JAPANESE INSTRUCTIONAL CIRCLES

by

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A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Education

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study aims to elucidate a common professional learning opportunity in Japan, *instructional circles*, which has not yet been studied systematically or described in detail. This study uses the mathematical knowledge for teaching (MKT) framework and research on features of professional learning opportunities that facilitate intended outcomes to describe the nature of professional learning opportunities found in instructional circles. Using an ethnographic approach, data were collected through participant observations and interviews. Analytical tools were used to categorize data into different ways content was discussed and how teachers engaged in those discussions. Results showed that instructional circles provided learning opportunities for teachers to enrich all aspects of their MKT. Although the facilitation features recommended in the literature were addressed, instructional circles did so in ways that differ from common practices in the United States. Describing the professional learning opportunities of instructional circles provides an opportunity for mathematics teacher educators to step back from overly familiar practices and look at professional learning from a different perspective. The benefit of taking this reflexive step is to view one's own practice more clearly and gain new insights into designing and conducting professional learning opportunities for teachers.

Chapter 1

JAPANESE INSTRUCTIONAL CIRCLES

Japan has performed well in international mathematics assessments in the last two decades. For example, Japan has scored in the top five countries for both the fourth and eighth grade-level mathematics assessments in international studies of mathematics and science (i.e., FIMSS, SIMSS, and TIMSS) (McKnight, 1987; McFarland et al., 2017; Hussar et al., 2020). Because Japan has consistently performed high in these assessments, its instructional systems have become the focus of many studies.

Research about Japanese mathematics instruction tries to understand the system that yields consistently high outcomes. Some of the studied aspects include examining classroom structure (Stigler & Hiebert, 1999), looking at the influences and usage of textbooks and other curriculum materials (Melville, 2018), and analyzing the quality of instructional features (e.g., Hiebert et al., 2005; Corey et al., 2011). Although instruction is only one factor that might account for high achievement, researchers have identified patterns in mathematics instruction in Japan that align with recommendations for best practices (Stigler & Hiebert, 1999; Takahashi, 2006; Watanabe et al., 2008). Researchers have generally evaluated Japanese mathematics instruction in grades 1-8 as high quality for supporting conceptual learning.

Learning about the teaching methods in Japan that include many practices recommended for U.S. classrooms has led to an interest in how teachers *learn* these methods. Most studies have pointed to lesson study as the driving factor of Japanese teachers learning these high-leverage teaching practices (Corey et al., 2011). However, based on my experiences living in Japan and interacting with Japanese teachers, I have identified other professional learning opportunities that might contribute significantly to Japanese teachers' practices. One practice that offers learning opportunities for teachers and could provide insight into Japanese teacher learning is *instructional circles.*

Instructional circles are somewhat informal gatherings of small groups of teachers that focus on analyzing and discussing specific practices and sharing advice rather than collectively designing a lesson or learning about a specific instructional method. Local teachers and educators voluntarily attend instructional circles sessions that usually meet once per month. Japanese teachers have described them as important professional learning activities that serve an essential function quite different from lesson study (H. Ninomiya, personal communication, September 2016).

While living and studying in Japan (2003-2005, 2017), I learned that instructional circles have been occurring in Japan since the 1940s. Instructional circles have changed from a school-based mandatory practice to a regional voluntary practice. The participants include teachers, content specialists (e.g., math coaches), veteran teachers, and sometimes experts in the content area (e.g., university professors). There are different instructional circles for each content area. Instructional circles are held in the geographic location of the teachers' schools.

There are two types of Japanese instructional circles. Japanese teachers describe the different instructional circles as *benkyoukai,* or the study instructional circle, and *kenkyuukai,* or the research instructional circle. The study instructional circle teachers are learning how to teach mathematics more proficiently, while the research study circle teachers delve deeply into nuances of mathematical tasks and the associated implications for student thinking. The overarching structures for these two varieties of instructional circles appear to be similar, but the discussion topics vary in content and depth.

This study explores instructional circles, a common professional learning opportunity in Japan that has not yet been systematically studied or described in detail. This study is guided by the following research question: How do Japanese instructional circles facilitate teachers' acquisition of mathematical knowledge for teaching?

Understanding that instructional circles are embedded in Japanese culture, the aim of this study is not to provide descriptions that can be imported to other cultures. However, descriptions of professional learning in other cultures can be used to reflect on one's own practices and provide new ideas or insights that can be adapted to achieve professional learning goals in local settings.

Theoretical Framework

Because instructional circles are complicated interactions among teachers within complex social and professional structures, many perspectives could be used to describe them. I focused on aspects that are likely to reveal the learning opportunities for participants by developing a framework that considers both the content of professional learning opportunities and how that content is studied or facilitated. In addition, due to the culture in which instructional circles are embedded, I used research that looks at important aspects of teacher learning in Japan to elaborate the framework.

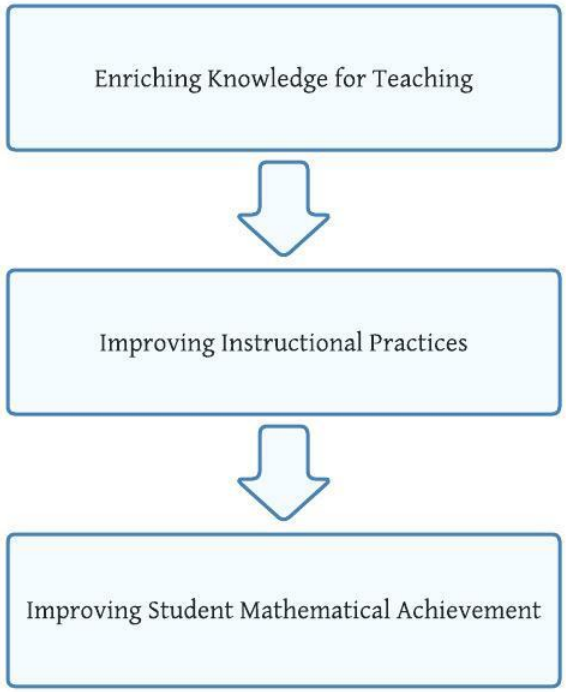
A Focus on Teacher Knowledge and Its Acquisition

The ultimate goal of professional learning for mathematics teachers is to improve students' mathematical achievement. The value of professional learning opportunities derives from assuming that improving student achievement depends on improving teachers' instructional practices (Desimone, 2009; Hill, Ball, & Schilling, 2008; Shulman, 1986). Improving teachers' instructional practices depends, