What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion?

The post lesson discussion provided a great deal of insight into how the teacher monitors and assesses student understanding which would not have been evident just from observing the lesson. He discussed his method for scanning daily work and using this as data and an ongoing record, as well as to inform future lessons, and estimated that it takes him about 20-30 minutes per class to review notes each day. His discussion about where individual students were in their understanding provided further evidence that he has a strong knowledge of student understanding and uses this to adjust his pacing and instruction.

The teacher also shared that students usually share their thinking and where/how they got stuck but were nervous with all of the guests present. This provided context for the students whom he called on and the amount of guidance he provided during discussion. It is important to note that it seemed that the teacher was modeling internal dialogue that the students should be having themselves during the lesson. Due to the nature of the lesson, he asked the students to think deeply about each strategy and made frequent check-ins throughout the lesson, each time encouraging students to reflect on their own progress of understanding.

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

It was very refreshing to see coming from the point of view of a group of visiting professionals, the support from the administration team. Although we did not specifically meet with the admin team, there was various levels of support present. There was a clear partnership with the university that allowed this level of teacher development as well. Interestingly enough, we have only seen this type of partnership through silos of individual teacher workshops without continuity throughout the Chicago district. Many support systems run independently of each other and without much follow up or a continued long-term vision. This leads to a lack of investment in our district as programs come and go. The teachers who do lesson study as common practice are in need of a closely knit structure much like this one. There is a need for a partnership with a university alongside insight from knowledgeable others. This leads to an infrastructure of a community of learners without punitive measures for those who open up with classrooms.

All too often we see the observation processes back at home linked to job security and longevity. Being invited into this classroom was a way to see that there can be teacher accountability without negative repercussions. We are fortunate to be a part of this learning process and to have accessibility to this classroom. Admin support not only could help change the development of meaningful partnerships for long-term success, they could change the narrative of what it means to visit a classroom and for what purpose. We feel we have learned so much, not only in this visit, but by visiting muriad of classrooms. Having an open environment helped our team understand the nuances to this lesson as to why certain decisions were made in real time. It was so valuable to meet with the teacher after the lesson as well. It gave light to some of the classrooms structures and culture of his class.

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

The most important takeaway from this lesson is the necessity to really know the students that you teach. This teacher is so thoughtful in his approach to collecting classroom data. He purposefully took the time to collect, scan and house data from years of reflections and information from countless lessons. This has improved his practice a great deal because he has seen each student's learning progression through a long-term lens. This allows him to make better decisions about what to do about students' misunderstandings or gaps when learning the content.

When students reflect on their understanding of a lesson, it is greatly important to spend time reviewing reponses. This teacher informed the group that those students who are reluctant to share during class now had a voice. By taking the time to review and collate classroom data, all students now are validated and their thinking about the prompts presented in class matter.

This lesson also allowed our group to see the benefit of independent classwork done by *each* student rather than in a group. We have had extensive conversations about the need for group work and that learning should be collaborative. This wasn't the main focus for this lesson. Students were working independently throughout the majority of the lesson. This strategy put the ownice on the student to fully understand the content. As mentioned before, the students were able to communicate with the teacher during their final reflection time. This also allowed the students to engage fully in the lesson.

Finally, the teacher's summative statement regarding manipulating symbols with a target and a purpose demonstrates an important role the teacher plays and is a form of Neriage. This statement can be seen as a synthesis of the students' work. It calls out a valuable problem-solving approach after, not before, students might have an intellectual need for it. If this point is demonstrated by students in the class over time, it would signal a shift in their mathematical ways of thinking. Since the teacher monitors their work closely, this should become a focus for monitoring. Identifying important problem-solving approaches is a high leverage practice that can be used as a guide for connecting students' mathematics during whole class discourse, as well as a way to set targets for their development.

Lesson Report

(Annotate with pictures, quotes, student work examples, board work etc.)

Report created by: Stephanie Kamai, Jade Meza, Shusaku Uchida
Name of Lesson:
Denenchofu Elementary School, Ohta Ward, Tokyo
Grade 4 Mathematics Lesson Plan: Let's explore quadrilaterals
Date of Lesson: June 26, 2019

What are the primary lesson goals?

- **Through the activity of classifying quadrilaterals, students will understand the definitions of trapezoid and parallelograms.**
- **Students will examine how many different kinds of quadrilaterals they can make by overlapping two figures.**

Where is the lesson located within the unit (in relation to previously studied topics and ideas to be studied in the future)? 7th of 16 lessons.

Summary of Lesson

Start & End Time	Lesson Phase Rationale for entries	Notes/Evidence
1:42	3 students shared aloud their reflection related to the previous lesson(s)- interesting student comments captured that give insight into their previous learning and current thinking	T asked S to share their reflection from the previous lesson S1 based on many parallel lines, why are they everywhere? S2 doorways have perpendicular and parallel, we probably wouldn't be able to close them without the lines S3 without parallel lines our school would be round
1:45	Introduction, build interest/access prior knowledge T used manipulatives in the shapes of triangles, rectangular and square in contrasting colors	T holding shapes, asks what are they? S rectangles T Are they really rectangles? S If all angles are right angles S If angles are all 90 degrees S If opposites sides are parallel S If they are thin T who can check? S brought set squares to the board to check

<table>
<tr>
<td></td>
<td>Posing Task</td>
<td>T do you remember yesterday? They’re not called opposite sides, they’re called adjacent sides that are non-perpendicular.

S If there are 4 right angles, it means that the sides are perpendicular

---

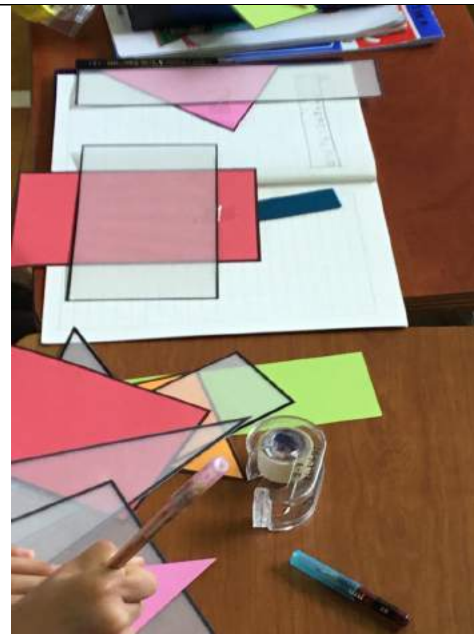
T shows shapes C+D What are these?
S Triangles!
T Can someone check?
S The orange one is a right triangle, the pink is an isosceles
Checks with set squares
T What tool can we use?
S A compass!
T Uses a larger compass to check

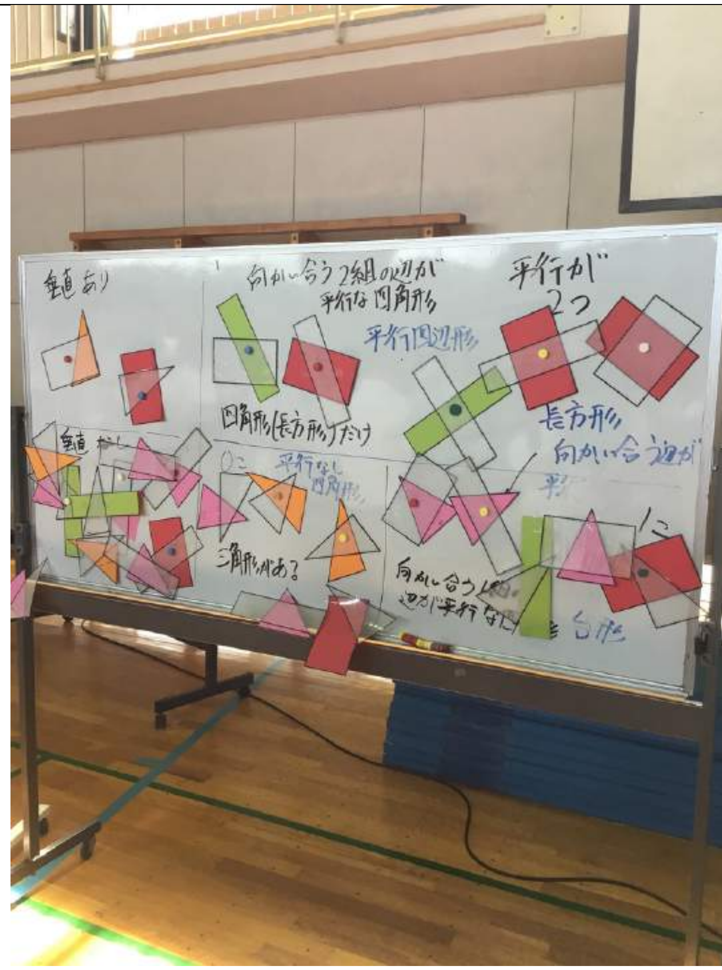
T Introduces laminated shapes If I overlap these shapes, what other shapes can I make?
S It depends on how you arrange them

T Traces new shape. How many sides does it have?
S 4!
T Is it a quadrilateral? Makes another shape with the triangles What about here?
S A quadrilateral!
T It doesn’t matter how I arrange it because they’re all quadrilaterals anyways. Writes the objective of the day onto the board.
S Copy information from the board.

T While you are overlapping your shapes, there are going to be some rules: (posted)
1. Make sure the black lines are visible.
2. The transparent shape has to be on top.
3. The top shape has to completely overlap the bottom one.</td>
</tr>
</table>

		 **Remember! We're making quadrilaterals, each of you will receive 8 shapes. You are going to tape them together and write your name on the top one.** *****Reminds S of their jobs. The back line of S seems to know this routine—they were assigned with returning the paperclips to the T.*****
1:57-2:03	**Independent Problem Solving** Individual Work	**Individual, pairs, group, or combination of strategies** • **experience of diverse learners** • **teacher's activities** 

2:04- 2:12		 **S *begin work*** ***2 in the back were having a discussion, the boy counted the sides to verify that he had made a quadrilateral*** ***The girl by herself took a moment to get started—had no one to have discussion with. Used set squares to check her shapes when they had right angles.*** **T Make sure the shapes you make are quadrilaterals! *Practice ends.*** **T Talk with a neighbor about the shapes you made.** **S *Arrange desks into groups of 4. The girl who had worked independently showed a shape that had the transparency flush to the edge of the other shape. 2 students debated whether it should count because the shape didn't overlap. They called the T over to check.*** ***He seemed to accept it.*** ***(Similar to the orange shape on upper left corner)***

		 **T I noticed some S were starting to group their shapes. Can these shapes be sorted? What do we do to sort?** **S -This one has parallel lines!** **You can look for parallel lines.** **-You can look for right angles.** **T Anything else? *Wait time.* If you can think of anything during the time, you can add it. *Hands out whiteboards*. You can write the properties for sorting on here. *Later.* Don’t sort on the board because you won’t have enough space.** **S *Work in groups to sort their shapes. One group in the back (Gr 1) had lots of discussion, primarily between the same 2-3 Ss. Seemed to sort shapes by opposite parallel sides and not. S in Gr1 was also drawing the quadrilaterals on the whiteboard. **Since some were not as engaged in the conversation, I wondered if they agreed with the sorting or were lost.***** ***Ask for T to check their groupings.***

		A group in front right (Gr2) initially agreed on sorting the shapes based on the number of right angle each shape has. They started out sorting the shapes by none, 1, 2, 3, 4, and quickly realized that they cannot have any shape with 3 right angles, since that will make the 4th angle 90 degrees. However, since the group only made one shape with right angles, they shifted to sorting the shapes based on the number of parallel sides. ***A Student in group in the back right (Gr3) shared with their group that the combination of a triangle and a rectangle will always make a pair of parallel sides.*** ***As a result, 4 groups out of 5 ended up sorting the shapes based on the number of parallel sides they formed, and one group used the perpendicular sides to determine the group.***
2:12	**Presentation of Students' Thinking, Class Discussion** Groups Share (Post 4	**Student Thinking/ Visuals/ Peer Responses/ Teacher Responses**

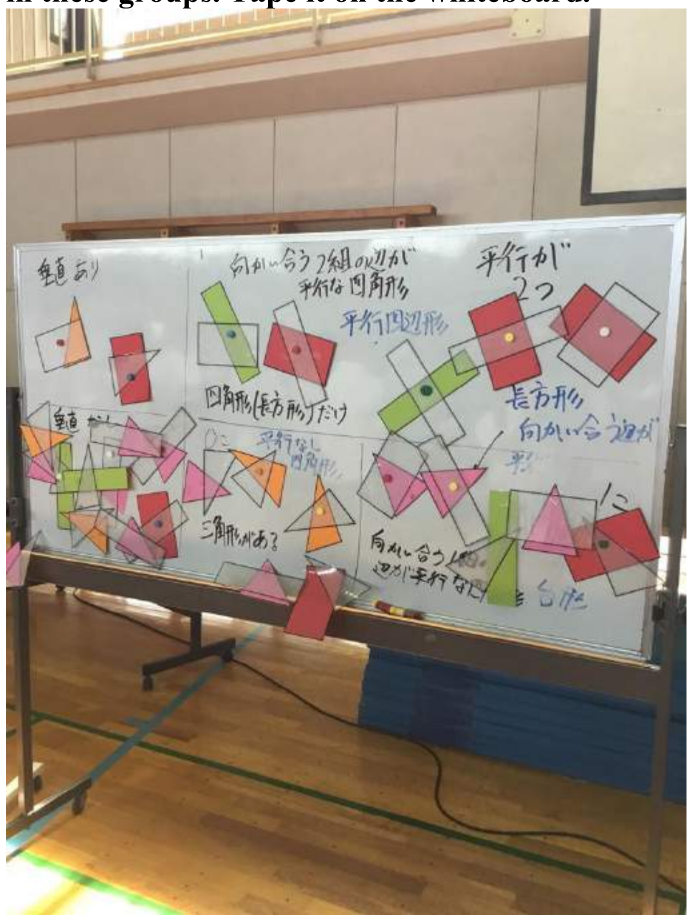
	shapes on the board)	***T appoints one group to post their shapes in different categories*** **T How do you think this group categorized the shapes?** **S Whether they have perpendicular sides or not.** **T Come check** ***S checks with set squares***  **T Did anyone come up with different grouping?** ***S Comes up and posts some shapes***

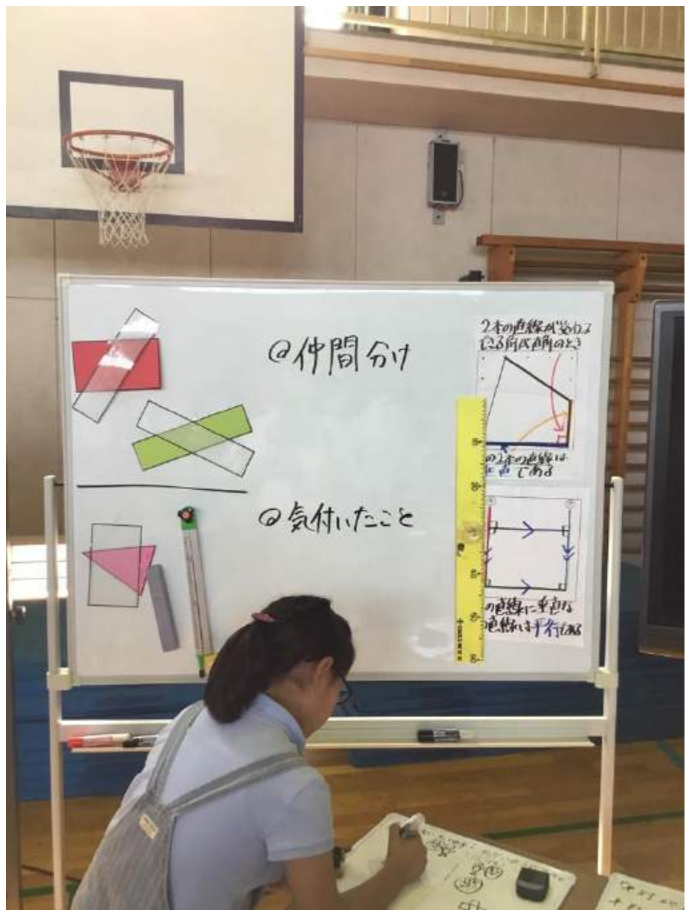
T Discuss as a group on how they categorized the shapes. How do you think they grouped them?

S If you're using a triangle or not
(Categorizing by shape, as told by Knowledgeable Other in post-lesson discussion)
S 0 or 1 parallel pair or 2 parallel pairs
(Categorizing by property)

T How can you tell that there's a parallel pair?
S Just by looking at it
S Since rectangles are made of pairs of parallel sides, if you have a rectangle, it is parallel

T Now write down in your notebook
" A quadrilateral with 2 pairs of parallel sides = Parallelogram.
A quadrilateral with one pair of parallel side = Trapezoid

		A quadrilateral with no parallel side (Asks students "How should we name this?") =No parallel quadrilateral." **T Choose one shape you made and categorize them in these groups. Tape it on the whiteboard.**  **T was concerned about student work placed on the board but did not address. Perhaps due to time limitations.**
2:25-2:30	**Summary/Consolidation of Knowledge**	**Strategies to support consolidation, e.g. blackboard writing, class discussion, math journals**

		T How did you group the shapes? What did you notice? **S were asked to write a reflection in their math journals** **S If a quadrilateral has all right angles, it means they are parallel.** **T Can you find that today? Let's talk about it in next class.** 

What new insights did you gain about mathematics or pedagogy from the post lesson discussion and IMPULS participant discussion? It was fascinating to see all of the participants, the sharing out of each group respective of the tools used and group work and how

helpful they, and the comments from the knowledgeable other. Teacher create the question but students create the objective after working a little bit. Comments made by the groups were surface level. For example, feedback was complimentary of the manipulatives, tools, group work design, but there was no evidence presented on the comments made. Professor Nakamura's insightful comments centered on ways the teacher should demonstrate what happens when shapes are moved and being more flexible. What is the best way to achieve? A question he posed for students to ask is "did I make 2 parallel lines with overlapping shapes?" Too many shapes at one time/smaller steps
Students needed more time to work independently before moving to group.
Reports did not share what did they think? S discussing is too naïve.

What new insights did you gain about how administrators can support teachers to do lesson study? Administrators can support teachers to do lesson study by creating a budget that supports training, equity, time, etc.

How does this lesson contribute to our understanding of high impact practices? Student to student, teacher to student interaction provides opportunities for students to construct knowledge, encourage student thinking, and test out ideas. There needs to be ways to capture student feedback, comments and ideas and teach, make corrections or provide insight. The following 3 points made by Dr. Takahashi are notated here for further thought.

Akihiko Takahashi 3 points to discuss

1-nature of the task: is the definition of parallelogram & trapezoid necessary
    common approach to introduce
    Tad-exclusive way of defining trapezoid; limitation of the definition
    After defining-need to look at properties
    Relationships
2-was objective or goal shared at the beginning-not an objective, more of an activity
3-group work and Professor Nakamura's comments
    S does not realize how valuable the group work is
    the movement is very important
    Eye to observe s
    Sharing quickly and simultaneously and not taking notes

IMPULS - Lesson Study Immersion Program 2019
Berenice Heinlein, Helen C. Peirce School of International Studies

The Impuls Lesson Study Immersion Program creates an opportunity for educators to experience lesson study and teaching through problem-solving (TTP) in its country of origin. I experienced this program June 18th-28th of 2019. I spent those ten days in Japan learning and growing with a team from my own school and 34 passionate educators from across the world. We spent three days learning at the Tokyo Gakugei University and seven of those days in local schools in the Tokyo and Yamanashi prefectures. We experienced general classroom lessons and research lessons presented at school, district, and prefecture levels.

<u>Lesson Study</u>

I have participated in a few lesson study cycles in the past and have seen many research lessons before. In Japan, it is the main form of professional development. Instead of sitting in front of a district mandated powerpoint, teachers improve by actively and intentionally participating in research. Part of the process includes creating a research lesson, observing the live lesson, and reflecting on new insights gained from the close observation of student thinking. When teachers observe the live lesson, they look for specific shifts in student thinking and take extensive notes. I was thankful that schools allowed for the IMPULS cohort to engage in this part of the process with Japanese teachers and staff.

One of the differences that I found to be most interesting is that the entire school is involved in the live research lesson. On specific days, students are dismissed early, with the exception of the class being observed. This is done so that every teacher can be part of the learning. It is not limited to teachers as all staff, including the school nurse and school cooks, are expected to attend. I love this. It creates a culture in which all adults are invested in student growth and an important part of the development of the whole child. It disseminates the misconception that one staff member can be more valuable or respectable than another. It creates a school culture in which no student is "your student" or "my student," but where every student is "our student."

In the post lesson discussion, teachers shared data, asked questions, and gave suggestions. The culture of the process is not evaluative of the teacher, but instead is one where everyone works together to improve the lesson, which was written by a group. The point was to grow together, and the teacher was celebrated for providing others the opportunity to learn from his or her best moments and mistakes. This creates trust among staff members and opens pathways for communication and collaboration.

I originally expected to see countless perfect lessons in Japan, but this was not the case. I did see some exemplary lessons, but I also saw many average lessons, and some lessons that had a lot of room for improvement. Despite the diverse quality of lessons, some things were consistent. In each post lesson discussion the staff was professional in the phrasing of comments, but made comments that were clearly meant to improve the lesson. There was no need for “oreo cookie criticisms” or for “sugar coating” comments, which I appreciated.

The facilitator plays a more important role than I realized, he or she had to ensure that conversations were productive and that it provided learning opportunities for everyone attending, not just the classroom teacher. The conversation was focused on the lesson, the learning, and the students, so the teacher was not vulnerable to personal attacks. Everyone was there to learn from the experience.

The live lesson ends with a “knowledgeable other,” often a university professor who is an expert on the lesson’s subject and/or the way students learn. He or she summarizes the discussion while proving final commentary and new learning for everyone. This experience pointed out how important this step is to the lesson study process. The knowledgeable other sets the final tone of the experience.

Teaching Through Problem Solving (TTP)

In Japan, lesson study is utilized for all content areas. I have most experience with lesson study as a tool for teaching mathematics because of its close connection to teaching through problem-solving, or TTP. Inquiry based forms of teaching, like TTP, are my preferred method of teaching and learning. In this learning structure, students are faced with a relevant contextualized problem to solve. It is clear that teachers are expected to teach this way in Japan. Lessons were always connected to realistic contexts so that students understand why learning the content is important and also so that students can better visualize the abstract situation. In Japan, many teachers discussed whether the lesson was engaging for students and whether the content was relevant. Students enjoying the process of learning was important to teachers, staff, and administration.

In mathematics, students use prior knowledge and conceptual understanding about the nature of numbers to move toward a solution. The teacher then displays student work and facilitates a discussion to create an opportunity for students to reason through difficult mathematical concepts collaboratively and to craft new learning about the nature and relationships of mathematics. Through this process, I learned that intentional board work and organization is crucial. Completed board work should tell the story of the class discussion and ought to reveal shifts in student thinking and learning.

These problems are accessible for students but are also challenging. The increased rigor encourages perseverance and teaches students critical thinking and problem solving skills. The discussion pushes students to think about how and why the mathematics works and to develop and critique arguments.

School Climate and Culture

Visiting several schools provided some insight on school culture norms in Japan. Schools provide students with many opportunities to practice agency and to take on leadership responsibilities. Students have jobs, create newsletters, lead announcements, and have their voices heard in decision making processes. A similar movement is visible in US schools. One of the biggest differences I noted is that within Japanese schools, student agency is coupled carefully with student responsibility. For example: all students clean at the end of the day. Many schools do not have janitors because students tidy classrooms and also sweep, mop, and clean hallways. Older students take charge of bathrooms as well. Students learn to grow plants in 2nd grade and help with the school garden from then on.

Even the lunch time procedures point out the communal service-driven culture. Everyone has lunch at the same time and entertainment over the intercom is presented by older students. Lunch is held inside the classroom and is served by students who wear sanitary outfits. Other students sit, wait, and chat until everyone, including the servers, have food. The food is healthy and similar to meals one might have outside of a public school, so students eat everything. When it is time to clean up, students sort plates, recycle empty milk jugs, and sort cutlery. The teacher and students go to brush their teeth before the next part of the day. Even the youngest students are held responsible for tidying after meals.

The sense of student autonomy and responsibility is entwined with student trust. After the second day of first grade, all students are expected to walk to school without parent supervision. It is safe in Japan and it teaches students that they are responsible for getting an education. Students are given two recess times a day and are often unsupervised in those times. Students are expected to behave appropriately and students often rise to the standards set for them.

Classroom Climate and Culture

When speaking to teachers, I was told that there is a large focus on team building within classrooms and in creating a community environment. I have always been taught that this is important, and I was happy to see that it was a foundational block for Japanese schools as well. A major goal in Japanese schools is for students to feel safe and happy. There is a shared belief that true learning will not occur otherwise.

A student announced the start and end of each lesson. A hyper-focused hour was clearly worth more than three hours with distracted and bored students. Within lessons, students were engaged and therefore behaved responsibly. Teachers did not give students behavioral cues and students were not told to be quiet. Students collaborated and had on-task conversations. Norms for discussions were clear. It was refreshing to see functional classrooms where teachers didn't seem to want to 'control' student behavior. Students were allowed to laugh, talk, and be children; lessons were made to spark student curiosity.

Teacher Organization Within a District

I am hesitant to overgeneralize the structures of the Japanese school system after visiting only seven schools. That being said, there are some observable patterns that I found interesting and that I have been thinking about consistently since I left.

In my school district and in many across the US, teachers apply to schools and often apply for specific positions and grade levels. Many Japanese teachers I spoke to about this were surprised and concerned. We had conversations about how some schools struggle to fill positions and how high performing schools have high performing educators that allow the school to remain high performing, creating a system of inequity. It is difficult to deny that there is a systemic problem with US education.

In Japan, teachers apply to a school district and are placed in a position and school by someone from the department of education. This is done to ensure that experienced and new teachers are spread out across schools, and to avoid complacency. After a few years, teachers can request a transfer if the school doesn't seem suitable. All teachers are transferred within a certain number of years, ensuring that no teacher remains at the same location very long. A single teacher will experience several schools in diverse environments. Schools in Japan have a very small performance gap across income levels, while the US struggles to provide equitable education to schools in low income areas. I do not think that a shift in this system will wholey fix these concerns, because the problem is much bigger, but I do wonder how much this teacher distribution process contributes to this difference.

Teacher Organization Within a School

Teacher distribution within a school is vastly different between Japanese schools and my experience in US schools. In Japan, teachers expect to eventually teach all grade levels within an elementary school setting. A teacher is assigned a grade level and after a year of teaching will loop with students for an additional year. Then, the teacher is placed with an entirely different grade level. I have thought a lot about the process of getting placed in a grade level and the system of looping for a year. I will explain my thoughts on both, but please consider the following paragraphs as unfinished trains of thought and not formulated opinions. I am still thinking through these concepts and am of course open to further discussion.

I personally have always dreamt of being a 4th grade teacher for the entirety of my teaching career. I often idealize a future in which I am a staple in a school community where everyone knows that I, Mrs. Heinlen, am a 4th grade teacher in a room that I can best describe as mine. This is a possibility for me in the US as long as I continue to perform well. The US has a culture in which expertise is important. Many teachers in the US might ask: “How can you be a good teacher if you are learning a new grade level every year? How can you be your best if everything is new and ever-changing?” Teachers can instead specialize and know everything about a specific grade level and benefit the school community by sharing an expertise. This is starkly different from expectations in Japanese schools. In Japan, teachers are expected to eventually teach everything and to teach well despite grade level and content. The questions I was asked were very different: “How can you teach a grade well if you have never taught the grade before or after? How can you be a good teacher if your experience with children and content is so limited?” I have wrestled with those questions for a while, because I desire to be an excellent teacher, but if I was placed in a 1st grade class I would have no idea where to start. I desire to grow and be challenged, but I might cry the year I am told to teach kindergarten.

I have taught 4th grade for four years and I love to teach that grade level. I often tell others that it is objectively the best grade level, having never experienced teaching other grade levels. Nonetheless, at the end of the year I sometimes wish I could loop with the students and teach 5th grade, provided that I have the same students. I think that remaining with a class can be valuable because relationships already exist and the class has a strong culture of trust. The teacher knows the students well, and can plan intentional individualized lessons. The students know one another and can feel safe taking risks. I also see value in students changing classes to create new relationships and experiences, and to learn how to handle change. That is why I love the Japanese system in which teachers loop with students for a single year, and then get a new set of students. I think I would enjoy teaching 4th grade, looping to 5th grade, and then going back to 4th grade in a cycle.

Final Reflection

I certainly learned many things through this experience and I recommend it highly. I have so much to think about as I reflect on how this will affect my own practice. As I continue to reflect, I plan to take time to prioritize the changes that will occur within my classroom. Overall it was an astounding learning experience.

Brian Girard

8th Grade Algebra

Helen C Peirce School of International Studies

Chicago Public Schools

Final Reflection on Project IMPULS and Key Takeaways from Lesson Study in Japan

As a teacher this is my third year being familiar with Lesson Study, I first learned about it when I took a positon at Helen C Peirce. Right away one could see the power of giving teachers the lead in their own professional development. It took a couple of years of doing Lesson Study in Chicago and a trip to Japan with Project IMPULS to really understand why it is so effective. On the surface it is clearly different than other professional development models, oftentimes teachers are sat in a room, talked at for a few hours, and then told what things need to happen to improve our practice. With a well-run Lesson Study, the agency is given back to the teachers, parents, and school community at large to work in a harmonious cycle of constant improvement. Here are a few of the key things I took away from observing and participating in Lesson Study in Japan.

1. Holistic Approach to Improvement

At Peirce I have been lucky enough to be a part of a building that does Lesson Study, I have sat in on, planned, and taught research lessons in my two years there. I am also lucky to live in Chicago and see it up close annually at the annual Lesson Study Conference. In Japan, there is clearly a different level of buy in around using this as a model to improve. In Chicago, we are working to improve our practice of Lesson Study by hosting an open house and incorporating more members from outside the math department. In Japan, it was shocking to see how the entire building and community took part in Lesson Study. From the parents who were outside directing traffic at each intersection, to the lunch staff and nurses taking part in post lesson discussion, all the way up to the highest levels of published university professors giving final comments; in Japan, Lesson Study is a thing that the entire community takes part in and it makes it very powerful. This is something we need to work on improving in our school community in Chicago.

2. Attention to Detail

The aspect of Lesson Study I value the most is the forced attention to the smallest detail. The visit to Japan really highlights the importance of this. When visiting Japan for the first time it is clear that attention to tiny detail is an integral part of the culture. Using Lesson Study has forced me as an educator to slow down and focus on the tiniest details. For a math teacher I think the value in this cannot be understated. In many professional development sessions we are given info for an entire year in a few hours. Lesson Study and the Japanese attention to detail turn this on its head; in a post lesson discussion teachers are forced to think about the how and why we choose to do something as teachers at a very microscopic level. Even if we are often crunched for time as American educators, by participating in Lesson Study and observing it in Japan, it causes us to slow down and at least think about why we are doing something. In my own practice, I cannot spend the same amount of time that goes into a research lesson on a day to day basis, but by partaking in Lesson Study, and seeing it in action in Japan it will help me to remember to really sweat the smallest details possible.

3. The Power of Meaningful Post Lesson Discussion

The final key takeaway for me was how different post lesson discussion looks in Japan than in the United States. I am lucky being in Chicago that I often get to see this performed by Dr. Takahashi or Tom McDougal. Sometimes the post lesson discussion in the US isn't as meaningful. Many times in the United States I've seen post lesson discussions either devolve into a discussion on teaching practices using the framework of teacher evaluation, or I've seen educators who just lob endless compliments towards their coworkers. It is refreshing to see lesson study performed in Japan where most of the commenters are clearly knowledgeable, and discussing either the research topic or asking questions regarding selections teachers make. The bluntness and straight forward critique of Japanese teachers by their fellow professionals is refreshing. Where some teachers in the US fight against Lesson Study because they are afraid of opening their classrooms, in Japan teachers were clearly open to feedback and viewed it under the lens of improving for the sake of student outcomes.

Thank you to the amazing group of educators and professionals I got to learn with and from on a day to day basis in Japan, I'd also like to thank the amazing staff at IMPULS and the great professors at Tokyo Gakugei University for sharing their time and knowledge. As a participant and believer in Lesson Study before going to Japan, this trip has helped me cement best practices around teaching and how to implement Lesson Study in our school community.

IMPULS – Lesson Study Immersion Program 2019
Jeffrey Rossiter – Peirce School of International Studies –Chicago, IL

My friends, family, and colleagues all ask me how my trip to Japan was and I don't really have a clear answer for them because it was so many things wrapped up into one experience. Now that I have had some time to reflect on how influential it was to my personal and professional development I still don't think that I have a definitive answer. At the end of last school year, our team went out on a limb and wrote a grant through Fund For Teachers, not knowing if this trip was actually going to happen. Next thing I know, we are all on a flight to Tokyo just trying to soak it all in. It was a whirlwind of train rides, classroom visits, lesson debriefs, and an occasional celebratory kampai. It was so much more and so enriching that I can only scratch the surface of what this trip meant to me.

Culture of Learning

Visiting Japan let me see what it means to have a real professional community of dedicated learners and participants who own the learning in the classroom. It's not like I don't have a similar experience in Chicago, however it is so much more prevalent in Japanese schools. It really takes a wider investment for all stake holders, not just a select few with ties to the school. This was the common denominator in all the schools we visited. Investment! Teaching can be very isolating at times and I am so happy to share this experience with a wider net of professionals from all over the world.

I guess it took me going half way around the world to find out that in order to learn more about my craft, I don't necessarily need to leave my own school, let alone the country. I need to become better equipped to have meaningful interactions with teachers at my own school. I need to be the focal point of this learning as well. I need to be better at what I do because my journey is not finished. I need to focus on my classroom and align my common vision with the students that I teach. I want to continue to develop the infrastructure at my school alongside my colleagues to make this vision of a community happen at my school.

Mathematical Discussions

Since the discussions and observations in Japan, I have thought deeply about my own classroom dynamics and how groupwork functions in my room. I think I am very fortunate to have a primary team that preps students to have meaningful discourse once they enter my room. A lot of the heavy lifting is done ahead of time and the school-wide expectation is there for students. I think it is valuable for students to have somewhat of a safety net that allows them to take risks in a 'safer' setting. They are able to bounce ideas off one another, and try out their ideas with limited risk.

There are different ways to hold groups accountable. Honestly, it is near impossible for teachers to know whether or not 4-6 groups are actually doing what is asked of them. This is even more reason to work on this structure in my room. Just because it is difficult doesn't mean that it is not worth doing.

My opinions of groupwork have stayed the same, but there is value in having students work independently as well. I would like to develop a better system of tracking student thinking so that all students can be held accountable for the high standard of learning taking place in my room. I also would like to do this in order to document all student voices, whether or not it is in the classroom. Validating these voices will be a top priority for me to work on this upcoming year. Similar to the 9th grade algebra lesson we saw, I would also like to keep a running record of the students' change in understanding. This would be quite simple to integrate into my lessons via a google doc or running form throughout the year. Again, having the opportunity for voices to be heard, either through reflection, classroom discussion is very important to me and my classroom. I will continue to grow in this area.

Planning and Revision

I have also thought how I am going to revised the prompts and the progression of the prompts presented in all of my units. I will definitely use the resources provided by the IMPULS this upcoming year. There is a database of lessons that I can tweak so that they can be integrated into my classroom and that they fit my students' particular needs.

I will work more on anticipating responses from my students. I really would like to get to know the students quicker than I normally do by having them solve problems from day one. This will get them into the mindset of my class quicker than previous years. I feel I know my students better and it gets easier as the year progresses. It is hard to know ahead of time what to plan for without really knowing how each classroom functions and works together.

Next steps

I just wanted to give a huge thank you to everyone involved for making this journey possible for my colleagues and me. You all played such a significant part in this journey. It was an amazing experience to observe math classrooms all over Japan and I will be bring this experience back to my school and help further this work at the district level. I am working on developing a public lesson this upcoming school year as well. If you are reading this, feel free to reach out. I can send along the details of the lesson. You are more than welcome to attend of course if you are in the Chicago area. I will be inviting more people from our community to have a more meaningful impact on the school. As we saw in Japanese schools, there needs to be a collective to participate in the learning taking place in the classroom. I cannot wait to share this experience with my students and my school.

IMPULS - Lesson Study Immersion Program 2019

Jinny Gerhardt, Peirce School of International Studies, Chicago, IL

Introduction

I came to the LS Immersion Program as part of a team from a school in the process of adopting Lesson Study as the primary form of teacher professional development, and was the team member with the most experience teaching but the least expertise in Teaching Through Problem Solving and Lesson Study. As a middle school diverse learners (special education) teacher, I do not have the specific focus on mathematics instruction that many in the program had, and tend to specifically seek out ways of how to support struggling students within the classroom in my professional development. With this perspective, I hoped to gain a stronger understanding of how lesson study and teaching through problem solving could impact the school's culture and support systems for teachers and students, as well as my own teaching and the learning of students with special needs within the classroom.

Culture of Learning and Growth

It is clear that there is a clear, established, and strong culture for supporting lesson study on an individual, school, district, and national level in Japan. As several colleagues have already discussed, it was impressive to see the whole school, including lunchroom staff and nurses, participate in school wide lesson study, and it was evident that parents and community members are regularly invited as well. Dismissing all of the students except those participating in lesson study allowed for all teachers to come to the lesson study and take part. These systems set up for implementing school wide lesson study clearly convey that all stakeholders are valued, and that everyone is investing in the learning of all of the students in the school. I could see many other added potential benefits, such as helping to establish norms for professionalism, pedagogy, and collaboration; strengthening partnerships with universities; providing meaningful feedback on the curriculum; and celebrating strong instructional practices. It was also valuable to be able to see district-wide lesson study in action, and how it also enabled teachers across schools to participate in lesson study and participate in the post-lesson discussions. As with school-wide lesson study, I observed benefits of hearing from knowledgeable others and the perspectives of teachers from various schools and subject areas as well as of opening one's school and instruction to others for observation, discussion and feedback. I attended a lesson study conference in Chicago prior to coming, and am excited that this opportunity will likely continue to be available; after this immersion experience, I see greater value in this and look forward to fostering cross-school relationships with other colleagues who are also implementing lesson study. In fact, I had the opportunity to get to know a teacher from another school from my district, and we plan to try to begin working together in this capacity in the near future. Having seen the benefits of having a district and school in which "this is how we do things," I hope to help my own school and district get to this stage of implementing lesson study. Right now, there is still apprehension and resistance from some, which is to be expected given the adoption of any new system, especially one such as this which asks teachers to be vulnerable. I agree with my administration's approach of making participation voluntary, and I think it is wise to enable it to be a teacher-led initiative that is heavily supported by administration, as she has done. With greater numbers of the teaching staff participating (including myself) and inviting others to do the same, I believe we are close to that goal. For me, focusing on its potential to create a culture of learning and growth and to further professionalize our work in schools are key to drawing in teachers and enriching the culture at our school.

Implications for Diverse Learners

As a special educator, I was curious as to how the needs of diverse learners are addressed in Japanese schools and I'm grateful I did have several different types of opportunities to gain insight. I was surprised and excited that I was able to visit and spend time in a cross-categorical special education classroom. I talked with the lead teacher both there and afterwards at the celebration about special education in Japan, and I was pleased to hear that he regularly participates in lesson study cycles, both within his school with general education teachers and across the district with other special education teachers. It was clear that he is a respected staff member and that his input is valued, both with regards to special education and teaching and learning in general. The staffing in the classroom (several aides as well as two teachers) allow for differentiation for core subjects, and it is clear that he and his colleague work to adjust the curriculum to meet the needs and level of the students. I did notice the wide disparity in functioning within the classroom, with some non-verbal or with more significant disabilities, and others presenting as similar to those I service in the general education classroom. He confirmed that some of his students do return to the general education classroom for certain subjects, but have no direct special education services at those times so they must be quite high functioning in those cases. I left the experience impressed with his dedication to fostering the students' independence (e.g., they served meals just as the others) and learning, but also wondering whether there might be more of a spectrum of supports possible for students with disabilities.

Elsewhere, (e.g. Yamanashi grade 4 lesson and Kunitachi grade 5 lesson), I was able to see the presence of what looked like other supports (e.g. aides) in the general education classrooms for students with special needs. I could see other staff members, aside from the lead teacher, working with individual students and providing what looked like scaffolding to help students during individual work time. It was not possible to know what they said or how it impacted the student's learning experience, but it did suggest that, given the resources, there is a place and space for inclusive supports within the mathematics classroom in Japan.

Another support approach I witnessed was tracking. In several schools, mathematics instruction was provided at different levels, with the stated benefits being smaller group size and differentiated levels of support based on student choice (according to school staff). I saw both benefits and drawbacks to this approach. In Fuda (grade 5), the instruction was masterful, and there were numerous examples of highly successful supports for student learning, such as visual supports like showing what 2.5 meters would look like with a tape measure, providing clear number lines to help with proportional thinking, and color coding the notes. While not TPSS per se, this instruction did, from my estimation, allow for productive struggle and new understandings, and allowed me to see exemplary direct instruction. I see potential for using something similar to this is in the context of reinforcement/reteaching and could see why tailoring the amount of support provided in this situation allowed students to experience success and strengthen their understanding of proportional reasoning. In another grade 5 lesson (Fuchu Daiichi), it was clear that the supports provided turned the lesson into a procedural "show and tell" format. Students were given no opportunity to apply their own mathematical thinking, were essentially led to a single approach to calculate which did not connect to the context in a meaningful way, and many did not demonstrate enough computational fluency to independently solve. There was no evidence of furthering their thinking after the lesson's conclusion, and many students remained passive throughout the lesson.

My experiences resulted in perhaps more questions than answers- Is there strategic partnering? Is work ever differentiated for students within the same classroom? Do some students have "resource" minutes or other planned times/structures to reinforce foundational skills? Does co-teaching exist in Japan? Were the supports I saw formal or more informal in nature? Do some teachers/schools flexibly shift between homogeneous grouping (e.g. tracking) and heterogeneous grouping? Are there concerns/strategies around how to address the students who remain passive throughout a TPSS lesson (e.g. just silently struggling and then copying down the board work)? Regardless, I appreciated the opportunity to see varying approaches to supporting student learning, and being able to reflect on these experiences and even these questions is part of my own growth as a teacher.

Implications for my own teaching

My experiences in Japan provided me with ideas related to my own teaching in minute ways as on a macro scale. I plan to implement a color-coding system for notebooks and board work similar to what I observed in several schools. I love the visual support it provides both within a lesson and in its use as a resource for later lessons. I saw first hand that the amount of time invested in planning board work and class discussion paid huge dividends, and I plan to use this as inspiration for my instructional planning this year. I also saw the value and importance of having both a unified system (curriculum, planning time, systems for lesson study implementation in school/district, and TPSS approach to instruction) and a focus on the specific, individual students in front of me. I am fortunate to have strong school leaders who can support the former, and a team of teachers who can help me improve my instruction from the perspective of the latter, all through the lens of lesson study. I am thankful for the experience and look forward to making use of it to better my instruction and the learning of my students.

IMPULS - LSA
Lesson Study Immersion Program 2019
Final Reflection
By: Wendy Ottinger

Looking back on the 10 days I spent in the Lesson Study Immersion Program, there is much to reflect on. Being given the opportunity to observe many lessons in different schools provided me with insight into the Japanese culture in the classroom and school setting, how Teaching Through Problem Solving is used, and the way that Lesson Study is implemented as the major means of professional development for teachers.

Japanese Culture in the Schools

Schools in Japan function much differently than those in the United States. While not everything may be ideal, I do believe that there is much that they do to help foster a wonderful learning community for students. There is an emphasis placed on giving children independence and autonomy at a young age. This was shown by how they are sometimes left unattended by the teacher and expected to behave accordingly, they are responsible for cleaning their classroom as well as other parts of the school, they serve their classmates lunch and clean up together, and they even take home plants to care for over their vacations. They are given responsibilities with high expectations. In each classroom I visited, I was so impressed with the respect students had for each other and the way in which they got along. A strong classroom community had been established. They were also so friendly and outgoing to all of us, welcoming us into their schools and their classrooms in such a gracious way.

In addition to the observations about the things specific to the children, there were also many things specific to the teachers that struck me. I think the most notable was the structure of the staff rooms. Rather than simply having that be a place to lunch and chat with your colleagues, this is their work area. I loved the way that the teacher desks were grouped based on grade level, facilitating regular communication with your grade level colleagues. The assistant principal was also housed in the same room. In one of the schools, the principal's office even had an adjoining door. What a difference this is to having teachers working alone in their classroom. In addition, the daily short staff meetings to discuss upcoming schedules seems like an easy way to bring the teachers together regularly. In Japan, it is clear that there is an expectation for teachers to continuously learn and improve.

Teaching Through Problem Solving

Since I have been using the TTP method of instruction, to the best of my abilities, for the past three years, I was hopeful that I would be able to learn a great deal to help me improve in my implementation of TTP. My biggest take aways from my time in Japan are the following. It is important to spend good time introducing the problem that is being solved, and the more engaging and purposeful you can make the problem, the better it will be. The problem that is being used must require a solution. While this may sound obvious, some problems will hook the students more because they really want to find the solution to the problem. It is also important that the context is very clear to all students. If this is not done, then the students will not struggle with the problem in the correct way. I was also reminded that it is very important to make sure that there is just one new concept or learning being addressed in each problem; there should be incremental concept building. If there is something unfamiliar besides the new type of problem being solved, it will complicate things and prevent the learning goal from being reached. In addition, it was confirmed for me that the clarity and structure of the boardwork is critical.

While I did see many wonderful examples of problem solving, I do still have some questions remaining. In my classroom, I consistently use “friend time” after the student’s independent time, where they are able to discuss their way of solving with a classmate. We saw very little of this during the lessons we observed. Is this something that should always be done? I have found that it is often a time when kids are able to figure out any errors they made and resolve misconceptions. It is also a way in which each child’s voice is heard, even if it is only by one other student. Another question that remains for me is how to engage all kids in the neriage. While most of my students are present and engaged, there are always a few that are not. We saw this in Japan as well. My final question involves students and their metacognitive ability. I have found that some kids are unable to really understand their thinking and the errors that they are making. This becomes apparent in the reflections they are making and the lack of growth they make from problem to problem. Those kids with strong metacognition are the ones who make the most gains from this type of instruction. Is there anything that can be done to help those who struggle in this area?

Lesson Study

Not having had much experience with Lesson Study, having only participated in one cycle three years ago, it was wonderful to have such exposure to the different types and levels of research lessons done in Japan. This is the primary type of professional development done in Japan, and the benefits are obvious. Teachers in Japan go through this process each year to help them reach specific teaching and learning goals. All that is learned directly impacts classroom instruction. The use of a live classroom for professional development is such a rare occurrence in the US, but it is clear that by using a live classroom you can immediately see if something will work or not. Lesson Study highlights the professional nature of teaching and provides an intellectual focus and challenge for all participating. It deepens conceptual understanding of specific content, as well as on the vertical progression. With grade levels getting to decide on the unit of focus each year, there is definite choice to help with the buy in for the teachers. In addition, teachers are able to watch other teachers teach multiple times each year. This gives teachers an opportunity to develop a shared understanding of what good teaching looks like, as well as to help even out the quality of instruction. It will also help spark creativity by having many different examples of what that can look like in teaching. Lesson Study also helps to promote a school culture in which the students belong to everyone working at the school rather than to just the current teacher.

The benefits of Lesson Study are numerous, and it seems obvious that all teachers would benefit from this type of professional development. I am so glad that we had some time to discuss next steps before coming home. Given that I was the only one from my district that came on this trip, the obvious hurdle for me is how to successfully bring Lesson Study to my site. Thankfully, I have an incredibly supportive principal and many colleagues who are constantly striving to improve, so I am hopeful that I can share what I have learned and help increase the level of professional development at my site.

Reflection IMPULS Lesson Study Immersion Program 2019

Henk Logtenberg – The Netherlands

Introduction

I participated in the IMPULS Lesson Study Immersion Program 2019 in Tokyo, Japan from 18-28 June. This study trip was a beautiful journey to the birthplace of Lesson Study. I thoroughly enjoyed the program's content, the cultural immersion and the personal exchanges with the staff, participants and the Japanese teachers. In this reflection, I will however focus on the program's content and the professional aspect. My goals professional development goals for this study trip were:

1. getting more ideas/tools to support teams and help them to get a deeper understanding of the problem solving aspects of mathematics;
2. getting more practical tools about the roles of the facilitator and knowledgeable other in a Lesson Study cycle.
3. getting more practical information/tools to create a design for the Teacher Training Education department of the Marnix Academy to use Lesson Study as a vehicle in the pre-service training program in cooperation with our 350 partner schools.

Preparation

Before the study trip, I shared my ideas about Lesson Study and the goals of this study trip with my colleagues at the University and the partner schools via the website of the Marnix Academy[1]. In the article, I described Collaborative Lesson Research in the context of Lesson Study; Marnix Academy and Lesson Study; my preparations for the study trip to Japan and the goals of the trip). I also organised an afternoon seminar on Lesson Study. The seminar, which was attended by colleagues and students of my University as well as ten teachers from five schools, focussed on one partner school's concrete experiences Lesson Study as a professional learning community.

Immersion program

Together with 33 American colleagues, one British teacher and the organisers of the Immersion program we visited/participated in:

a. Elementary/secondary schools/classes in the prefecture of Tokyo and the prefecture of Yamanashi;

[1] https://www.marnixonderwijscentrum.nl/nieuws/ArticleId/66/vrijdagmatinee-lesson-study
https://www.marnixonderwijscentrum.nl/nieuws/ArticleId/70/studiereis-lesson-study-japan-2019
https://www.marnixonderwijscentrum.nl/nieuws/ArticleId/77/op-expeditie

b. Post-lesson discussions at school-, district and prefecture level.

Understanding problem solving

A Japanese mathematics lessons has four elements (Fujii, 2017): *Hatsumon* (opening with a key-question); *Kikan-jiunchi* (walking between the desks and making notes); *Neriage* (classroom conversations led by the teacher), including *Bansho* (boardwork) and *Matome* (summary). All these aspects are used to stimulate the Teaching Through Problem Solving process. During the classroom visits, I observed in each lesson parts of the aspects that are used to stimulate the process of Teaching Through Problem Solving. I found it remarkable that not all the elements were used in every Japanese Math Lesson. However, in most lessons I identified one or two aspects, which were excellently implemented. It was impressive to see how much effort the teachers put to their board work (Bansho). With the help of the board work (colourful, with paperwork) they used students' input to demonstrate the progression in the understanding of a concept.

Another point that I will use to support teams in the Netherlands is the use of the context to get into the heart of the concept. In Yamanashi, a teacher (Year 3) used the context of tennis balls in a tube of 4 balls to find a solution for the task 23 : 4. The question that the students needed to answer was: 'how many tubes does the teacher need to bring the balls in tubes of four to another place in the classroom?' Approximately half of the students thought the answer was five tubes; the other half thought the teacher would need six tubes. During the *Kikan-jiunchi* and *Neriage t*he students demonstrated their solutions and explanations.

In the post-lesson session, the Knowledgeable Other (KO) asked if the preparation teams had used the right context. He gave an example of the same task, where they were using 23 persons and boats. Every boat could bring four persons – at the same time – to the other side of the river. How many boats do we need? The KO explained that this context provokes students to think about problem solving instead of drowning in calculations.

The Lesson Study cycle

The IMPULS Lesson Study Immersion Program gave me the opportunity to experience first-hand the tremendous amount of work Japanese teachers put into the execution of a Lesson Study cycle: from preparation, to logistics and the post-lesson session (e.g. storing away the chairs). Power to the teachers!

I found it very useful that we had a short meeting (pre-lesson session) about the goals, concepts and position of the item in the curriculum of the research lesson before we observed a lesson. It provided my colleagues and me with an update on the 'state of play' and it prepared/inspired us, the observers, to observe the lesson and to participate in the post-lesson session.

Another valuable learning point for me was the structure of the post-lesson sessions. I learned that:

a. it is important to make a short list – in cooperation with the participants - of subjects you want to discuss during the post-lesson session;

b. important items to discuss during a post-lesson sessions are: tasks; the data (results) of the students to the task; how the task worked out; the anticipations of the students' results vs. the information they received, and the outcome: what does it mean for the next step; has the task has made a change in the thinking of the students?

For me, the Immersion program 2019 confirmed that the Collaborative Lesson Research Cycle (Takahashi & McDougal, 2016) is an effective cycle to make Lesson Study concrete in schools. For the Marnix Academy I developed the Marnix Academy Lesson Study (MALS) cycle, where the educational values (Fujii, 2017) of the Marnix Academy are integrated (Fig. 1).

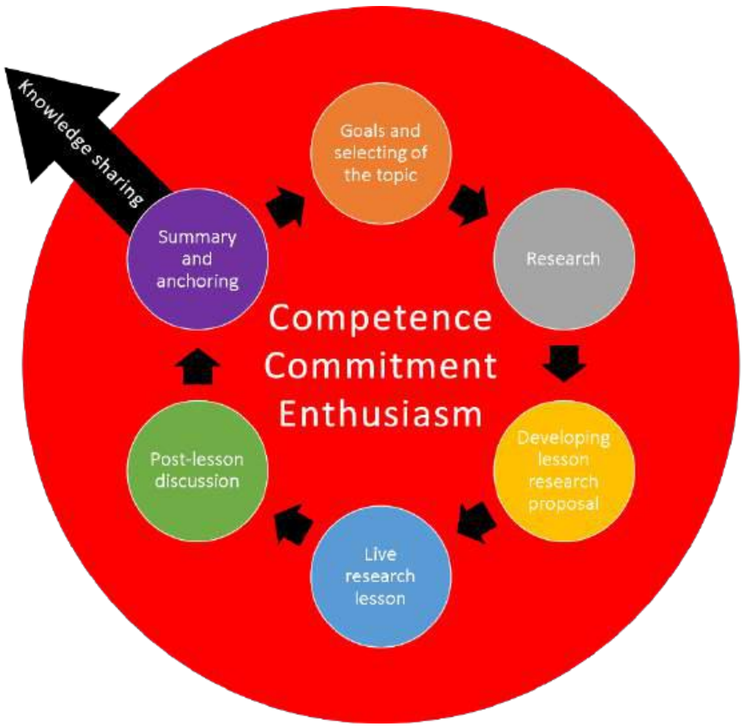


Figure 1: Marnix Academy Lesson Study Cycle

The design for the Lesson Study Training Program for the Initial Teacher Training at the Marnix Academy

At the Gakugei University, the students are three weeks involved in a year/period in a Lesson Study Cycle during the pre-service training programmes. It is short, but a very intensive time that the students are collaborating with their peers, teacher-coaches and University professors in a Lesson Study trajectory. During a walk, Prof. Fuji shared with me that the question of the school must be the starting point for the Lesson Study Cycle at the school. A point that is one of our bases at the Marnix Academy to bridge the gap between theory and practice. Next academic year (2019 – 2020), we will start with a pilot Lesson Study (Together on Expedition, TOE) at the Initial Teacher Training in cooperation with some of our partner schools. The subject will be: science and mathematics. Every subject has a KO from the University, a coach from a partner school and five students. Science will start with a Lesson Study Pilot where the students get their University lessons and research lessons at the partner school.

For the framework of the TOE program, we are using the three level model of Sugiyama (2008):

> Level 1: Teachers tell students important basic ideas of mathematics, such as facts, concepts, procedures and practices;
> Level 2: Teachers explain the meanings and reasons of the important basis content and practices of mathematics in order for students to understand them;
> Level 3: Teachers provide students opportunities to understand these basic mathematical content and practices, and support their learning so that the students become independent learners.

The Lesson Study pilots at the partner schools will focus on level 2 and 3: designing lesson plans; examining the effectiveness of the plan using mock-up lessons; learning basics for Lesson Study during student teaching.

For the practical part of the program we will study the Theory and Practice of Lesson Study in Mathematics (Huang, Takahashi, Da Ponte; 2019 -especially Part IV).

Conclusion

I have reached many of my goals and got a lot of input to concretize my plans with Lesson Study. Teaching through problem solving showed me that it is very important to choose the right context for the understanding of a concept. The post-lesson sessions taught me the essence of an easy structure and clear questions during the post-lesson sessions to get into a deeper level of the concepts of a lesson. Through the masterclasses, conversations and the literature I got a lot of concrete tools and ideas to strengthen the outlines for the Lesson Study Training Program at the Marnix Academy.

Next Steps

Upon my return Japan, I wrote a short blog entitled 'Power to the Teachers. In this blog, I shared my first impressions of the Immersion 2019 Program with colleagues of the University and the partner schools.[2] I also wrote a longer article for a Dutch Mathematics Magazine: 'Lesson Study in Japan', about the math lesson at the elementary school in Yamanashi.

[2] https://www.marnixonderwijscentrum.nl/nieuws/ArticleId/79/power-to-the-teachers

As a next step, the Marnix University will organise a Matinee-Cafe Lesson Study[3] for all the teachers in Utrecht in cooperation with Educational Institutions of Utrecht (e.g. the University of Utrecht, several elementary schools boards, etc.). In a hands-on workshop we aim to show participants how important it is to use the data of the students (notebook, conversations, reactions, etc.) to get an impression of students' understanding of the concept. The second part of the workshop will focus on the structure of a post-lesson session. We expect approximately 75 persons.

Closuring remarks

I am very glad that I had the opportunity to join the Immersion 2019 adventure in Japan. I thank all staff members and my new International Lesson Study colleagues for this wonderful experience! I recommend this program to all mathematics teachers interested in learning more about Lesson Study.

[3] https://www.marnixonderwijscentrum.nl/nieuws/ArticleId/81/matinee-caf-samen-leren-met-lesson-study

Francisco Luis -Llaguno

Bil. Kindergarten Teacher

ACORN Woodland Elementary School-OUSD

IMPULS–Lesson Study Summer Immersion 2019 Final Refection

I want to express my gratitude to **Project IMPULS-Lesson Study** at Tokyo Gaugei University for the unique opportunity to participate in this Program in Tokyo, Japan during the summer of 2019. As a veteran kindergarten teacher, I believe that children are the best hope that every country and the world has. Children represent the future of humanity in the world. Educating these children in all academic subjects, including mathematics, is a responsibility of educators and administrators in each country. I learned so much, along with other educators, from our visits to several schools in Japan. Although the focus of our visits was to immerse ourselves as practitioner educators into Japanese math lesson study, personally, I enjoyed observing that kids are kids around the world. I was delighted to see, during our visits to schools, that students are nurtured with music, games, sports, and lunch. I observed that students are very involved in their own education process and development. I noticed that students from early ages are encouraged to assume their own responsibilities and work diligently toward becoming independent learners. Students are educated with carefully designed and planned lessons by dedicated teachers and staff. I was amazed by the great level of collaboration, professionalism, respect and pride at the school communities we visited. I learned so much from observing live math lessons, and math lesson study sessions as professional development. I was inspired by observing students working diligently and engaged in classrooms discussions and note-taking. I also enjoyed the cultural experience of observing, and in some cases interacting, with students. I heard them talking, singing, performing, and acting as children. I observed their work and perceived their empathy and kindness even though we didn’t share the same language. I admired the dedication of teachers and staff in each classroom of the schools we visited. I am also very appreciative to professors, particularly to Dr. Fuji and Dr. Takahashi, grad students and support staff at the Gakugei University for hosting and meticulously planning our work, arranging our school visits, and sharing their research with us. I also learned so much from colleague’s perspectives during discussions.

At ACORN Woodland Elementary School, my school in Oakland, California, we have practiced lesson study for several years. We have been fortunate to be coached by Dr. Takahashi and Mills College staff. However, some teachers who initiated lesson study have moved, and new teachers have come in. It requires every new school year to motivate, share, update, and improve our practice of lesson study in lower and upper grades.

Lesson study has multiple aspects that I, as a novice in the field, find difficult to cover. My reflection is focusing on three major takeaways from my observations of Japanese Lesson Study that I will share with my colleagues at ACORN Woodland at the beginning of the school year 2019-20.

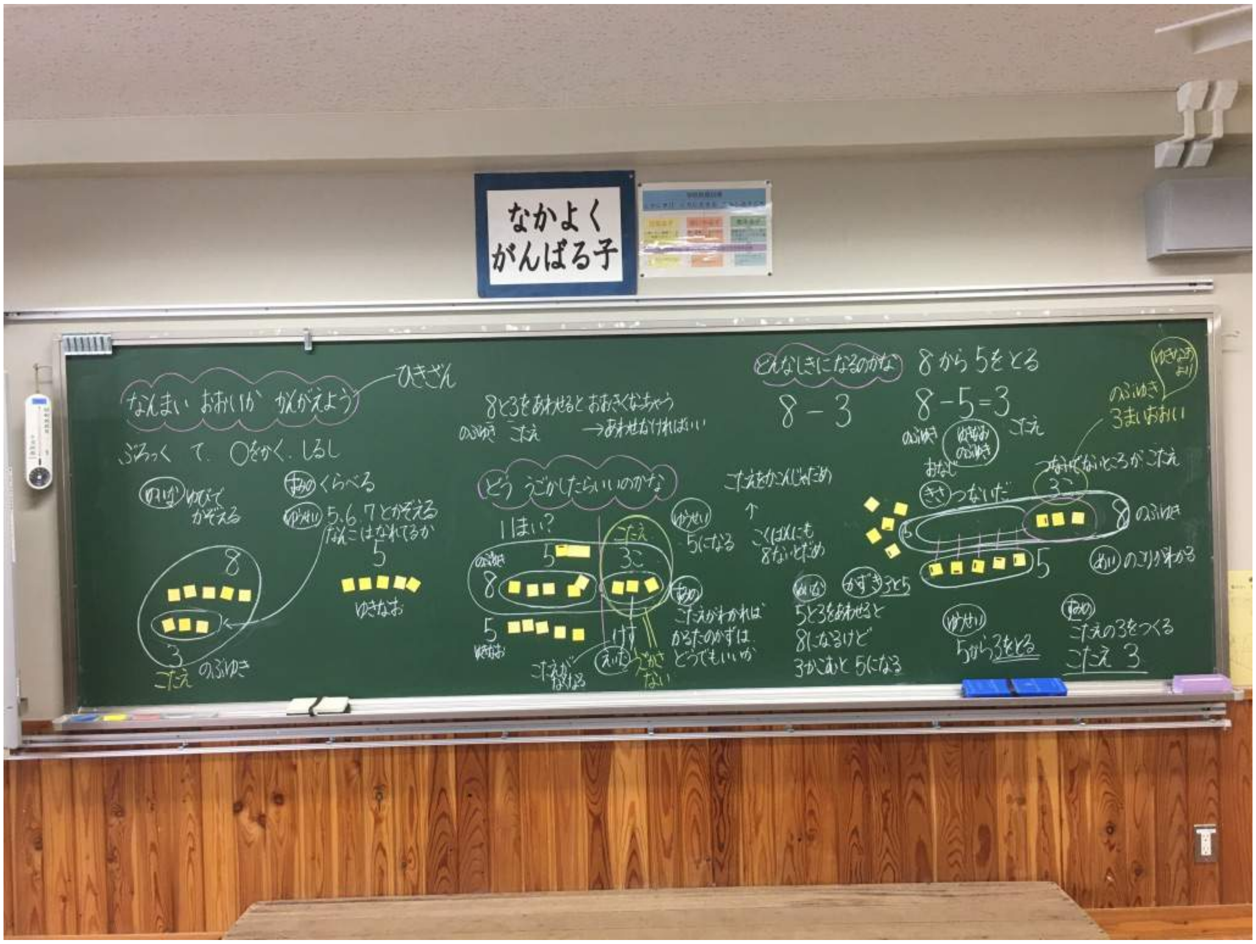
1. ***Neriage* is the core of the lesson; board work provides structure.** Based on my observations across all lesson we observed during the immersion program, I will make a rough analogy of delivering a lesson in lesson study with the human body: *neriage* is the muscle and board work is the skeleton or bones that provide structure to the lesson. I noticed that the board work records and reflects the mathematical reasoning that students present during *neriage,* which is the whole class discussion. It has a logical sequence. It involves mathematical concepts, relationships, operations and algorithms. It is a visual tool for students to see and clarify misunderstandings after working independently solving a problem. Students are engaged in understanding new concepts and developing their own notes in journals. Board work reflects the natural direction of the discussion based on students understanding and lesson study design. In most cases board work evolves logically for students to get to the desired conceptual learning; in other cases it reflects the need of review previous concepts taught. In summary, board work speaks by itself.

2. **Teachers must be skilled in facilitating *neriage* and record ideas on the board by**: a) providing opportunities for students to express their own ideas after struggling to solve a problem; b) capture the essence of the student's mathematical reasoning or provide opportunities to students to come up to the board to write their findings; c) monitoring the time during *neriage t*o be productive; d) monitoring the flow of communication during discussion to be done from students to whole class, not from student to teacher or deviated to a lecture from teacher to students; e) use clear handwriting to permit students to visually understand the logic sequence of the discussion; f) indicate and label reasonings that look similar and can be organized together or can be differentiated; g)

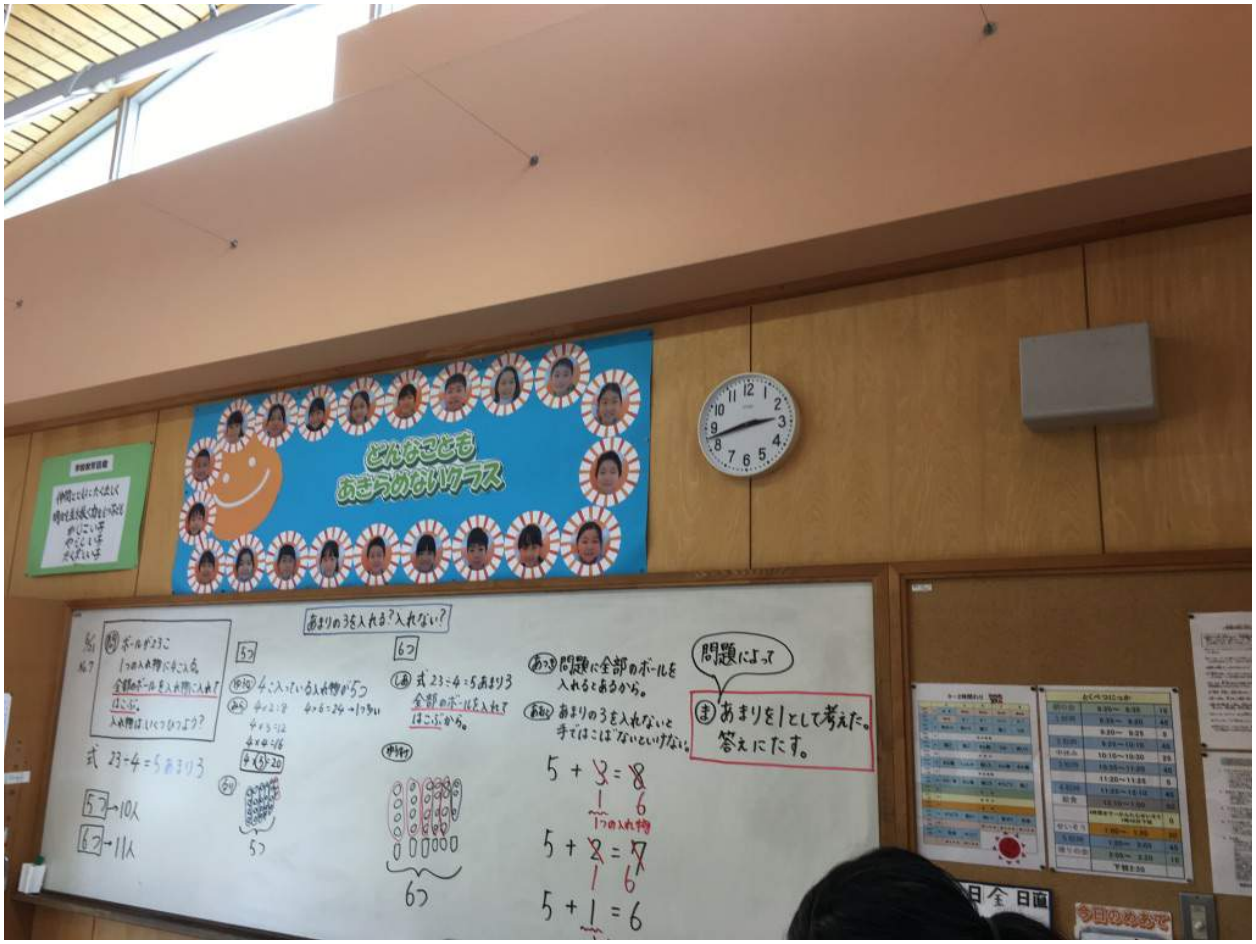
reiterate conceptual understanding; h) use graphics or lines to establish relationship of ideas and concepts, and g) facilitate that the lesson discussion gets naturally to the desired and planned conceptual understanding, or in some cases to clearly reflect student's need of reviewing previous taught concepts.

3. **Teachers need to be trained to conduct lesson discussions.** In order to be good facilitators during lesson discussion and board work, teachers need to be trained on: a) understanding math content during lesson study planning; b) understanding standards, goals and sequence of lesson; c) developing skills to understand student's ways to express ideas and summarize the essence of the student's reasoning on the board; d) developing a sense of time and spatial sense when handling work board; e) monitoring an equilibrium of student participation to reflect as many ideas observed during individual work; c) stick with lesson plan without interrupting the natural flow that the discussion is taking; d) be able to recognize misconceptions and misunderstandings and address them appropriately; e) be clear of the desired mathematical conceptual understanding without forcing to get to it, but encouraging students discussion to reach to it, and f) be flexible to recognize the student's needs to review previous concepts taught when the discussion is not reaching the lesson's goals.

I understand that growing as teachers takes time. I appreciate the opportunity to participate in this project and hope that the learning from this program will be reflected in my daily teaching practice with my kindergarteners this school year. I also hope that my contributions will help my school community. I hope to follow up and contribute to the work of project IMPULS.



Picture 1: Board work of Grade 1, Number 2 class, lesson: What is left and what is the difference? University of Yamanashi, Facility of Education, Attached Elementary



School, on June 22, 2019

Picture 2: Board work of Grade 3 Lesson: Let’s think about division (division with

Remainders) Showa City, Oshihara Elementary School, on June 21, 2019

Picture 3: Grade 4, Quadrilaterals; District Wide Lesson Study at Denen Chef Elementary School on June 26, 2019

Maira Lopez Cruz
2019

Final Reflection for Project IMPULS and Key Takeaways

As a first year teacher, I feel grateful to have been part of this incredible program. After I participated in the IMPULS - LSA Lesson Study Immersion Program this summer in Japan, I feel like I've gained many tools to enhance my teaching practice. Within the short 10 days, I learned so much from purposeful discussions, observations, and reflections.

Takeaways:

Getting the opportunity to visit Japan and be part of the lesson study changed my perspective about lesson study. Visiting Japan allowed me to experience and be part of a professional community of dedicated educators. It was clear that every participant in the community was involved and valued the work around lesson study. I really appreciated how educators in Japan worked collaboratively in their community. It was visible that teachers and faculty in Japan have strong values and interest in their work. Norms like sharing a common space to plan and communicate daily has benefited the community. Planning in a common space is a great strategy and would be beneficial for teachers in the U.S. I believe It will allow teachers to feel supported and not so isolated.

I thought it was amazing how every teacher, including nurses and liberians were involved in lesson study. I find that extraordinary especially, because there are teachers in the U.S that push back participation when its not their grade level or subject. I believe that having everyone be part of the lesson creates a sense of community within teachers and students. Another observation that I made was how the teachers that presented the lesson took feedback from co-workers and speakers during the post lesson. At multiple schools it seemed like teachers seriously listened to everyone and tried their best to understand their perspectives. This showed that teachers were open and eager to learn from others rather than taking the feedback personally.

I was blown away with the amount of rigor that students were given. The content and the questioning were challenging but presented in an interactive way. I felt that I learned the most from the third grade lesson that we observed. The lesson provided students with time to explore and interact with the problem.The problem that included physical tennis balls was engaging thanks to the teachers background knowledge of her students. Teacher had great pre planned questions with anticipated responses that were clearly asked to further students understanding of the concept.

Overall I truly appreciate the opportunity to have participated in the IMPULS program alongside talented and strong educators. I'm excited to take my learning into my own practice as an educator.

Malia Vitousek
Summer 2019

Project IMPULS- Lesson Study Reflection

The Project IMPULS lesson study program was highly informative, enlightening and thought-provoking. Through observation and discussion of Japanese teaching and professional development practices, my view of student and teaching learning has broadened. While my current school, Acorn Woodland Elementary, has a fairly robust lesson study practice, there are many components of lesson study which I hope to strengthen or encorporate.

Major Takeaways:

1. **Student Welfare:** In schools we observed I was very struck by student independence and responsibility. Students opened and closed the class periods. Students raised questions, shared thinking, and often drove learning. Students carried multiple responsibilities around the school, including: serving lunch, cleaning classrooms and school buildings, maintain libraries and public resources. Additionally, students were given, seemingly, more independence during free time and breaks. Students were able to freely walk through the halls, talk and play with friends, and be kids. In my school experience, in the US, students are not given as much responsibility or as much freedom. I would love to cultivate a more trusting environment at school so that students are able to develop more independence and pride in their learning.
2. **Professional Development as a Community:** As a teacher, I often feel that it is my responsibility to create professional development opportunities or to grow my practice by seeking out books, courses, and lectures. However, what I observed in Lesson Study in Japan, teachers are constantly collaborating to grow. Whether in school offices where desks are set up to foster conversation and idea-sharing, in school-based lesson study where are staff members are active in planning and discussion, or district-wide lesson study where teachers come together to discuss challenges, successes, and learn from one another. Development does not happen in isolation and it is all the more powerful when teachers have the opportunity to connect and foster one anothers growth.
3. **Strong Questioning as the Foundation for Math Instruction:** In my opinion, the most effective lesson we observed began with relevant, challenging questions. Students then were posed additional probing questions during the neriage phase. Students, ideally, were asking questions of one another as they attempted to solve and understand each others solutions. Lessons that did not feel as successful often had few questions and more teacher-led explanations. Planning for the inclusion of thought-provoking, guiding questions, is certainly a challenge, however, developing a deep foundation of content knowledge, as well as understanding your students strengths and needs, can lead to better questioning and high student achievement in math.

I deeply appreciate the opportunity to participate in the project IMPULS Lesson Study Alliance program. I hope to take what I have learned, share it with my school community, and better serve my students. Thank you.

After a very rich meal, I am wont to talk a long walk and perhaps take a digestif with friends. For the past three weeks I've been digesting this amazing Tokyo experience with some mental walks, with some readings, and discussions with colleagues. This reflection wanders quite a bit, so let me preface with a list of destinations:

1) What struck me during our time at TGU and the Tokyo public school system

2) Systematizing the progress toward level 3 teaching seems to be working at some level.

3) I'm seeing connections to research I have read previously that supports why Lesson Study and TTP are working.

4) How will this experience change my work this year?

1) **What struck me during our time at TGU and the Tokyo public school system**

a) Kids are kids: observing students in the classroom and having a focused discussion on what we saw together is an amazingly rich experience. I knew already that I would love seeing the insides of schools, and debriefing the lessons with skilled observers, but was so glad we also had the opportunity to meet students over lunch! To see the students behave so differently during a class than kids here in the schools where I work was so eye-opening. Once the lesson was closed, however, they seemed just like mine! The culture of respect for community, cleanliness and fulfilling one's purpose struck me at each of the different schools.

b) Dr. Takahashi's slides showing the levels of teaching and then the achievement of Japanese students on the TIMSS exam were eye-opening. These have come up for me again and again as I absorb and consolidate my experiences. (It is also on p. 168-169 of *Essential Mathematics for the Next Generation*, which they generously gave to each of us.) The Japanese students and grades 4 and 8 were able to successfully tackle problems they had not seen before to a greater degree than kids who had been through more curriculum in both Singapore and the US.

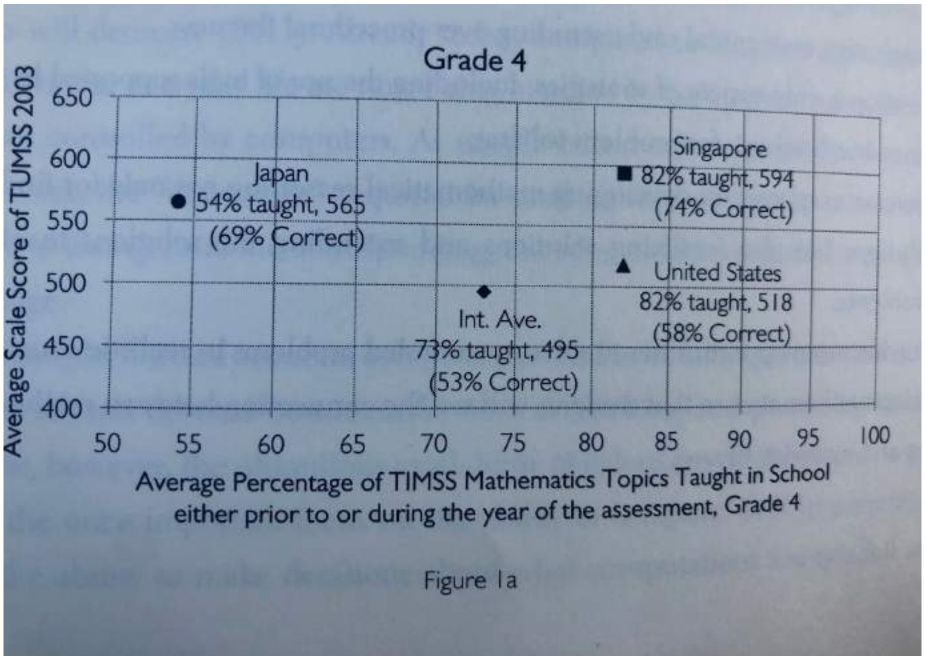


Figure 1a

c) When Tokyo decided to not hire new teachers and instead to let the overabundance of the workforce "age out" in order to decrease the surplus of teachers needed relative to the falling student population, the result has been a dearth of older teachers available now to mentor and model Level 3* teaching to a very green workforce. We need to use our existing great teachers effectively to continue to manage homeostasis of the workforce, or even better, to improve our system and help move all teachers to Level 3 teaching.

When talking about effective teaching, I will use Sugiyama's (2008) three levels of teaching as a framework. These three levels are:

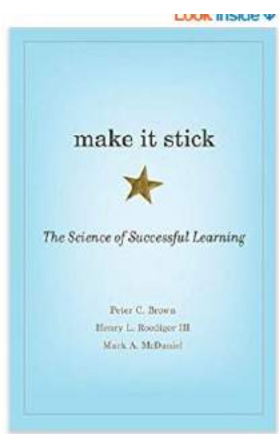
- Level 1: Teachers tell students important basic ideas of mathematics, such as facts, concepts, procedures and practices.
- Level 2: Teachers explain the meanings and reasons of the important basic content and practices of mathematics in order for students to understand them.
- Level 3: Teachers provide students opportunities to understand these basic mathematical content and practices, and support their learning so that the students become independent learners.

d) While we did not get an opportunity to converse with all of the teachers to get their insights into how they felt Lesson Study improved their practice, we did get that opportunity with the TGU middle school teacher on June 25. He did value the feedback and did not shy away from it, reasoning that how else would he be able to improve if he didn't get it? Again, this seems to be a cultural difference between many teachers in the US and those in Japan. While there are many teachers I work with who are reflective and actively looking to improve their practice, there are more who show up between vacations, working hard each day to get through curriculum and enjoy the students, but don't want to be hassled by PD. Helping my teachers see reflection and critique as essential to becoming a Level 3 teacher is an area I would like to focus on this year in my Lesson Study work. I have seen this with colleagues who already understand this dynamic and with whom I have a trusting relationship. Is there a vehicle for spreading the cultural norm that seems to exist in Japan?

3) I'm seeing connections to research I have read previously that supports why Lesson Study and TTP are working.

Last year I listened to the audiobook version of *Make It Stick: The Science of Successful Learning* by Peter C. Brown, Henry L. Roediger and Mark A McDaniel. I was struck then and have since revisited and yes, been re-struck, by how congruently readings support this TTP method:

I highly recommend you give this book a listen/ read!



"Learning is acquiring knowledge and skills and having them readily available from memory so you can make sense of future problems and opportunities." (Chapter 1) This is the basis for all the unit planning I've seen and heard in TTP and Lesson Study.

Rereading notes or text is one of the least productive strategies for effective learning. Along with massed practice (drilling of a skill or content), rereading a text or notes are two of the least productive methods, despite their apparent evidence of fluency. Mastery, or durability, of a topic is achieved through harder, more effortful (and productive) struggle. (Chapter 1) I see this as evidence that the textbook should not be used, but taught.

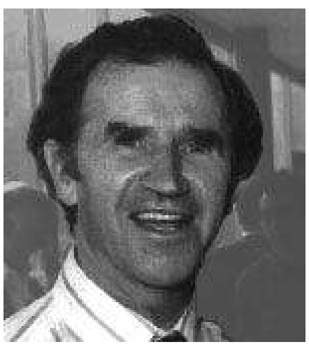
Having to solve a problem you haven't seen before makes for stronger learning, even if there are mistakes in the original solution path. (Chapter 1) This is the essence of TTP.

When you are adept at picking out the underlying rules of a concept, you are more successful at solving problems in unfamiliar situations. (Chapter 1) This supports the evidence from TIMMS showed by Japanese 4th and 8th graders solving more problems than they had been exposed to previous to the test.

“Reflection can involve several cognitive activities that lead to stronger learning: retrieving knowledge and earlier training from memory, connecting these to new experiences, and visualizing and mentally rehearsing what you might do differently next time.” (p. 27)

“All new learning requires a foundation of prior knowledge...If you’re just engaging in mechanical repetition, it’s true, you quickly hit the limit of what you can keep in mind. However, if you practice elaboration, there’s no known limit to how much you can learn. Elaboration is the process of giving new materials meaning by expressing it in your own words, and connecting it with what you already know. The more you can explain about the way your new learning relates to your prior knowledge, the stronger your grasp of the new learning will be, and the more connections you create that will help you remember it later.” (p. 5)

This morning I read a fascinating article, *Relational and Instrumental Understanding* that struck this chord again. https://www.atm.org.uk/write/MediaUploads/Resources/Richard_Skemp.pdf



Richard Skemp, University of Warwick, writing in the 1970s, discusses relational and instrumental understanding of mathematics. His preference (and mine) is for teaching so that students develop relational understanding in mathematics makes use of an interesting analogy: He describes a music curriculum in which children are taught that the five lines of a stave represent certain letters, as do the spaces between them. They learn to distinguish different symbols and their names (what we call “notes”). The children have lessons in music every day and are told it is important. They learn to write the notes onto the musical 5-line staff, and how to write certain popular songs correctly. They learn to distinguish what key a piece is written in, how to transpose a piece between the key of C and the key of A. The process involves lots of memorization and recitation. When the children are asked to write an accompaniment for a certain melody, or string of notes, they are overwhelmed and quit in frustration.

Another group of children might be taught a different music curriculum that begins with learning to associate the written notes with certain tones. Children spend several years learning to make tones on instruments themselves and soon can imagine the sounds just by seeing the written sounds and can create their own melodies through improvisation.

Teachers will only be able to teach relational understanding of mathematics if they have had the opportunity to have that kind of understanding themselves. When we give teachers who do not have it a text that is written with that approach, they will only be able to filter it through their instrumental lens. Regularly practiced Lesson Study has been the way to bring teachers into the mindset, experience and finally, expertise needed to teach mathematics with relational understanding.

One other great analogy I read since my return came from blogger Chase Orton, writing about his work with teachers and lesson study,. He wrote about how one could imagine a faculty at a school much like a football team. It is worth a read and I would love to hear your impression. I'm planning on trying this analogy out this year as I try to encourage teams to sign up for grants for lesson study.

http://undercovercalculus.com/why-lesson-study/

4) How will this experience change my work this year?

In PAUSD, we do have a small number of curriculum coaches who will work with teachers who raise their hand for help, but this is not a system. My work this year will be to start a lesson study group at my own site and engage district coaches. To further promote Lesson Study I will work to get groups I could coach involved through Silicon Valley Math Initiative, and to bring as many people as possible to the Nueva Innovative Learning Conference Lesson Study Day on October 16 in San Francisco. I hope my IMPULS colleagues will join!

https://svmimac.org/
https://www.nuevaschool.org/conferences-institutes/innovative-learning-conference

We do have standards of teaching in PAUSD, which every new teacher spends 2-3 years proving they have "mastered" and then teachers continue to revisit them in some form, albeit not in a publicly accountable way. One of those ways could be a study group, so I need to explore if Lesson Study could become one of those ways and then, if so, work to get it systematized.

Teachers do theoretically have time to collaborate by grade level and across grade levels in PAUSD, but again, it is not systematic or publicly accountable. We do provide lots of opportunities for teachers to become very good at Level 1 teaching: "Opportunities to learn through reading books and articles, listening to lectures, and watching videos or demonstration lessons. We provide limited Phase 2 PD for those teachers who opt in to special study groups or PLCs. But we miss the mark by not having regular lesson study groups, that would provide "opportunities to plan lessons carefully, to teach based on the plan, and to reflect upon the teaching and learning based on careful observation. I now see the imperative of Dr. Takahashi's four bullet points, all of which are provided by Lesson Study:

- More opportunities for analyzing student learning processes.
- More opportunities for receiving and providing critical feedback on teaching.
- More opportunities for reflection on teaching based on the evidence of student learning.
- More opportunity for collaboration on designing units and lessons with reflection.

I am very eager to continue my conversations with my colleagues here in Silicon Valley who brought Lesson Study out here about how we continue to structure our work with teachers. I know I had the misconception at first that the lesson had to be taught by someone other than the students' classroom teacher. I did get that straightened out a long time ago, but now I realize there are other "snafus" with regards to whether or not we are really doing Lesson Study.

- We encourage teachers to focus on planning the lesson together and choose the person who will teach the lesson at the last moment. This is to encourage all teachers to participate fully in making the decisions and the plan being a group product rather than one person's usual steps. (We do encourage understanding the students who will be taught in depth when it is a lesson taught at their school.)
- We have demonstration lessons using classes that are completely foreign to the teaching team, so that we have the opportunity to watch a lesson together and discuss it.
- Administrators are regularly not involved, or seen as educational leaders who would provide useful insights
- We rarely have a knowledgeable other at the end of a public lesson. I recently added this back into the sessions I was moderating and found it immensely edifying. I am going to encourage the return of this practice for SVMI.
- Dr. Takahashi mentions in his article, *Essential Mathematics for the Next Generation: What and How Students Should Learn*, (p. 166-174) there is limited evidence of Lesson Study outside of Japan having an impact on teaching and learning. I did hear the Chicago teachers talking about Collaborative Lesson Research, so I am eager to learn more about that this year. I am hoping to attend the Chicago conference in April, as well as have them come west to collaborate at public lessons.

I have found Phil Daro's article "Taking Time to Make a Difference "(p.130, <u>Essential Mathematics for the Next Generation</u>) wonderful as I think about the moves I make as a teacher in a math lesson as I try to pick up the Teaching Through Problem Solving Method. I am going to be sharing this with my colleagues!

Not last or least, another area I struggle with is the journals. Having a son who is not interested himself in writing down his thinking, but will do so beautifully if given the opportunity to talk, how to build in scaffolds or allowances for that difference? We didn't hear discussion at all of learning differences or modification structures. What is the thinking about addressing cognitive differences among learners in a homogenous classroom? As I continue to learn about TTP, I am eager to learn more about this.

As with all good learning situations, I feel full but hungry for more. I am eager to continue the work. Thank you for this amazing experience! I look forward to our future work together.

IMPULS Lesson study - June 2019

Anthea Oppong-Kwarteng

During my time in Japan with IMPULS, I was eager to observe lesson study to uncover the secrets to success for a Japanese lesson study. What I uncovered was a complex, multi-layered approach to teaching and a new perspective of lesson study as the future of continued professional learning.

I was honoured to witness first hand high impact practices in a range of schools across Japan, yet simultaneously concerned over how I could possibly translate all I was seeing to my colleagues in the UK. Prior to my arrival, I curiously pondered how large the gap between my diverse, inner-city London pupils and those we observed would be, perhaps they would be too far ahead to compare? Immediately we met children through a cultural exchange program during our first visit at Kunitachi Daigo Elementary school and all my qualms were quickly hushed 'kids are kids' after all, as Dr Takahashi often quipped. The children impressed me with not only their reasoning and subject knowledge, but mostly with their classroom culture. Along with my American colleagues, I met a class of inquisitive fifth graders from Tokyo, who were keen to learn about kids like them on the other side of the world. I was immediately struck by their confidence and charisma, which veered slightly towards boisterous as well as their curiosity. Later we shared lunch together, served by the students, who impressed me further with their maturity and consideration, no one ate until everyone had been served, a cultural practice with morals embedded to encourage patience and community, values which were consistently present across all seven schools.

Upon reflection, across all the varying schools we visited in Tokyo and Yamanashi the following high impact practices were evident:

Student conversations: How can teachers ensure high quality discussions emerge throughout the lesson time?

- Angles lesson in Yamanashi- teachers engaged learners through creating a disequilibrium and debate amongst learners.

- Division with remainders lesson in Yamanashi- teachers also used debate but ignited by a clear, visual context to a relatable problem. The children connected with and invested in the problem meaning they all understood the problem and were engaged throughout the lesson to participate actively in the discussion. Their active participation took the form of: pupils presenting their thinking on the board, explaining and debating with their peers.

Teacher questioning: What kind of questions can facilitate high quality student discussions? Teachers seemed to focus on high level questioning to steer learning forward and drive the momentum at carefully considered points. Teachers rarely accepted an answer without reasoning, creating a stimulating learning environment where pupils questioned each fervently.

Setting clear and realistic lesson goals: Are the learning goals clear to observers and children alike? How does the task lend itself to the goal being achieved? Is it effective? How can teachers measure the effectiveness of the task? I fervently etched these questions into my notebook and mind after observing a series of lessons.

Lesson study provides teachers with an opportunity to plan detailed lessons together, with a detailed explanation of what has been covered so far. A summary of what is to be achieved and how (the micro steps to achieve each goal).

Goals broken down into subsections: -

1. ***Interest and motivation***- creating a context that the children are hooked into
2. ***Mathematical reasoning-*** to be able to show the concept in a range of ways CPA- concrete, pictorial and abstract all represent a unified idea.
3. ***Skills and procedures-***
4. ***Knowledge and understanding-*** misconceptions understood and avoided through questioning and resources

These subsections taken from a plan for a grade 3 lesson on division with remainders at Oshihara school. This left a lasting impression, the children were hooked immediately with the idea of their teacher needing cases for the tennis balls she had. They scrambled, enthusiastically at the end of the lesson to see how their problem solving had resolved the issue at hand. No translation was necessary to see that every single child in that classroom was invested in solving this problem, due to the story their teacher (and others involved in the planning across the district) had concocted to their delight. Despite over forty observers and the uncomfortable heat, all children remained engaged throughout the lesson, no disruptions or visible behaviour problems.

Detailed and constantly revised plans: I was interested to see that teachers do not engage in a lesson study pre-brief, the plan is updated and altered continuously right up until the lesson. It is the responsibility of individual teachers involved in the study to ensure they are up to date with the most recent plan. The balance between community raising teachers (novice and experienced teachers work side by side) was emphatic, however this is equally balanced with personal responsibility. Any teacher who veers too far off the collaborated plan must justify their decision making during the post-lesson discussion. In our first post-lesson discussion, a teacher was questioned by his peers as to why he ventured off the plan, this prompted a calm yet debate amongst teachers over how best to approach proportionality.

Anticipated student responses: How well do you know your children? Teachers always planned in a detailed set of anticipated responses and planned in their questioning, considering how best to overcome misconceptions as well as keep the momentum going to achieve learning goals.

Experimenting and risk taking: Teachers use lesson study as vehicle for trialling changes in the curriculum. Lesson study is to help teachers prepare for the change by providing a space for teachers to experiment and try out new ideas to support learners before the change is fully implemented.

Let's Explore quadrilaterals lesson- grade 4 at Denenchofu Elementary in Tokyo- the lesson was discussion based, focused on group work and the use of concrete materials and cumulative learning to deepen understanding. The task set was well pitched for both levels of challenge as well as effective use of group work for cumulative learning.

What new insights did I gain during my time, during my own experience of lesson study, prior to arriving in Japan and working with IMPULS I was yet to see the role of the knowledgeable other in practice. It was interesting to hear the insight of university academics who were affiliated with the schools', critique and question decisions made, to help unpick learning. This provided many points for consideration during our small group reflections. I am now looking to liaise with academics in the UK who understand the culture of our school, to work alongside teachers to push our post lesson discussions further.

It is easy for those who have yet to experience lesson study to view it as something separate from everyday teaching and learning, but this trip truly inspired me to view lesson study as something much more than a whole school approach to developing teaching and learning. Lesson study is about creating a professional learning community, where teachers across, schools, districts, countries and cultures can cross boundaries, experiment, explore and risk failure to learn.

DeVaughn D. Exum
Bret Harte Elementary School
IMPULS Lesson Study Summer Immersion 2019

This summer, I had the honor to experience a truly eye-opening education culture that truly put student learning first. Along with my colleagues and other educators from around the world, whose work impacts students across ages, languages, and grade levels, I was invited into various classrooms and schools and gain many insights that I can bring back to my school, my district, but most importantly, my students.

Culture of Constructive Criticism

One of the biggest lessons that I have taken from the Lesson Study Program is how the culture of constructive criticism influences all aspects of the teaching process. Japanese teachers spend their field study time doing lesson study alongside their partner teacher during their teacher education programs. These incoming teachers spend three weeks developing lessons with a team, performing public lessons, and having those lessons critically analyzed by the entire school staff. By having aspiring educators practice this style of open, constructive criticism during their teacher programs, it lays the foundation for educators to have honest, detailed conversations about whether or not the students learned the desired objectives from the lesson. Teachers take time and practice giving and receiving criticism that is focused on the lesson and not a personal critic of the educator. This shift in how they process criticism allows for more authentic feedback. Teachers do not take the critiques personal because they are aware that the goal of the critiques are to create the most efficient learning experience for the students.

I want to bring this constructive criticism back to my school site. This upcoming school year will be the second year of school-wide lesson study for our professional development model. Although my grade-level team conducting Lesson Study and public lessons for the past 3 years, I am aware that I have coworkers who are still getting comfortable with the process. By bringing in knowledge, experiences, and examples gained on this trip, my coworkers and I can work to build a safe space where our staff can have these constructive conversation and understand that the critiques are not about the individual educator, but about student learning. This does not always come naturally for U.S. educators and I want to build this into our staff culture.

Math Discussions

Another key takeaway from the program is the emphasis on student talk during lessons. I can speak from myself when I say that the debrief portion of the lesson is not always the focal point for learning. Visiting various Japanese classrooms really highlighted the necessity for students to always have chances to talk during lessons. Many of the lessons we observed were designed that have students spend a large portion of any math lesson talking and sharing their thought process with the class. IN my own experience, this is not usually the case. As I continue to build my practice, I want to work and create lessons where students need to talk and share their mathematical thinking aloud. By having different students share their ideas, the whole class can create understanding from a lesson.

These math discussions amongst the educators and staff are also essential for a productive lesson study. The honest post-lesson discussion can provide data to be used to improve future lessons. When you have 15-25 staff members watching a lesson in real-time, the data provided can be overwhelming. By having enriching discourse, the teachers and staff and can share their noticings and use their background knowledge of the students to give customized, useful information for the teacher to use. For example, an observer can bring new insights that the lead teacher may have missed during the lesson. This is needed for student growth.

Planning

The level of planning that goes into each public lesson is amazing. Many teachers had their desks grouped with their grade level partners, allowing them to easily communicate and work together when needed. This was common across multiple schools we visited. Teacher truly know and understand their classes. In one public lesson, the teacher anticipated the exact student responses and which percentage of students would follow various methods. This level of accuracy highlights the relationship and connection that educators must have with their students to provide the individualized education each student deserves.

Summary & Next Steps

In summary, I am still in awe of the work that I saw during our tours of various elementary and secondary schools. And this awe has inspired and invigorated me to build this space at Bret Harte Elementary school. As a staff, we are working to shift our school culture to one where teachers and staff members can have those, although sometimes difficult, honest conversations about the effectiveness of our own teaching practices. During this second year of school-wide Lesson Study, our school will continue to focus on developing independent learners. One way we can do this us by getting to know our colleagues. We can gain so much by knowing and trusting our fellow educators. They told essential knowledge about our students that we can use when developing lessons. By talking and learning about other teachers, we can build the rapport needed to accept constructive criticism because we understand that the criticism is not personally, but for the betterment of our students. WE can learn so much by talking. This is my main takeaway from the IMPULS Program -many of these actions are simple. By talking to each other and allowing the space for students to talk to each other, we can set our students up for understanding and success. By adopting these common strategies like group planning and allowing student talk time, we can drastically improve our practice and out student's overall abilities as young scholars. I am excited to bring the observations, techniques, and skills back to my school staff so we can have another year of student growth. I;m ready to do the work.

Jacqueline Smith
Bret Harte Elementary School
Kindergarten Spanish Immersion Teacher

Lesson Study Reflection

It was truly an honor to be part of such an inspiring group of educators and people who care about the future of our children. Working this summer and learning in Japan opened my eyes into a world of possibilities for my students and my fellow teachers at both my school and in the Bayview community of San Francisco. I am a Kindergarten teacher at Bret Harte Elementary School and was in Japan alongside three of fellow colleagues. Last year was the first year my school went whole-school with Lesson Study, and I was able to teach a public lesson in my classroom. This upcoming year I will be part of the Teacher Fellowship and will lead Lesson Study in the lower grades K and 1. I know that participating in this program, learning alongside everyone, and seeing firsthand how different schools and grades do Lesson Study will only expand the excitement and drive needed for Lesson Study at my school.

There were many things throughout this programming and learning period that stood out to me and provided me with ideas to improve our practice at our school. It is important that during a public lesson, all staff are there because the students are all of our students. In order to ensure success of students throughout the school, everyone at the school must support each other. It is also a great opportunity for teachers to really understand what is going on in each other's classroom, and gives opportunities to observe fully the lesson, students, and their learning. This can only rally happen through the use of a live classroom setting. Lesson Study also allows for teachers to work together to fix the learning gap. The teachers at my school are all passionate about their practice, teaching, and students, but it is also crucial to bring that passion to help each other so that all students throughout the school can benefit as much as possible.

At our school, Bret Harte, we are all working collectively on creating more independent learners. With Lesson Study, the teacher can provide students with opportunities to understand these basic ideas, and support their learning as these students become more independent learners. Students are encouraged to help each other, especially when there is a high number of students. This independent learning style was noticed not only during math lessons, but also during lunch, PE, and other class subjects, even in the lower grades. Students helped pass out lunch, moved tables around, and worked together throughout the day. It was clear that they were taking ownership of their classroom community and learning, and were thus much more successful during times of math discussion, or "Neriage". Kids need to talk more with each other and rely less on the teacher, allowing the learning process to actually be their own.

Intention and thoughtfulness is vital when creating lessons and planning. In the Japanese classrooms we observed, board-work was precise, clear, and well-planned out. The students often reflected back on their notes throughout lessons, and using the clear board-work encouraged the students to take their own targeted and organized notes. This is beneficial in my classroom, but also throughout my school. I currently teach in a Spanish Immersion classroom, and many of my students are new to learning the language. This organized and intentional board-work could really benefit all my students, but especially my Spanish Language Learners.

During one of the public lesson discussions, the final commentator noted that students cannot understand without teacher questions- thee questions need to be prepared and focused in order to prompt learning. Teachers need to think about how the students think and how they can connect with each other. When creating the lesson, teachers need to focus and plan inadeptly, and during the lesson, teachers need to be walking around and seeing students in order to continue the lesson. The most successful lessons I witnessed were the lessons where the teacher constructed the lessons based on student voices. Teachers also validated frustration and encouraged students to build off of each other to continue the discussions and learning process. Students need the opportunity to debate and discuss in order to create dialogue and learn from each other.

A great takeaway from observing Lesson Study firsthand in Japan, is that teachers are continuously learning and that it important that we care about the process of both teaching and learning. In my school, this will be our second year using Lesson Study as a whole school and I truly look forward to seeing the enhancement and upward spiral of learning in both or professional development and lessons in the classroom. Last year, many teachers at my school were apprehensive about this approach to professional development, but I believe that this year will be much more impactful and successful. We now have five classroom teachers who have gone to Japan, as well as our principal, and other teachers were encouraged based on last year's successes. Lesson Study allows for teachers to support each other, and build a better community for the students. This whole process is to benefit our students, and it is truly essential that teachers, faculty, staff, and administration not only witness the learning going on each classroom, but are involved and can help support the children throughout our community of learners. I am hopeful that the newness and thus trepidations of my colleagues will subside this year, and we can continue to build excited, engaged, and encouraged independent learners at our school.

Jade L. Meza Lyon

LSA 2019

First and foremost, it was such a pleasure getting to engage in an amazing experience. I would have never dreamed that as a teacher I would get to visit another country to see how they do my job there. I had this impression of Lesson Study before I went and have a completely different perspective of it since engaging in the Alliance. I remember being so hesitant and skeptical of the process--mostly because I did not fully understand it or its purpose. But now I really think that the process of Lesson Study should be a part of a developing teacher's learning; I think it allows for an educator to truly engage in the work being done in the classroom. The process allows for you probe the mathematics as well as how children learn in order to better implement a lesson and mathematical practices. When I went into the program, I truly felt that Lesson Study was just an additional item on my to-do list that would end up costing me more energy and adding more stress. Yes, it is true that it takes a lot of energy, I now know that it is well worth the "trouble" because it makes you a better educator and actually affects student learning. My goal is to now have my school's model of Lesson Study appear more like that of the model done in Japan. We had somewhat cohorted and overly structured our Lesson Study in our school when it should be more organic (but this could be because we needed to learn all the components of it in order to learn more about it.) Our process lasted over SEVERAL months and I think it should be condensed in order to not lose sight of the goals and objectives. I really wish that our district would adopt this process for introducing new curriculum/textbooks. We just received this new reading curriculum and nobody really knows how to effectively implement it and I think Lesson Study would help address that. I see so many areas of our district that would benefit from Lesson Study--I just wonder what I can do as a teacher to jumpstart the process!

Another aspect of the Lesson Study process that many of us in the program were taken aback by was the full transparency educators had and the honesty that we saw in post-lesson discussions. Many said, “that could NOT happen at my school, people would get offended”. It reminded me of how little trust we have at many schools. Many critiques on our “craft” get taken personally because teaching in America is very personal and honestly isolating. As a teacher I do feel very alone because I am often planning alone, developing alone, and working...alone. As much as I go to colleagues for ideas and resources, at the end of the day it is me getting the work done. But I feel that *that* is something that we can work on. It is just a matter of changing mindset and recreating the structures and systems put into place within schools.

One of the things that truly fascinated me more than the process itself was just how schools in japan are structured. They are much more liberating than schools I have experienced here in the States. I was amazed that students would walk to school on their own from age 6! I thought that was incredible; there must be a lot of trust and respect within the community. Another interesting difference between schools in the States and those we saw in Japan was the distinct lack of supervision and structure during playtime and breaks. I wonder how that would work in schools here. I think it allowed students to actually learn from play. I think that the more we structure children’s playtime, the more WE as adults are influencing the outcome--is that true learning if we do not allow for mistakes and differences? It just felt like the schools were actually made to support and educate children. Oftentimes “American” schools are equated with prisons and after visiting a different country, I understand the comparison. It is probably a major factor as to why we have so many varieties of schools (e.g. charter, private, unschooling, etc). I think Japanese elementary schools set students up to be independent, problem-solving individuals and I now am left to wonder, how can we start to do this here in the States with the limitations that we have put in place in the name of “student safety”? I also found it interesting that almost all schools had a teachers' lounge where teachers actually worked in together. Most schools in the States are very isolating in the sense that you are expected to get work done in your own classroom and there is no cooperative workspace where you can brainstorm and develop ideas with other perspectives. This collaborative nature really drove home the idea of community and trust.

Instruction in Japanese elementary schools looks very different from what I have seen/am accustomed to. I did not start note-taking until sixth grade. During some lessons, I saw first-graders taking notes while their teachers were giving instruction! That is unfathomable in my school (as of right now). I was intrigued by the idea that most teachers mapped out their boards prior to the lesson--I wondered what purpose this truly served. I sometimes come up with ideas "in the moment" based off of what a student comments so I have a hard time understanding how every single moment can be planned. But it does show the level of care and time placed on a singular lesson. What really struck me was the lack of student-to-student interaction in the classroom. Most of the student learning was individualistic, which starkly contrasted the collaborative nature within the school environment. In my credential instruction, we were always advised to follow an 80-20 model: 80% of discussion comes from students and 20% from the teacher. I was intrigued to see the opposite in Japanese classrooms (except for the final lesson we observed). I primarily saw students engaging in discussion with the teacher and note-taking from the board. The last commentary we listened to addressed this and I remember him not really liking the group work. This surprised me because I felt like this had been the most interesting lesson we watched and I actually learned a lot from the way it was structured. I think striking a balance between both pedagogies could really benefit students as a whole.

Christina Isles-Dr. George Washington Elementary School.
Implus-LS Alliance Lesson Study-Summer 2019
Reflection

In my experience, there are pivotal learning opportunities that happen in education. As an educator, we are allowed to step out of our own classroom and comfort zone and become the students and learn from other educators in this field. This two week professional development, allowed me to change my cognition, my way of approaching math and teaching.

1.) Collaboration- When Reading the lesson plans that the teacher provided over a two week period, it was very evident that the group of educators were planning their lessons with extreme thought. Thinking of their students and planning their lessons in a supportive and solution based environment, allows the collaboration that students and teachers deserve to increase everyone's learning. For an educator to change their teaching, they should be exposed to other ways of teaching and/or strategies. But not only be exposed at a basic level of listening and watching others, but direct interaction with the strategy or new teaching. Hands on works for kids and hands on works for adults. The collaboration allows for more hands on deck, in the sense that more eyes on the students, more ideas come out of the more that you notice about the students, but also makes the process of lesson planning more meaningful for the students.
2.) Learning Walks- I was very appreciative of the process of the lesson study at a school level, city level and district level. It is a very humbling experience to stand in front of your colleagues, teach and then listen to their feedback. But, WOW, how it can elevate your teaching. Especially if you are a novice teacher, watching your peers can give you ideas to try back in your own classroom. My experience with learning walks has been inconsistent. I have worked at schools, where we were dedicated to this process and I have and currently work at a school where we do not have the (wo)man power amongst our school, to have other teachers step out of their classrooms to look at their colleagues. I was impressed with the value that the teachers placed with creating and consistently using Lesson Studies as one of their biggest tools in learning from each other.
3.) Debrief-After the lesson, the debrief was a great tool, to compliment what went well, to ask clarifying questions and to give purposeful feedback to help change their teaching. As a lower elementary school teacher, I would watch the upper school math lessons and think, "Wow, that was great." But it wasn't until the debrief, when I heard other colleagues speak, of all the different components,

techniques, learning strategies and holes that a lesson had. Most teachers crave feedback, and not only, pats on the back (those feel nice too!, but the feedback that can elevate our teaching. This led me to think about all school Lesson Studies. I am currently the only teacher doing lesson studies at my school. I do have a team, but there is not another lead. The school down the way from mine, in conducting an all school lesson studies, focusing in the same area. There is more buy-in under these conditions. I sometimes feel, I am putting my admin out of their way, when I need to learning walks in other classrooms and/or schools. But what I bring back is immeasurable. I saw this first hand in Japan. It was a long day and quite warm in the facilities that the lessons and the debriefs were held in, but it was disappointing to see how many teachers were not as involved as I think should have been. This lead me to think about how much Buy-In there is, and how can more be done. I was intrigued, when the first move of a debrief was the teachers breaking into small groups, discussing what they saw, and then moving to the larger group.

4.) Japan Math- In all honesty, it wasn't until I returned with the Japan Math CD and book, that I better understood and slightly elevated my understanding of Japan math for my grade. It was not something that we are using within my school. I was introduced to it at a higher level than the grade I teach, through my own son's learning. One of my biggest takeaway, when comparing Japan Math and SFUSD math, is the order in which concepts are introduced, Japan's concept order making more sense to me.

I was an experience I will value and take with me as I start my school year. Exposing me to wonderful teachers, mentors, students and a culture which is wrapped in beauty. Thank you for this opportunity.

IMPULS FInal Reflection
By: Ashley Hughes 3rd Grade Hillcrest Elementary

Being a second year teacher, I am honored to have been included as an IMPULS participant this summer. I never would of thought as a public school teacher I would find myself among a group of diverse, seasoned educators from around the world studying math practices in Japan. It's hard to balance all of the new content and structures that you have to adopt as a brand new teacher but, Lesson Study and TTP have been such useful models to help me feel supported in my learning and teaching practice as I continue to deepen my understanding of mathematics. I've soaked up so many important learnings from IMPULS that I feel excited to meet my new 3rd grade class and apply my learnings to my practice.

Here are my major takeaways:

1) The Launch
   After watching the 3rd grade public lesson on division with remainders, I was struck by how interactive the teacher's launch was. She used physical tennis balls, a box, and containers to pose a math situation for her students. By doing this she was able to elicit excitement and engagement from her students before they even began to solve the math. This form of a launch reminded me how important it is to spark students interest in a math situation before you pose a math problem. I often fall into the routine of providing students with some context and then posing a problem for them to solve. This lesson showed me that my launch doesn't always have to be made up context that the numbers fit into but rather, it can come from a situation that is posed in the moment using tangible objects that students can manipulate. Another thing I learned from this launch was how the math situations we use need to prompt students to feel like there is a need to problem solve. In this lesson the teacher created a situation where she needed to fit 23 tennis balls into containers to carry them to another location. I often feel like I deliver the context to my students and then give them a pre planned, rehearsed math problem rather than allowing for the context to push my students into creating the math problem themselves. I think the latter gives students more ownership over the math they are solving when they feel like they created the problem themselves. I intend to spend time this year integrating the math situations my team has prepared to ensure that all situations lend to problem solving naturally.

2) Community Engagement
   It was beautiful to witness the entire school community participate in each public lesson. Teachers from all grade levels and subjects, staff members from different positions, along with family members were present during the post lesson discussions. It really shows how committed each staff member is to the academic success of all the schools students. In many U.S schools I feel like is often a mentality of "my students" vs. "our students" which stifles the collaboration between grade levels and makes it feel like only your team is committed to the success of your grade level at any given time. Having all staff present to observe and participate in the post lesson discussion demonstrates that there is a strong culture of observation, improvement, and reflection among the entire

school. From some of our conversations, I learned that when a teacher opens up their classroom for an observation, there is always 2-3 teachers that will come from another school to watch. Observations in Japan are seen as a tool for growth and constructive feedback rather than a moment of judgement and cruel criticism. I hope that my school site can foster more of a culture of observation this school year not only as a tool for accountability but also as a way to support new teacher who need constant feedback to help shape their practice.

3) Student Voice

I was happy to see a variety of ways teachers choose to incorporate student voice. One geometry lesson had students working in groups to come up with solutions. This lended to all students being able to have a response based on the group work if they were struggling on their own. In the division lesson I noticed the teacher would have a student come up to write down their thinking and have another student who has a similar idea explain what the student was doing so that more perspectives could be heard while saving time. Another move I saw a lot was teachers capturing important statements from the students. They would write them on the board next to their work or in a place that would help steer the conversation in a particular direction. I think this move is beneficial because it helps students remember important parts of the discussion that they can build upon and it also helps the teacher in case they need a focal point to reference when the conversation goes off course. I find that I often get stuck in a rigid routine with TTP so it was refreshing to see different ways I can conduct more engaging lessons that will help my students discover the mathematics.

Elisa Szeto
1st Grade Teacher
Hillcrest Elementary School

I am filled with gratitude for this wonderful experience to be a part of the IMPULS immersion program this summer and having the opportunity to learn so much from continued observations, discussions and reflection within the ten days we've had collectively together to learn more on Lesson Study and Teaching Through Problem Solving. It is clear that Lesson Study is a critical component in professional development for all teachers in Japan and I am in awe to see such hard work and thoughtful planning for all of the lessons we were able to observe. There are so many important things to take away that I've gained from my time in Japan back to my own school site that I look forward to sharing with my colleagues and trying within my own classroom.

1. Culture of Learning

From our classroom observation lessons, it seemed that as young as first grade is where students have begun to establish basic social emotional/academic skills in order to have the ability to work with one another in an academic setting as well as socializing with each other. This serves as a foundation in allowing students to be able to cooperate with one another and develop a classroom community where students are able to work together to help and serve one another. During the lesson observations, I also learned that teachers and students take a great importance in note-taking early on to preparation for future grade-levels. From watching how teachers instill this critical skill to their students by modeling and scaffolding, it allows students to develop a comfort level in using math notebooks that inspires me to think about how I can emphasize the importance of notebooks and how it can be a tool that can be used throughout all units within Lesson Study.

2. Student Discussions

As a classroom teacher, it is very important that I am thoughtful in planning the types of discussion that I hope students can be engaged in. From observing the classroom lessons, I was able to see students' listen to each other's ideas and share with the whole class, as well as the teacher jotting down students' ideas on the board. Teachers need to spend an incredible amount of time to help build and foster a community of learners where students can feel comfortable and respected in their classroom environment, where students can share their mathematical thinking with their peers. I want to continue to learn how to teach students the ability to ask thoughtful questions to one another, as well as being able to answer one another where they are making sense of the math. By learning how to teach students how to critique and question one another, I hope it'll give students more opportunities to build more knowledge on their own, rather than just teachers giving more knowledge. One helpful strategy I saw during a classroom lesson was when the teacher would ask another student to explain the strategy that another student was writing on the board. I thought that was a great way to keep students engaged in the lesson and also allows students to be held accountable with their learning. From my experience in Lesson Study and TTP, I learned that it's very important to think about all the potential misconceptions students may have, consider the varied student responses' and think about how to strategically plan the board work as you monitor student work. All of this takes careful planning and craft which was very present as I was listening from post-lesson discussions and seeing the thoughtfulness from the lesson plans itself.

3. Timing and Pace

As a new teacher, timing has always been a challenge not just in teaching math, but in all subject areas. One thing I've learned after observing many classroom lessons in Japan is that teachers and students really take the time to carefully ask questions and giving students time to try and make sense of the problem on their own. There were some lessons where we were not able to see through all the way to the end, because of the student discussions that were taking place within the classroom. As an educator who is working on incorporating more TTP into my daily lessons, I want to work on my pacing in terms of launching a lesson, monitoring independent work as well as student discussions so it doesn't feel rushed towards the end of the lesson. I've learned that it is okay to not have to finish the lesson on that specific day - but it can be continued the next day thus the value and importance of note-taking in the math notebooks. I've realized from my own experiences that when you're running out of time from teaching a lesson and feel the urge to rush through it, students are unable to think critically and reflect on their learning. One helpful strategy that I observed during a few classroom observations was seeing students share their summary aloud to the whole class after giving ample time writing down their learning in their notebooks. This allows students to hear different perspectives that they may not have considered before, as well as valuing the importance of reflection. I hope to incorporate this into my practice as a way to help guide my students in developing their skills during the learning process.

Lesson Study has broadened my understanding of mathematical content and made an impact on how I teach reflectively amongst my colleagues from participating in cross-grade level teams as well as being on a grade level team this past academic year.

Being a new educator that has been exposed to Lesson Study and TTP for two years, this type of professional development has allowed me to deepen my skills that I hope to continue to practice with my students and allowing them to develop their identities as mathematicians. I feel so grateful to be able to learn from so many educators from the United States, United Kingdom and the Netherlands. Being a part of such thoughtful and meaningful post-lesson discussions was eye opening and informative as everyone brought in their own experiences and perspectives. It is truly inspiring to have gained the knowledge that was shared. Lastly, I have a deeper appreciation with the amount of time and dedication in making Lesson Study and Teaching Through Problem Solving as a regular practice.

Lesson Study Immersion Program 2019
Impuls - LSA
Final Reflection
July 31, 2019

Katerina Palomares, Principal
Hillcrest Elementary School
San Francisco Unified School District

After having had the opportunity to participate in the Impuls - LSA Lesson Study Immersion Program this summer in Japan, I noticed that the practice of Lesson Study, specifically mathematical learning within the structure of Teaching Through Problem Solving, is created and supported through a generational cycle across the country. The cycle of teaching and learning starts from the early years of a student's educational journey and continues through their path as adult learners and community members.

Early Learning Foundation

From our general visits/lesson observations at schools and the post lesson study discussions (at the various school sites and at Tokyo Gakugei University), I observed that students' basic social/collaborative and academic skills are established early in their educational path not only within a classroom lesson, but within the different aspects of their school community. At the site visits, students as young as 1st grade, learned basic collaborative skills through their ability to work and socialize with their peers to prep and serve one another during lunch periods. They learned early on how to immediately shift and transition from recess breaks directly to their lesson at hand when peers would announce the beginning & closing of a lesson. These may seem to be subtle, but provide a foundational support in the development of school & classroom community that impacts the learning environment during a lesson. Students have an early application of being able to cooperate, work together and respect the importance of being present and participatory as soon as the lesson begins.

During the lesson observations, even in the lower graders, teachers already begin to integrate the students' note-taking skills early in preparation for future grade levels. They develop a level of comfort of using math journals to work out their thinking and to incorporate reflections. Although not all lessons reflected maximum interaction amongst all students, the lessons did provide space & time for students to listen to each other's ideas or share their own thinking to the whole group while most of the time, the teachers recorded their ideas on the board.

From one of our group discussions, I learned how generally in Japan, teachers would spend an intense amount of time at the beginning of their school year to develop community amongst the students, which again would support the social & academic need to build collaborative skills as they move through the grades. Again, with the intention of building community early in the year at any grade, this would provide a more comfortable, familiar and respectful learning environment for students to feel confident in sharing their mathematical thinking with their peers which is key in any Teaching through Problem Solving lesson. From observing the variety of lessons, I believe that since these students have been practicing and applying these basic social & academic routines from grade level to level (Primary, Intermediate and High School levels), these skills are reflected then when they become adults, such as the teachers that we observed as adult learners.

Adult Learners

The cycle of developing and strengthening teaching & learning continues on through the generations when the young students become adults and begin their teacher training program at for example, Tokyo Gakugei University. I learned how Lesson Study is uniquely embedded within their teacher training program which then provides them the opportunity to strengthen their own collaborative skills as adult learners. It introduces Lesson Study practice in their early stages of professional learning as educators (even in different subject areas outside of Math), just as young elementary students get introduced in the application of new skills. As developing novice teachers (1-10 years experience per our discussion) either train at the university or at a new job/school assignment, they are immersed in lesson study components such as having to collaboratively plan & determine which student/classroom struggles, issues or problems on which they want to focus their lesson. Additionally, practicing Lesson Study enables teachers to collectively identify specific questions or strategies to engage and build the academic interactions & discussion amongst their own students during a public lesson. They learn how to either predict what their own students may provide as answers or teachers learn how to monitor and adapt their flow of questioning or facilitation based on observed student interactions during a lesson. By incorporating the Lesson Study practice early in a teacher's training, the teachers, as adult learners, are nurturing their own reflective and analytical skills continually as they move from the university or to new job/school assignment. They learn again, how to apply their skills of listening to constructive criticism from colleagues, administrators or expert commentators. This cycle of learning then becomes a natural expectation as part of the educational career or pathway, no matter what district or prefecture one may work at, giving Japanese educators multiple opportunities to participate in Lesson Study and to publicly facilitate a Teaching Through Problem-Solving lesson.

Adult Community Members Supporting Lesson Study Practice

Beyond the teams of teachers presenting school or district-based public lessons, I observed how adult community members, such as Math Professors (new & veteran), grad students and families or support staff, reinforce & support the cycle of mathematical teaching & learning through Lesson Study. The professors, who have gone through their own cycles as young students and as young teachers in Japan, now serve as continual models for the future generations of educational practitioners of Lesson Study. Professors, such as Professor Narita, (one of the youngest professors with the Doctorate) had the opportunity to serve as an expert commentator in the post lesson study discussions, while Professor Fuji was fortunate to work and witness his own previous students serve as current Professors and expert commentators as well. At site visits, parents, families or support staff acted as another branch of support for students & teachers learning together by assisting with the logistical preparation within the school before/during/after a school-based or district-wide public lesson. Because they too witness the facilitation and practice of Lesson Study within school or district communities from the elementary level to the teacher-training programs, they understand that the use of Lesson Study is a vital aspect of school learning in one's own educational journey.

Final Cycle of Thought

Having been a participant in this Lesson Study Immersion Program and as an administrator with the fortunate opportunity to collaborate with other district schools to develop our own site's knowledge & implementation of Lesson Study, I have a deeper appreciation of the extent of time, community effort and dedication to establish it as a regular practice. We have the opportunity to understand that the practice of Lesson Study and the skills to collaboratively plan & facilitate a Teaching through Problem-Solving lesson, can be a tool to support a generational cycle of learning from our youngest students to our most veteran staff and supporting families. We can use our early staff implementers of Lesson Study, school-wide collaborative structures and district departmental expert commentators to support and uplift the generational cycle of teaching & learning development for our school communities. We have the opportunity to apply it as we regularly welcome new students, staff, district support or when we find ourselves with new academic struggles or issues that may be trending within our school or district.

Justin Stoddard
3rd Grade Teacher
John Muir Elementary
San Francisco

IMPULS-LS Alliance Lesson Study Immersion Program 2019
Final Reflection

There is a great deal to take away from the ten days we collectively experienced in Japan. Having participated in the program the year before, I can confidently say there is always more to learn from continued observation, reflection and discussion of Lesson Study and Teaching Through Problem Solving in action. When thinking about how we will take our learnings back to our school site (John Muir in SF), there were many important things to reflect on and consider for the coming academic year. One thing that I really want to focus on improving is finding ways to increase student engagement during boardwork. The boardwork discussion (*neriage*) is such a crucial point in a TTP lesson that can significantly leverage the opportunities to collectively dispel student misconceptions and move the students' thinking forward, that I definitely want to find ways to keep them engaged during the discussion. One helpful reflection by an expert commentator of one of the lessons we observed noted that the teacher can double or triple student engagement by having students with similar strategy explain what a student is doing while they are writing their strategy on the board. This is definitely a move I want to explore next year in my TTP and LS lessons.

Timing is always a significant challenge for me, and most others I believe, and I want to intentionally create time and space for students to update their thinking in their notebooks after or during the boardwork discussion. I think there are great advantages to make student thinking visible through this process--not only for myself as their classroom teacher, but also for the students so that they can more effectively use their notebooks as references of prior learning in order to create more access points to the current task at hand. I also want to make changes in student thinking visible during the lesson as a whole class in order to show students that changing their thinking is a common and important move as a mathematician and to show them that we all have opportunities to change our thinking during the learning process. In addition, I personally want to improve upon my role in guiding students to use their previous notes and work in their notebooks to inform how they approach the task. In order to help them more effectively access their prior learning, it is crucial that I spend more time on demonstrating the value of neat note-taking.

As the teacher, it is so important that I am mindful of how I am helping guide student discussion of the boardwork. Someone mentioned during on of the post-lesson debriefs that we must listen to what is said by the students, not what we WANT to hear. No matter how much intention and planning goes into the development of our unit plans and lesson plans, it is vital to meet students exactly where they are at so that we can strategically move their thinking forward. Participating in this cycle of school and lesson observations made it very clear to me the deep importance of thoroughly researching potential student misconceptions, exploring and considering anticipated student responses, strategically planning out the boardwork based on what presents itself when monitoring the students during independent work time. One specific goal I have as a teacher and as a teacher leader for our Lesson Study efforts at John Muir is to improve my ability to utilize strategic questioning during the boardwork discussion in order to shift the focus of the discussions away from a Teacher-->Student & Student-->Teacher model to one that is more Teacher-->Student-->Student-->Student. I want to teach students how to thoughtfully ask questions of each other and answer each other in ways that deepen their mathematical reasoning skills and elevate their abilities to critique the reasoning of others and their own ability to make sense of the math.

There were a couple of other important things I noticed when observing the posing of the tasks in a number of the lessons in Japan. Many of the teachers took the time to have some meaningful interaction with the students in order for them to truly understand the context of the problem. Often, they would pose a situation without even mentioning or revealing a problem at all and engaged the class in the process of developing a sentence for the story problem or situation they were making sense of. I found this to be a very helpful way to engage the students from the very start and gave them a sense of collective “buy-in” or interest in solving the problem. This also helps students who have trouble reading to understand the problem so they have an entry point into solving it. In addition, there was consistent attention paid to referring back to the units when discussing the equations and the meaning behind the numbers. I think this is an important move I need to be mindful of for future lessons in order for me to best ensure that my students are making sense of the math they are engaging with.

Coming into this year’s program, our school site had just finished its first year of school-wide lesson study. I felt that the year was very successful, however we definitely have more room to continue to grow. One area that I would like to improve upon is teacher engagement and interest in lessons outside of their own grade level. In Japan, Lesson Study has been a part of their professional development for decades and It appeared as though there was an established collective understanding of the benefits of participating in and observing other grades’ lessons. I want to explore ways that we can provide teachers at our site more opportunities to better see the benefit of participating in the whole school LS process.

Lesson Study has been one of the most impactful and rewarding forms of professional development I have participated in since I started teaching 14 years ago. As a veteran teacher in a city/school district with such a high amount of teacher turnover, my experience has been that the majority of coaching and support naturally must focus on the newer, less experienced teachers who are establishing their foundations as educators. That all changed for me when I started participating in lesson study. It was the first time that I truly felt challenged and meaningfully guided through a student-focused research based style of reflective teaching that truly was responding to exactly where my students were at. In addition, It has provided me numerous opportunities to see the cross-grade level connections to the standards and content being taught in a way that illuminates the importance of the work that we are each doing in our own classes. Not only is it providing me an opportunity to develop my sense of agency and deepen my skill sets as an educator in all subject areas, it is also developing a sense of agency and voice within my students and provides them meaningful opportunities to develop their identities as mathematicians and learners of all subject areas. It is clear to me that lesson study provides a rich opportunity for educators to develop individually, as grade level teams, as a school site, and collectively as a district. This institute brought together educators from all over the United States and from England and the Netherlands. It is exciting and inspiring to learn about how Lesson Study is growing and spreading! It was truly inspiring and informative to engage in post-lesson discussions with everyone because we all bring different perspectives and experience to the table. This resulted in such rich, deeply reflective and meaningful discussions around student learning and how we can elevate our and continuously improve our craft. It continues to instill a great sense of hope and belief in the work that we are all doing both individually and collectively! I look forward to diving back into the work this fall! I am incredibly overwhelmed with gratitude for all of the hard work that went into making this program possible for us all. I want to deeply thank everyone who worked so hard to make this possible!

IMPULS Lesson Study Immersion Program 2019 Reflection

I would first like to start off by saying thank you to the Lesson Study Alliance team for offering this program. I was able to not only observe and be immersed in multiple schools and classrooms but be apart of the debrief and reflect with a team of teachers in a different country. I am extremely thankful. I would like to start off by reflection about the public schools in Japan. One aspect that really stuck out and remained constant throughout all the schools we visited was the independence the students had no matter the grade level. The classrooms are run by the students from the start of class period to the end of the class period, even lunch! Because the students have so much ownership inside the classroom, it transfers to the ownership they have during instruction time. I've never seen a classroom/school/district that has had that high level of independence and several questions pondered. How did the students become so independent? Is this taught in the lower grades? What does the independence look life for younger grades, kindergarten? Are students raised like this (homelife)?

The school culture from my views seemed to be one, a unit. Every classroom in the school had student work showcased inside and directly outside the room. And every one of the pieces was so artistic and colorful and combined art with the other main ficuses (math, writing, reading). It made me a guest very happy to see how much art is valued in Japan. It made me think about how can I emulate and integrate art with other subjects (math, reading and writing).

Thinking back at the length of the school days in Japan, I wonder how is so much content being taught with the number of breaks the students have. It made think about the US school system and how we expect our students, especially young students to go through learning all day without any breaks. I like how the students had a 5 minute break in between subject changes. It allowed students to move around to visit friends and have a sort of "brain break" and then be prompt and ready to go for the next subjects. Amazing. They pay attention for that amount of time with focus because they know there will be a break soon.

Going into this program fairly new to teaching through problem solving, I was hoping to see the full roces from introduction of the task all the way to the summary/new learnings. The main thing I see in the US is the summarizing or the ending of the lesson. It's quite difficult to one, get to the summarizing/new learnings. Most public lessons i've seen don't make it to that part of the lesson. Another difficult task that I as a teacher struggle with is allowing the students to authentically come up with the new learnings/summary without teacher influence. Because during this process teachers are facilitators and its different from the "traditional" teacher role. This is a difficult task and I noticed that teachers in Japan that use teaching through problem solving are still working on authentic summaries produced from the students.

Another point that is pondering my mind throughout each lesson we observed is how teachers in Japan teach through problem solving and differentiate at the same time. I remember during one point in one of the lessons there was 1 student that I was observing that during the whole didn't write get started or write anything down. This student intrigued because he reminded me of students in the US that may need teacher check ins to help him get started. How does teaching through problem solving help all students? How do teachers differentiate through independent work and simultaneously take notes of student work? How do we ensure that student voice and student represents most of the students in the class?

After observing many different classrooms, it seemed that students don't really talk to each other or share thoughts with each other. There was one lesson where the teacher incorporated a lot of group talk. This seemed to be deemed as ineffective whereas in the US we see this as an essential part of learning. The keynote speaker argument against small group sharing is that the teacher isn't allowed to hear all the students thoughts/conversation. But it also works in reverse, through independent work with no conversation with other students nearby the teacher will be in the same situation and would seem to hinder students in my opinion. I'm not saying whether one way is better than the other, I just see the benefits of students communicating their thoughts and process with another classmate.

My final thoughts on the program is that I truly enjoyed this experience and wish more educators are able to experience this type of professional development. As a kindergarten teacher, I wish that we were able to visit and/or observe a lesson. I feel like it would be very beneficial to see how the teachers are setting them up to be independent and hold the cognitive load. Maybe the program can think about that for future educators that go through the program. The next steps for me is creating a classroom culture where my students run the room and have autonomy. Building their independence so by the time they get to move up they are able to take over. I also want to work on students being able to share their process and most importantly the students listening to each other and actually processing what the other student is saying. I also want to work more on developing more student to student talk and working on students actually “dissecting” their work and their peers. As a teacher I want to get better and into the habit of taking notes during independent work. Using those notes to facilitate a productive discussion that has purpose. This trip also reminded of the importance of intentatiality in our teacher moves need to be. And I want to continue to work on that from student talk, whole class discussion and teacher/student questioning.

This trip allowed me to see and learn a lot from another culture. I’ve captured a lot during the trips to the various schools and I am excited to implement the practices into my classroom this school year. Looking forward to more growth in teaching mathematics!

Thank you.

Yekaterina Milvidskaia
Hight Tech High
Graduate School of Education

"Every system is perfectly designed to get the results it gets"

Coming to Japan I was curious to see what systems were in place to support lesson study as a vehicle for teacher development and growth and what results did they yield. Here is what I discovered.

Early on in the trip I attended a Japanese tea ceremony. I watched patiently as a single cup of tea was prepared. Each step of the process was done with intention, grace, and precision. In my mind making tea was a two step process. Boil water and add teabag. Done. But my naive and overly simplistic viewpoint is not dissimilar to the views often held by the public about teaching, especially teaching mathematics. Teach them how to do it, give them some problems, and have them practice. Done! What most don't realize is that there is an art form to teaching mathematics, especially teaching in a way that, "**can provide students with opportunities** to understand these basic ideas, and support their learning so that the students become independent learners."(*Sugiyama, Y. 2008, Trans. Takahashi, A., 2011a)*

This type of teaching is referred to as level 3 and it is this type of teaching that the Japanese educational system has been steeped in developing over the years. This was the first hint of system in place-there was a shared vision of what the goals of instruction should look like. It is shared among teachers, university education programs, school administrators, and the public. The US we are often debating over what "good" mathematical instruction should look like and we find discount between what the research says and what we find in practice. Additional, because there isn't a shared vision and there are many misconceptions around what instruction should be like, teachers who are aiming at level 3, have to fight admin and parents who are accustomed to learning mathematics in a more traditional setting of "sit and get". This is an added challenge making it difficult for us teachers to feel supported and in some cases can feel disheartening and isolating.

It is this common vision that is used as north star that guides the system as a whole. But having a vision is not enough, there must also be concrete structures to support this vision and pathways to reach out.
Some of the other structures that I noted…

- Most new teachers in Japan go through the same teacher education program that aims to train teachers to teach in this way
- Curriculum writers write textbooks for this way of teaching

- Public events are held to demonstrate masterful teachers that can model this for others in the field.
- Dedicated time in the yearly schedule to hold lesson study events
- Multiple flavors of lesson study: site wide, district wide, and national
- A culture of collaboration between university researchers, district personnel, curriculum writers, and school sites.

"Lesson Study is not about improving the teacher it is about improving teaching" was a quote I noted by Dr. Takahashi that I continue to repeat like a mantra as I share with others about my experience**.** Lesson study in Japan IS a system for improving teaching that harnesses the power of a learning community.

This idea of community is something that I saw so interwoven not only in the educational system but throughout Japaese culture. For example, parents rely and trust of the community when they send their first graders to school by themselves. Time is spent at school to build community each day as students serve lunch to each other and share a meal. School nurses attended a mathematics lesson study!

When I am asked about my experience I kept coming back to this word, community, and one other one…

"If you are going to erase it then don't write it on the board" was another one of Takahashism that I noted. This quote was referring to the intentionality of the board work (bansho). What this experience highlighted for me was that every instructional decision, like the tea ceremony, was done with intention. From the words used in the problem to how to record students' solutions on the board. I appreciated and learned most when our post lesson discussions reveled in the details of the instructional decisions. To me, this solidifies why teaching is truly an art form.

Matome

In a world that currently feels quite divisive it was a privilege to share the experience with an international group of educators committed to this work. It is with a bow of deepest gratitude that I thank the organizers of the IMPULS program, the schools that welcomed us, and the wonderful students who greeted us enthusiastically for an experience that I will cherish for years to come.

I am excited to continue our journey at High Tech High with lesson study as we begin site based research team fellowships and prepare for future public lesson study events.

Heather Dallas
2019 IMPULS

I am grateful to IMPULS for the varied and deep professional growth opportunities its recent 2019 collaborative lesson research provided for me and my team.

In the articles we read, nomenclature given for key instructional activities like Neriage: contrasting and synthesizing (literally kneading) student solutions or Matome: summarizing mathematical progress made, served to highlight and prioritize them.

In the lessons we observed, two opening routines:

- a student duo's call to "do your best" and
- the teacher's introduction of the day's question

paired together with two closing routines:

- the teacher's Matome and
- the student duo's encouraging conge

provided thoughtful bookends to the lesson package. These respectful and humane bookends supported student understanding and retention.

On a number of occasions, we observed expert practitioners exemplify exquisite board-work that served to both record the content of the lesson and visualize the lesson structure. This board work further communicated respect for students: through the time taken to plan, the care taken to execute that plan, and the careful commemoration of student voices for all to see.

The Doing of Mathematics was the goal of the majority of the lessons observed: problem solving in the public lesson on quadratic identities, proof in the everyday lesson on fraction division, modeling in the public lesson on tennis ball packaging, and creating definitions in the public lesson on quadrilaterals. These higher order goals communicated a high view of students as thinking reasoning individuals who want and have the capacity to make sense of the world around them.

Observing the Collaborative Lesson Research in action revealed it:

- aims to answer a research question,
- involves the participation and facilitation of school and district administration
- does not necessarily involve the re-teaching of a lesson
- includes pre-planning and post- discussion with a university "Knowledgeable Other".
- occurs at the school, district and inter-district levels and.
- ends with celebration!

I wondered whether the same structure and board work we observed in the classroom lessons would serve to further the CLR's goal of answering a research question: recording the research question, recording the thoughts shared by teachers and administrators, Neriage by the Knowledgeable Other, and finally Matome by the Knowledgeable Other or other stakeholders.

Certainly the knowledge my team and I gained through the IMPULS programme will impact the Collaborative Lesson Research we facilitate with our district partners and the K-12 lessons we write at the Center. But what I am most grateful for, and what made this experience invaluable for me, is the impact this knowledge will have on my personal teaching of mathematics. I hope to honor this experience by working hard to transform this knowledge into skill.

Thank you IMPULS for the opportunity to learn from your expertise and the expertise and your local master teachers.

Top Three Take-Aways From My Participation in the 2019 IMPULS –LS Alliance Lesson Study Immersion Program

1. Japanese teachers treat their colleagues as professionals. This is based on my observation of the post-lesson study discussion sessions. There is a clear protocol that all staff members follow, where every member of the learning community has the opportunity to share their ideas and comments without interruptions from colleagues. When there are conflicting opinions, Japanese teachers give specific constructive feedback rather than making general comments. I would love to see more U.S. teachers dress and behave professionally, and grow together for the common goal of improving classroom practices and ultimately increase student achievement.

2. Japanese teachers do not prepare for their daily lessons “on the fly.” There is clearly a significant amount of time spent planning the daily lessons, including the anticipation of student responses. Although there is no guarantee that a perfectly planned lesson will go just as expected, there is undoubtedly a strong positive correlation between outcome versus amount of time invested in preparing for the lesson. One of the common fallacies among U.S. teachers is our dependence on textbooks because it is the most effortless way to teach lessons. However, most of us don’t have the skills to assess the quality of our adopted textbooks, so we blindly follow page by page. I would love to see more U.S. teachers teach at least partially without the textbook, but I realize that this would require first building up their mathematical confidence and content knowledge.

3. Japanese teachers do not use lesson study professional development to showcase their best practices. Instead, they use lesson study as an opportunity to identify a topic that is difficult to teach, research it, collaborate on planning it, executive the lesson, and reflect on the outcome and design of the lesson. The only way we will grow in our trade is by trying new ideas and by practicing our areas of weaknesses, not by redoing what we already know how to do well. We see the opposite in U.S. classrooms—teachers always choose to do a demo lesson on a topic at which they’ve been successful at teaching, either because of pride, crave of accolades from our colleagues, or plain fear of showing our vulnerability. This is a mindset that we need to change in U.S. teachers.

Thank you, IMPULS staff, for the opportunity to learn from the best. I wish everyone a great school year!

Why Your PLC Needs Japanese Lesson Study

This fall my daughter will go to college to study elementary education. Having completed twenty years teaching in the classroom and five years supporting my colleagues as an instructional coach, I have many questions: Will her classes truly prepare her? How long has it been since her professors prepared a unit of instruction and taught it to students? What kind of school will she work in? How will she grow as an educator? Once she enters her profession, what kinds of professional development would I want for her to deepen her professional knowledge and expertise?

If you asked me this question five years ago, I would have confidently answered Professional Learning Communities. Professional Learning Communities, or PLCs, hold great promise for reforming education. In PLCS, teachers work together as professionals to improve instruction. They ask three of the most important questions in education: *What do we want students to learn? How will we know when each student has learned it? How will we respond when a student experiences difficulty in learning?* Teachers work together to plan instructional goals, analyze evidence of student learning, and plan interventions for students who need help. No longer are teachers working in isolation, trying to figure out the latest and greatest new professional development.

Yet, I believe that the PLC process has a missing ingredient: development of pedagogical expertise and content knowledge. That is why <u>your PLCs need lesson study.</u> Let me be more specific: your PLCS need true Japanese lesson study, not the Americanized adaptation we have developed over time.

Japanese lesson study describes an ongoing process of internally driven professional learning which has been successfully implemented in Japan for over 130 years. Teachers sit down at the end of the school year and identify the content that was the most difficult for them to teach. Each school also has a set of specific learning goals identified for each school year. In the new school year, teachers conduct a full literature review and work as a team to develop a research lesson which can meet the goals of the school and teach the specific challenging content. For example, in additional to learning how to best present the content, teachers also work on a research question such as, “How can we provide students with opportunities to explain their work?” But this isn’t just a standalone lesson. It is developed within the context of the full unit of instruction. During the planning, teachers map out the instructional unit, anticipate student responses, plan what they will write on the board (board work), and strategically plan guiding questions to move students forward in their thinking.

After 6-8 weeks of preparation, the school plans a minimum day for students and asks one class of students to stay. All staff gather together to watch the lesson which is taught by a member of the team. It is important to note that this lesson was designed with the needs of this specific group of learners in mind. Teachers take notes and listen closely to every aspect of the lesson. When students are working or discussing content with their peers, teachers circulate amongst them, listening and taking notes. Students are accustomed to this process and are undistracted by the guests in their classroom.

After the lesson, the students go home, but the work is just getting started. Teachers look at student work and ask the lesson planning team questions about the lesson. Finally, a “knowledgeable other” such as a mathematics education professor from the local university provides expert commentary on the lesson as well as instruction on the content to build the content knowledge of the entire teaching community, not just the team that developed the lesson.

The whole process of Japanese lesson study is compatible with the work of the PLC. Teachers work together in professional communities, holding one another accountable for their contribution to the work. Everyone is working towards the goal of providing high quality instruction for all students. Teachers look for evidence of student learning. The work is job embedded and teacher-led with the heartfelt philosophy that we are all teaching all of our students.

So why does my PLC need Japanese lesson study?

1. Pedagogical Expertise: Japanese lesson study is about the art of teaching. No teacher is considered a "master." The goal is to help all teachers move from Level 1: Telling, to Level 2: Explaining to Level 3: Facilitators of learning who provide students opportunities to understand ideas and support their learning so that students become independent learners. All staff are life-long learners. PLCs are often limited in the time that they can spend on the development of a single lesson or unit of instruction. This means that a struggling teacher may leave their PLC not sure how to improve their instruction. In Japanese lesson study teachers have the opportunity to systematically plan lessons together and then to see that lesson brought to life with a group of students.

2. Developing Teachers' Content Knowledge: Japanese lessons study also develops teachers' knowledge of the content they teach. They learn content at all grade levels and develop an understanding of the vertical progression of content. The knowledgeable other provides content expertise to deepen the professional learning of all staff.

3. Classroom Community: Classroom community is the secret sauce that allows learning to take place. Not only must teachers have clear procedures to help their classrooms run efficiently, they must also set the tone for how all members of the community interact with one another. Teachers need opportunities to see how other teachers develop relationships with their students. Japanese lesson study provides an opportunity for teachers to observe the community of another classroom firsthand.

4. Developing a lens for quality: The process of Japanese lesson study helps develop a common vision of our school goals and what high quality instruction looks like.

Japanese lesson study offers the opportunity for teachers to take their Professional Learning Communities to the next level, developing their pedagogical and content expertise while collaborating with their colleagues.

Michelle Sidwell
Lesson Reflection
IMPULS: Summer 2019

I am so grateful for my experience with the IMPULS lesson study program. I am not sure I have ever attended a professional development event in which I learned so much in a two-week period. I am so excited to share all I have learned with the districts and schools I work with. Here are some of my biggest takeaways:

1. *Focusing lessons on the needs of YOUR students:* In American lesson study, the focus tends to be on improving a lesson plan to create a better lesson plan. The directors of the IMPULS program however constantly reminded the participants that there is no "perfect" or even "great" lesson that will successfully teach any group of students the chosen topic. Careful lesson design is crucial to success in the classroom, but the planning must be focused around the individual students. In American lesson study, the classroom to be used is often decided after the lesson-planning process has begun, but this does not happen in Japan. The lesson cannot be created until the teachers know which students will be serviced and what their individual needs are. During the post-lesson discussions, the teacher who taught the lesson that day would frequently reference choices he or she specifically made in the lesson plan to address specific characteristics of the students in his or her classroom.

2. *Community and administrator involvement:* I was surprised to observe how involved non-teachers were in the lesson study process. In American schools, administrators do not frequently attend professional development events due to the all the demands on their time. When they do attend events, their involvement usually involves general encouragement and a reiteration of the importance of the event in achieving a broader school mission. In the Japanese schools we observed, administrators not only attended the lesson study events, they actively participated in the discussions. Their suggestions and questions showed deep levels of pedagogical and mathematical understanding and set the tone for the events. Additionally, all teachers at each school attended the lesson study lessons. In America, younger grade teachers often feel that seeing a 5th or 6th grade lesson is not very relevant to them and vice versa. In Japan, all teachers clearly believed that each child's learning is the responsibility of all-stakeholders. I was also impressed that so many parents and community members attended the district lesson study events.

3. *A community of professional researchers:* A common complaint among teachers, especially in lower grades, is that teaching does not provide opportunities to be intellectually and professionally challenged. Teachers also complain of a lack of comradery among colleagues in what is often described as a lonely profession. From what I observed, I believe true lesson study can help address both of those concerns. Japanese lesson study focuses on a research question and participants take time to read current research on the topic. They use that research to inform choices they make in the

lesson plan in complex ways. During the post-lesson discussion, teachers go far beyond surface observations and debate pedagogically and mathematically difficult questions. The teachers have developed a sense of community where they can share ideas and get feedback.

4. *Kids are kids*: When Japanese teaching strategies are discussed, Americans often feel that these same strategies would not work with their kids. While there are definitely unique cultural factors that affect Japanese education, I was happy to observe that kids are kids everywhere. We observed kids who were really struggling to understand concepts, gave wrong answers, and did not participate. Sometimes a teacher failed to get a good discussion going on the first try. I really admired how the teachers didn't use these children as an excuse for why a problem-based approach can't work. The teachers asked additional questions or employed other strategies and did not give up. This reminded me that no classroom of kids is perfect and we shouldn't expect them to be so.

5. *Patience*: The Japanese teachers we observed were so patient! Teachers patiently spent an entire period on one problem. In one classroom, a teacher ran out of time before the students had really understood the meat of the lesson. One student smiled and asked the teacher if he would just give them the summary statement. The teacher replied that if he did that, there would be no learning and that they would pick up the work tomorrow. In some classrooms, the students were not answering the problem the way the teacher and lesson plan had anticipated they would. In these rooms, the teachers would patiently ask questions and provide additional time for the students to think.

6. *Board work:* The board work we observed was beautiful. I feel that if I looked at the board after a lesson I did not observe, I would have a pretty good idea of how that lesson played out. The goal of the lesson is clear and the comments from the students are carefully recorded. Students also leave each lesson with a summary statement that allows them to quickly reference the new ideas from that lesson. Note-taking is a very difficult skill that even college students struggle with. The board work we observed made it easy for even struggling students to take clear, organized, and meaningful notes. Teachers modeled the importance of clear notes by taking the time to use meter sticks to draw lines and carefully color-coding their work. This extra time also helped slow the teachers down so that they were moving at the speed of learning. This visual and written summary of the work could also benefit ELL students who can't translate fast enough to follow verbal discussions.

Hoʻopaʻa Haʻawina
By Stephanie H Kamai

This paper describes how I began using the lesson study approach, the lessons learned along the way, and finally the most recent activities I engaged in to understand more deeply the thinking, preparation, and content expertise linked to the lesson study process. I conclude with how I brought ideas learned at the 2019 Immersion Program in Japan to the UHWO Annual Summer Field Experience Institute upon my return to Hawaiʻi.

In 2017 I implemented the lesson study approach in the Student Teaching Seminar, and co-requisite Student Teaching. These are courses that I teach at the University of Hawaiʻi, West Oʻahu campus. Lesson Study seemed to have promise as a way for preservice teachers to have authentic, real time experiences that would support their transition from preservice to inservice teaching. I was drawn to the idea that lesson study put the learning and investigations into the hands of my students giving student teachers more autonomy, practice, and collaboration with their peers. Based on student evaluations, student research lesson study papers and my own observations, and where approriate, revisions were made. An area that continues to be of concern is the quality of observations taken during each research lesson cycle. The lack of preparation prior to deciding the lesson to use was also of concern. The grouping of student teachers was often a challenge since many of them were placed in different schools and/or grade levels.

The most consistent feedback I received was that lesson study was very difficult but students did report that they learned a lot and increased their sense of collaboration and cooperation with their peers. Our teacher education program promotes peer collaboration in each education course. However, student techers reported that the lesson study experience was different and required an increase in peer collaboration. During student teaching seminar students are expected to collaborate and submit most of the assignments as a group. Most students reported feeling uneasy and uncomfortable at first but learned how to work together in different ways. I find this feedback to be extremely valuable since inservice teachers are expected to collaborate but often find it challenging to do so. The goal is to support this process more intentionally in future semesters.

While there is not a lot of information on lesson study as it is used with preservice teachers I used many of the resources on the Lesson Study Alliance website. I read several articles by Akihiko Takahashi, Catherine Lewis and others. In fact the available resources were invaluable in starting the process and I appreciate that resources are readily available. I believe in the process but wanted to learn more. I was interested in finding ways where more could be done to address these particular areas of concern. So I reached out to Tom McDougal of the Lesson Study Alliance and Chicago Lesson Study. He shared an opportunity to participate in 2019 IMPULSE in Japan.

Visiting the schools in Japan was such an invaluable component of the program. I know first hand how complex it is to gather a group of educators, adjust school schedules, maintain the integrity of the learning environment, and host groups of visitors. The scale on which it was accomplished was truly amazing and I am grateful to all who engaged in this monumental task. Each day I found myself thinking that if we tried to initiate some of the things that were common practice in the educational system in Japan to the schools in Hawaiʻi, it was certain that we would get a call from educators and/or union representatives. For example, it is rare to see administrators and teachers assigned to the same workspace but it makes a lot of sense.

That arrangement would make administrators and teachers uncomfortable, to say the least. We say we want what's best for kids but fall short of taking action that takes courage, resources, and leadership.

Personally, I felt like a fish out of water because I was the only attendee without a math background. I was reminded by a fellow participant that everyone uses math. So true. I pondered on my lack of math content expertise and wanted to engage the math content in the lesson study process prior to the start of the semester. Upon receiving the book on mathematical practices at the end of the IMPULSE program I found a way to use math content in the Summer Field Experience Institute that I organize each summer. *Having Kittens* was a great way for preservice teachers to engage in the process of talking about math using a real world issue.

As I plan for the upcoming semester, I will make a few changes to the curriculum in the courses that I teach. After attending the immersion program this summer, I saw first hand how lesson study can be effective using 1 research lesson cycle. Therefore, I will be eliminating lesson cycle #2 and use the time for deeper conversations and preparation prior to choosing a lesson to teach. I also plan to use Lesson Note to conduct observations.

Nancy Sirois
Final Reflection - IMPULS - Summer 2019

I'm hoping I can capture in writing my thoughts and perspective about the time I spent in Japan and with the IMPULS project. As the only person attending who had not experienced Lesson Study in some form, there was much to learn and absorb as we made our way to different schools to observe teaching through problem-solving and the discussions that followed. Many things come to mind that really stood out for me but as I reflect and share this experience with others, there seem to be three areas that have left the greatest impression.

Teaching through Problem Solving: - Planning the lesson

This is something I have used in my own classrooms and help teachers with as a math coach but watching this in action and also having the opportunity to discuss this with other teachers helped me solidify my belief in the importance of knowing the lesson focus and problem from as many angles as possible. It is so important to start lesson study with a theme (what is the problem or area of concern) and have a relevant task, problem or question that is intellectually challenging and invites students to use deeper mathematical thinking. Teachers must anticipate student misconceptions and the multiple ways they can approach and solve the problem. For example, for one lesson, the third grade teacher introduced a problem about how many containers she would need to carry multiple tennis balls. She immediately engaged the students using real tennis balls and connected the problem to a real-life situation.

Teachers are always expected/encouraged to differentiate and focusing on TTPS allows for this to happen naturally. Connecting the problems to real-life situations that engage students gives them an opportunity to build meaning through multiple entry points so all students can be successful.

As a coach, I feel excited to begin the next school year helping teachers spend more time on TTPS. I work with many newer teachers and taking the time to dig deep into the standards and plan problem-solving lessons is incredibly important and necessary for student success. When teachers have to teach all subjects, it is challenging finding the time to focus on this on a regular basis but this should be a priority throughout the year.

Post-Lesson Discussions and Knowledgeable Other

I'm not sure I'm ready to tackle full lesson study at this time but I did learn so much about ways to facilitate post-lesson discussions and having a knowledgeable other available. We have used learning labs in my school as part of professional development and those can be effective but watching lesson study in action really inspired me. The role of the facilitator is vital in having a focused and clear discussion. First it is so important to take the time to have groups of teachers come up with comments and observations along with asking for clarifying questions. Then focusing on only 3 main topics was key is leading a productive discussion. When the discussion focused on what the teachers wanted the students to learn by the end of the lesson, it was powerful.

After the teachers have discussed the lesson, having a Knowledgeable Other (KO) reflect on the lesson with photos, examples and anecdotes, it became professional development for all teachers present. Having a KO focus on the progression of a standard and the difficulties/misconceptions of students was a very impactful way for all to gain not just more knowledge about the lesson and standard but insight into what good teaching practice looks like. It may take me some time and definitely continued learning about lesson study, but my intention is to implement a true lesson study post discussion in the future.

Board-work

The emphasis on board-work practices was inspiring. As teachers used the large blackboards/whiteboards to record expressions, diagrams, student thinking and the progression of work, I was struck at how important this practice is to keep a record of the lesson. Several things stood out for me:

- It helps students see the connection between the different parts of the lesson as it progresses
- It is a way to keep a record of the lesson and i appreciated the teacher pre-work that went into the lesson planning and board-work.
- It helps students remember what they need to do and the focus of the lesson
- It supports students being able to compare, contrast and discuss the ideas and strategies that students present
- It helps organize student thinking
- It fosters student note-taking skills as teachers model how to organize the problem and the work.

The teachers who used the board effectively to support student discussion led to students comparing and synthesizing several different solution methods that students were able to clarify and justify. Japanese teachers use the board as a visual aid so students can participate in the discussion as well as build understanding of the mathematics involved. Although most of the lessons we observed didn't have a huge amount of student to student discussion, I can see how using the board to build a lesson can lead to very rich discussions and student understanding. I would like to learn more about how Japanese teachers are taught to best use board-work during instruction. I'm excited about sharing this teaching tool with my fellow teachers.

Japanese Schools

There was much to learn about how Japanese schools support student learning but one thing that stood out was how independent and responsible students were throughout the day. Although the class sizes were large, students were organized and got to work quickly. They were responsible for their own materials and supplies and only once did I see a totally unprepared student.

Students are given the responsibility of taking care of the classroom and it shows. The cubbies were perfectly organized, the classrooms were clean and helping each other with transitions was seamless. Students served lunch to other students and no one ate until all were served. Between subjects, students are left unsupervised in the classroom for 5 minutes! I can't even imagine that happening in American schools.

Schools take the time to focus on how to work together and it shows. There was so little instructional time lost when students transitioned from one activity to another. Students were polite and well-behaved. From what I understood while touring the schools, time is taken to build both a classroom community. There is a sense of self-discipline and responsibility. Students get themselves to school (starting in first grade) and learn how to work together as a community. It felt like schools taught the whole child, not just academics. Being in the schools solidified my belief that focusing on the community among teachers, students, in the classroom and school community instead of only individual needs is a big part of what makes Japanese schools so successful.

I have been spending time, since my return, on figuring out my next steps. There is much to think about but I'm so excited to begin my Lesson Study journey. I'm hoping I have more opportunities to see Lesson Study in action and I know that I can reach out to any of the amazing teachers I met when I have questions or need help. Participating in IMPULS has inspired me to bring back what I've learned to my school and to introduce lesson study to my district. Wish me luck!!

IMPULS-LSA Lesson Study Immersion Program 2019
Shusaku Uchida

Experiencing the research lessons and visiting the schools in Japan was an eye-opening experience. The amount of effort that goes into each *kyozai kenkyuu*, lesson planning, predicting anticipated reactions, board work planning, lesson itself, and post-lesson discussion, was unbelievable. Moreover, school community that involved every teacher, every student, and every person in the neighboring area was something that I found to be very unique and inspiring.

The Sense of Community in Lesson Study

As a person with a Japanese background and an experience of living in Japan for few years as an adult, I was familiar with this community-based society of Japan. People followed rules and their mannerism was most of the time impeccable. However, I also felt that people were very disconnected in the city area, even though it is one of the most densely packed cities in the world, and many of the Japanese companies felt more like a system than a family. So, I was not very sure about the "community" aspect in school, just because I've seen both side of it, and I knew that education was a part of the cause for both sides. However, visiting the schools throughout the project, I did get to see the positive side of the "community-based" aspect of Japan.

The thing I found the most surprising was the fact that every single teacher was involved in the lesson study. When I first heard that even the school nurse and the librarian will be attending the lesson study, it felt very unreal. First question that popped up in my mind was, "Why would they do that?" However, after meeting the teachers, the answer seemed to be very obvious.

I remember talking to the school nurse of Kunitachi Daigo Elementary School at the dinner later that day. I was surprised by how she had her own ideas and thoughts about her school and the students and were very curious about the education in the United States. She asked me about how diverse the American schools are and how she thinks about level-based classroom assignment. It was very surprising, because I did not expect a school nurse to be this engaged in the topic. She cared about the students attending her school not only as a nurse, but as a professional in education.

By this time, I already understood why every single teacher attended the lesson study. Every teacher is a professional who cares about their students. Just because they do not have their own homeroom, it does not mean that they do not have any students to take care of. Just because they do not teach any traditionally academic classes, it does not mean that they do not have any responsibility in students' learnings.

The attitude of teachers who were receiving the critiques showed how each school also had a caring environment within the teachers' community. Teachers who taught the research lesson knew that each criticism they received was not a personal attack towards them, but it was an advice to better their teaching. It is difficult for teachers to self-evaluate their lessons and not be defensive about it, especially when their colleagues and principal is in the room. However, this did not seem to be the case in the schools we visited. Teachers and staffs seemed to have successfully built a very trusting environment.

The sense of community in school built by the teachers and the administrators helped to form an environment where each and every lesson study attendee cared about the students and thrived to create a better lesson. It was very obvious that every teachers and administrators had a shared goal and leveled viewpoints, where they were all working as one team to reach the goal.

The Art of *Bansho* and Note-Taking

There are many things that the teachers in Japan practices to make their teaching more organized. I was astounded by the amount of board work (*bansho*) planning teachers do in Japan. I've always thought that Japanese teachers wrote beautiful board works but had never even imagined that there were planning behind it. Now that I think about it, it does seem quite obvious that there are some kind of practice behind it, but I've never thought about it since they pursue it so effortlessly. I also noticed that Japanese classroom and their chalkboard do not have any anchor charts. This allows teachers to use every single inch of their boards, which lets them complete the lesson without erasing a thing.

As of the notebooks itself, all of the elementary students I saw were using graphing papers. Lower graders used graphing papers with bigger grids and the as you go up the grades, the grids became smaller. When I was at a stationary store, I saw notebooks with grid sizes varying from 22mm size grids to 5mm grids, which is a very systematic way to train students to write neater and more compact as they develop more precise pencil control. Also, some of these notebooks were especially made for mathematics class usage, and other subjects had its own version of notebooks too. Students wrote one character per grid, which made the notebook very organized and easy to read. Teachers even wrote on the board so that it will fit perfectly in the width of students' notebook. This especially works well with the Japanese language, since all of the letters are spaced out evenly and there are no spaces in between each word. It may not be very suited for writing down in English, but I did think it is a very nice way for students to organize their math notes and calculations, since writing down each number and lining them up according to places is crucial.

However, students' note-taking skills are something that does not always come naturally. Japanese students seem to be copying the board work without any special instructions, but it is a skill that must be taught. The fact that teachers do professional developments just on note-taking skills is very fascinating. People may think that note-taking is just writing down notes and it's just a preference of how each individual learns, but it is more than that. Organized notes will let students consume information more smoothly and efficiently and students will be more likely to develop a habit to refer back to their own notes, since it is easier to follow. When students develop a habit to refer back to their work, their metacognitive sense will grow naturally. In addition, teachers will also be able to check on their notebooks to see how much the students are understanding and see the points they are struggling in the lesson, which can be used to reconstruct and revise their lessons.

Another interesting thing regarding note-taking is how students check their own answers in the notebook. When teacher asks them to circle the answer in red if you have it correct and put and 'X' and write the correct answer next it if you got it wrong, students followed that instruction. It must be difficult for some students to cross out their answer and fix it without erasing the whole thing, since their "mistakes" will be recorded permanently. If I was in their position, I will have to fight the urge to erase the "mistakes" and rewrite the correct answer, because I would be embarrassed for anyone to find out that I had a wrong answer. There must be an atmosphere in the classroom that says that it is okay to make a "mistake", or even encourage students to make them. Students seemed to know that they will eventually learn from the "mistakes" they made, and they probably will refer back to their "mistakes" when they get stuck in any future lessons.

Taking a note is not just "one way to study", but it is a tool for students to further their understandings by reading and writing what teacher is saying, to motivate themselves to focus on the lesson, and to metacognitively check on themselves, as well as for the teachers to check on students' understandings.

Bringing Back the Experience

Now, how can I bring all these information back and apply it to publishing? Note-taking part is more straightforward. Our current lesson book is designed for students to write down their thoughts and ideas, so we can provide more space (with or without grids) for students to take more organized notes. It also seems that Japanese students seem to have a better pencil control in general, so I would like to look into that. However, we haven't had any support towards teachers' *bansho.* Board work ideas may be something that we could add to a teacher's guide. Or, more teacher's manipulatives that would help teachers organize their boards may be something we should consider.

As of the sense of community and the classroom environment, we do design our program for students to share their ideas in class and also in partners, which I believe somewhat contributes to building a healthy classroom environment. We have games that students play in partners, which will enhance student to student communication, but maybe we should add games that students can play as a group or a team. Maybe something competitive. Are there anything other than games? How can we enhance more communications that would contribute to class building? That is something I need to have more research about.

IMPULS-LSA
Lesson Study Immersion Program 2019
Final Reflection
Kim Hollowell

I had the opportunity to participate in the IMPULS Lesson study immersion program during the summer of 2019. As a team of educators from around the world we observed lessons at eight different schools ranging from first through ninth grade. This unique opportunity provided me with insight and exposure to high leverage practices that I hope to share with my colleagues in San Diego.

Value of Community

The idea of community is interwoven into every facet of the educational system in Japan. Japanese teachers truly work as a community to challenge and push each other to grow as professionals. Teacher's desks are arranged together in a communal lounge that is used for planning. This physical space serves as a hub that provides opportunities for teachers to collaborate daily as well as gives administrators access to participate and oversee teacher planning. I really appreciated the genuine respect and commitment that was evident in how teachers were invested in providing feedback to one another. Parents in Japan trust the community to take care of the students so they let students even walk to school starting in first grade. Students also interact as a community. Teachers shared that there is time spent at the beginning of the school year to build community within their classrooms. This sense of community among students was observable during lessons as well as during lunch. Students work together serving lunch to their classmates and eating as a community. I had the opportunity to watch students serve lunch and eat with them on several occasions and I can say this was one of the highlights for me. In that moment, I learned so much about how community connects people and how that connection is valuable in more than that moment. I think the connection created during lunch also helps to create an environment during lessons where students feel safe and ready to learn. During the lessons I watched students work as a community of learners to build upon each others ideas. This community problem solving was instrumental to student learning.

Connecting TTPS and the 5 Practices

This was my first official exposure to Teaching Through Problem Solving (TTPS). I learned that all concepts and procedures should be introduced through problem solving. I have extensive experience with implementing Smith and Stein's Five Practices of Orchestrating Productive Mathematical Discussions and I was struck with how TTPS builds upon the same ideas. From the research lessons, it was clear that teachers *anticipated* student responses and planned purposeful questioning to push student thinking. Teachers *monitored* students as they worked on problems independently or in small groups. The *select, sequence* and *connect* steps played out a little differently in TTPS but still had many similarities. In TTPS, Neriage is the heart of the lesson. Neriage is the Japanese word for the whole class discussion phase of the lesson. Students are expected to struggle and find their own way to solve problems because this experience will be the foundation for making connections and learning. The progression of learning is recorded using Bansho by visually sequencing math ideas and discussion using board work. Students shared their strategies and ideas and the teacher recorded this work on the board. The students were doing the thinking and really carrying the cognitive load for learning. Students listened to each other and added onto and challenged each other's thinking. In the past when I have used the Five Practices, students shared their thinking and presented strategies but a common practice was to have students show their work under the document camera. Unfortunately, when a student finishes sharing they took their work with them or even if they did leave the work it was difficult to show more than one example under the document camera at a time. By using boardwork to record each student's thinking the progression of strategies and learning is clear and visual. This could really help students that might need more time to push their own thinking toward the lesson objective. My biggest realization about boardwork was that by having the visual progression on the board it allows students to more easily make connections between strategies that can lead to generalizations and meaningful reflections.

Lesson Study / Research Lessons

Prior to my experience with IMPULS I had some experience with implementing lesson study within my district. During the immersion program, I had the opportunity to observe both site-based research lessons and district research lessons. Lesson study offers an opportunity to develop a shared understanding of what good teaching practice entails built from concrete image and experience. Schools choose a research theme that sometimes covers all content (example:improve student to student discourse). Logistically teachers usually participate in one research lesson per grade per year and rotate which teacher teaches each year. Each year the research cycle is about five weeks and when teachers are not in their cycle they spend time observing colleagues in different grades. So, schools conduct six lessons per year in grades K-5. In Japan lesson studies are done on minimum days by asking students to stay after school. This is a great idea that would minimize the need for substitute teachers. During a lesson study there are structures that were common among most sites. Detailed research lessons were planned either by the teacher that would teach the lesson or as a grade level team. Then one teacher teaches the entire lesson and all other teachers and staff observe the lesson. After school on the same day there is a lesson debrief. The debrief begins with a welcome and then the lesson study team or teacher share their own reflection on the day's research lesson. The lesson study moderator's role is so important to the productivity of the post lesson discussion. For example some moderators asked observers to focus the discussion on task, learning objective and grouping, student interactions, errors, questioning. Once the discussion begins, teachers ask questions focused on understanding reasoning behind instruction choices made during planning or teaching. I was impressed by the level of commitment and thought that colleagues put into questioning during the debrief. The questions were based on evidence observed and usually asked for insight into the metacognition of the teacher about their instructional choice. This process helped me to appreciate the intentionality in every instructional choice made during planning and teaching. Following the discussion, a Knowledgeable Other that was not involved in the planning will share a commentary on the theme, curriculum, lesson plan, what happened in class and next steps.

Next Steps

This year I am hoping implement lesson study within my school district. I am currently the math coach for fifteen elementary schools, five middle schools and three high schools. I have been soliciting teachers and grade levels that may be interested in participating in a lesson study cycle this year. Additionally, as part of the San Diego Math Network, I am hoping to share my learning from the immersion program with other districts in our county

Reflections on Mathematics Teaching and Learning in Japan and Japanese Lesson Study through the lens of the Common Core State Standards and Its Associated Literature Base

Osvaldo Soto
University of California, San Diego
Center For Research On Educational Equity, Assessment & Teaching Excellence

What does it mean to be a [teaching] professional in Japan? Japanese Lesson Study is the process by which this is transmitted from one teacher to another. *Akihiko Takahashi, IMPULS Opening Presentation (2019)*

Background

When the opportunity to attend Project IMPULS 2019 manifested, I eagerly perused it as an opportunity to deepen my understanding of Lesson Study (LS) in general and Japanese Lesson Study (JLS), in particular. And, while it would be a worthwhile endeavor to connect my experiences to the broader LS literature base (e.g, Lewis, Fernandez, Fujii, Takahashi, Watanabe & Yoshida, Stigler & Hiebert), this effort is beyond the scope of my limited knowledge about the subject and time. I hope that what follows will be taken as intended; an attempt by a novice in these field to make sense of a set of new cultural, content, teaching, learning and collegial experiences from someone with 17 years' experience as a secondary school mathematics teacher, 16 years as a mathematics education researcher and 10 years as a professional developer, but no experience with elementary schools, LS and JLS, or Japanese culture.

Our experiences (a brief summary)

Project IMPULS began with a valuable orientation to the program delivered by Akihiko Takahashi, professor DePaul University. Prof. Takahashi's presentation introduced important constructs and rationale for understanding the structure of typical Japanese Lessons and JLS, beginning with the current cultural need for Teaching Through Problem-Solving (TTPS) and its connection to JLS. Prof. Takahashi explained that Japanese mathematics education has undergone a shift in perspective from "What to teach" to "What should be learned". Takahashi went on to describe connection making as a central mathematical activity of focus. The implication for instruction is that teachers should foster students' capacity and desire to express their own ideas, recognize and accept differences in the ways they, and others, express their own ideas and develop the ability and habit of relating these ideas to each other, including defending and critiquing their mathematical ideas. This is reflective of a dual focus described by Fujii (2017) as a focus on "content" *and* "process", similar to the CCSS content and practice standards – where practice standards express explicitly stated ways of thinking (or reasoning) *and* desirable dispositions.

The orienting presentation brought to mind the CCSS's (Standards for Mathematical Practice) research base (e.g., Al Cuoco's notion of Habits of Mind, Guershon Harel's DNR Theoretical

Framework, Alan Schoenfel's work on problem-solving and the TRU Math framework (2013), Stein et al's (2008) work on Orchestrating Mathematical Discourse and Rowland and Zazkis' (2013) work on Contingency Teaching). Cumulatively, this literature base supports problem-solving as a means of learning mathematics. Finally, the presentation communicated that JLS is a structures that addresses teachers' understand teachers' knowledge base: knowledge of mathematics, knowledge of student epistemology and knowledge of pedagogy/curriculum (in the sense of Shulman (1986) and Harel (1993)) and beliefs about teaching (Philipp, 2007). Structured participation in these communities of practice can explain why JLS has the capacity to address teachers' knowledge base and beliefs by collectively shifting the focus of attention to what students know as teachers collectively negotiate the significance of observed events with knowledge of the distinction between the intended and enacted goals of each lesson (Lave and Wenger (1991); Brown and Duguid (1991)). The role of the commentator helps to frame these conversations, highlighting the importance of the final commentator in the JLS structure. In all observed all cases this was a mathematics education researcher.

Commonly observed features of Lessons: Consistencies and Inconsistencies

Consistent with the observation of Stigler and Heibert (1999) and Fujii (2017), typical lessons included the following elements: Teaching through problem-solving (TTPS), beginning with an introduction of a problem of the day, time to solve problems (by students), comparing and discussing solutions (Neriage), time for reflection by students and a summary provided by the teacher. While these elements were consistently present, the quality and characteristics of their implementation varied from lesson to lesson.

Teaching through problem-solving

There is a robust literature base with mountains of empirical evidence supporting the perspective that students learn *through* problem-solving (Polya, 1945; Brownell, 1946; Geeno, 1983; Thompson, 1985; Harel, 2008a,b). Going even further, Harel (2008b, p. 894, 895) explicitly states this as a premise of his theoretical framework. "Any piece of knowledge humans know is an outcome of their resolution of a problematic situation… In essence, this premise is the basis for the position, held by many scholars (e.g. Brownell, 1946; Davis, 1992; Hiebert, 1997; Thompson, 1985), that problem solving is the only means of learning." Lamentably, Takahashi (2008) noted accurately that, "Although teaching through problem solving has been suggested by NCTM and other reform documents in the U.S., it is hard to find lessons that employ this idea in U.S. classrooms." And so, returning to Takahashi's orienting presentation and Fujii's observation about the dual role of content and process, an important question guiding this reflection is, "How is TTPS implemented by Japanese teachers and to what aim?"

In order for students to learn through problem-solving, it is essential that they form a rich image of the problem before (and during) the problem-solving act. Harel (2013) refers this as the *mental act of interpreting*. One excellent example stood out above all others in this respect. A lesson in which the teacher asked students to place tennis balls in containers as they learned about division with remainders in a real-world context. In each observed lesson, the mathematical problem was always clearly stated. However, in some, there was evidence that the question was not clearly understood. However, in the previously referenced example the teacher took time to have students act the problem out in order to form a rich image of the problem before giving the students individual time to solve the problem and during the *Neriage*. Though some things might have been lost in translation, it seemed evident when teachers understood this essential element of TTPS and when they did not. Personally, I found it pleasant to observe several instances in which teachers observed, commented and gave suggestions during debriefing session addressing this important aspect of problem solving. Such comments were indicative that teachers were attending to the needs of the learner and using this as a form of formative assessment (Schoenfeld, 2013).

Internationally, mathematics educators are concerned with the questions, "What mathematics should students learn?" and "How should students learn that mathematics?" (Harel, 2008c; IMPULS, 2017) Researchers and practitioners alike should be concerned with the questions, "Who is doing the mathematics in classrooms" and "When they do engage in mathematics, what characterizes the mathematics of students are engaging in?" In my observations, it was typical to see researchers and teachers collecting data regarding both of these questions. Prof. Takahashi's use of the Lesson Note stood out and was particularly powerful. During the debriefing observations, I witnessed many teachers referencing data on specific students. However, with respect to the goal to focus on content and process, more could be done to collect data regarding characteristics of students' understandings (e.g., the CCSS Standards for Mathematical Practice, Al Cuoco's construct Habit's of Mind, Harel's DNR-Theoretical framework's construct Duality Principal - ways of thinking and ways of understanding).

Fujii's (2017) [in Essential Mathematics for the Next Generation, p. 86] noted that, "… we are uncertain of how to approach a mathematics curriculum in terms of the dual nature of content and process". I would like to ground this concern in an example. In one example (a geometry lesson) there was rich conversation about the value of *defining* as a mathematical activity. During the debrief, it was noted that this was a strength of the lesson. Pedagogically, this was a powerful example of a time when mathematics instruction attended to process, not just content. In another example where a teacher 9th grade students sought to advance the class' ability to reason algebraically, the acts of *conjecturing* and *pattern-seeking* were prevalent. In the debrief it was mentioned that the teacher did not have an opportunity to address the act of *generalizing*.

Harel's triad of mental acts, ways of understanding and ways of thinking, influential in the CCSS Standards for Mathematical Practice can be use here. All of these italicized terms are examples of what Harel (2008a, b; 2013) calls mental acts. Harel calls the products of these mental acts *ways of understanding* and their associated characteristics, *ways of thinking* (for a more thorough description see Harel 2008a,b). In the 9th grade lesson's debrief, I was able to point to out that there existed cases where students' explanation/proving could be characterized as either Ritualistic, Empirical or Deductive (in the sense of Harel, 1998). In this case, it was productive to describe student thinking in terms of their *ways of thinking*. However, reflecting on Prof. Takahashi's orientation presentation, more work is needed to clarify the characteristics of students' mathematical knowledge.

Time to solve problems (by students)

Typically, I was surprised by how quickly teachers felt students had made sufficient progress to engage in whole-class discourse, along with the amount (or lack thereof) for time to collaborate with peers. Two noteworthy exceptions made this observation stand out. One where the teachers asked students to create quadrilaterals by overlapping triangles with rectangles and categorizing the quadrilaterals created. The richness of the task, combined with the effective use of individual work time and group work time led to a rich classroom discourse in which the students experienced a phenomenon before being introduced to its label, but a need for labeling was created. The time students were given and their ability to work together afforded access to the mathematics (defining). The rich images students formed allowed them to ask relevant questions, critique the reasoning of others and defend their own.

Discourse Types: Student-Student and Student-Teacher

Though this is not a part of the framework I've been following. I'd like to say a few words about the amount of student-student discourse. While teachers typically used the practice of "turn and talk" and in some rare instances small group (larger than pairs) work, in whole class conversations discourse generally followed Mehan's (1979) Initiate-Respond-Evaluate pattern in which the teacher initiates or elicits a response to his/her question, a student responds and the teacher evaluates. Interestingly, many observed teachers seemed typically alert to the pattern, but could not break free of it. For instance, in our first observation the teacher repeatedly asked, what do you think? Yet, he struggled to students respond to each other. Therefore, in whole class discourse the pattern remained Student-Teacher with few instances in which student responded directly to other students. This was generally the case in most conversations and the topic was addressed occasionally in debriefing sessions. Schoenfeld's (2013) TRU Math framework addresses this issue through the dimensions of equity, agency and identity.

Comparing and discussing solutions (Neriage)

Simon, M. A., & Schifter, D. (1993) and Schifter (1998) described instances of aimless instruction, "mathematical show and tell", among a group of American teachers learning to teach from a student-centered approach. Schifter described these teachers' struggle to change teaching practice as "having a foot in two worlds" and teaching as an "image driven activity". Without good imagery teachers' attempts to honor student-thinking often appears robotic, at best – aimless, at worst. Over time, math educators like Smith and Stein have made attempts to shape teachers' images of student-centered instruction including offering a framework for orchestrating mathematical discourse including: anticipating student thinking, monitoring, selecting, sequencing and connecting were frequent topics of conversations of debriefs (Stein et al, 2008). In my experience, American teachers struggle with all five.

In contrast, Takahashi's (2008) description of *Neriage* is purposeful throughout and JLS is an attempt to provide structure for sharing powerful images of teachers using student thinking purposefully from one generation of teachers to the next. Neriage, appears to bring together what Stein et al called sequencing and connecting and is considered the heart of the Japanese approach to teaching problem-solving. When implemented well, this powerful teaching practice entails teachers attending to students' mental images of problems and their problem-solving approaches, as well as comparing and contrasting them. Rowland and Zazkis (2013) refer to as a form of "contingent" teaching; meaning that the lesson is "contingent" on what students do. Neriage requires teachers to draw on a deep knowledge base, as well as holding a deep commitment to the belief that students are important partners in knowledge construction in the classroom.

Unfortunately, due to teacher large scale retirements among teachers in Tokyo and reliance on transmission from teacher to teacher in the JLS model, it was clear that in our small sample space of observations, the quality of implementation of Neriage was often impoverished. While the observed board work was reflective of earnest preparation and thorough planning, it was observed that too often teachers were more committed to their plan than their desire to value students' thinking or did not know how to help students connect their thinking to the thinking of others.

One notable teaching practice in a student-centered classroom is handling errors. This was observed quite infrequently in a public space. The vast majority of student presentations or comments the teachers selected were correct answers. Frequently, this limited the range of teacher questioning. Much more could be said about this topic were it not for space limitations.

Time for reflection by students and teacher summary

In all observed instances teachers attended to the acts of reflecting and summarizing. The use of notebooks in Japan was consistent and striking. It is clear that this is a deeply embedded practice in Japanese instruction. That said, my observations reminded me how difficult it is for teachers, all teachers, to ask a productive question at the end of the lesson that can help students tie together what has been done in a classroom in a way that is indicative of what they have learned that day. This is to be expected as reflection on one's own learning, especially while fresh, is notoriously difficult and meaningful summaries are subjective. What matters, and my most power take-aways, were images of teachers in the practice of collaborating on this difficult topic, both in terms of (1) anticipating productive questions during the planning stage and implementing them in the moment and (2) learning from students' responses to these questions. JLS is a structure in which this practices seems to occur regularly and teachers experienced teachers can shape the nature of conversations around this and many other elements of the teachers' knowledge base.

Professional Development: Structures for collaboration

I have addressed the benefits of JLS as a PD structure throughout this paper. What follows relates more to the aspects of JLS supported by the Japanese Ministry of Education's commitment to education. The level of commitment among Japanese teachers to hone their craft along with the nature of their debriefing conversations stood out to me as an international observer. Certain elements of the Japanese educational system that stand out as affordances for JLS stood out, including:

- the length of daily dedicated contract time afterschool for teachers to collaborate and reflect on and study the curriculum,

- the proximity of teacher desks in the teaching lounge and the expectation that they would spend time there at the end of the day under the direct supervision of the school's vice-principal
- weekly time dedicated to site meetings and lesson studies
- site-wide LS, district-wide LS, and national LS
- the system of university affiliated schools that allow mathematics education researchers and practitioners to be in close contact, grounding research in practice (commentators)
- the presence of a national curriculum

One troubling practice that appears to be on the rise, fueled by the broader condition of declining birth rates in Japan, is the practice of tracking within elementary school classrooms. Though this did not appear to be a ubiquitous practice yet, researchers in the United States have experienced and warn against its potential harm to students as an inequitable practice (Boaler, 2011; Schoenfel, 2013; NCTM, 2018). The TRU Math framework includes equity as one of five dimensions of classrooms targeting robust mathematical understanding.

Summary

I left my time in Japan with deep appreciation for the structures Japanese mathematics educators work in with respect to their educational system, curriculum, shared image of mathematics lessons, and form of professional development (JLS). And, for the project staff's knowledge about Japanese and American culture and mathematics standards, as well as their thoughtfulness about the structure and activities of the program. At the same time, I am reminded that Piaget's work teaches us learning is marked by messiness. The lessons I observed were generally clean – almost sanitary. American math educators refer to this as productive struggle. This is likely a matter of what has been lost in linguistic and/or cultural translation. I believe Prof. Takahashi may have been referring to this when he spoke of teachers', and especially new teachers', challenge to teach mathematics rather than simply teach the curriculum. Problem-solving, true problem-solving, is riddled with uncertainty, false starts and a dramatic element. These are difficult things to translate, but I feel JLS has the capacity to foreground these issues if researchers and teachers so choose. In all, I am grateful for this learning opportunity and hope this reflection can help close some small cultural or research gap. Thank you IMPULS staff!

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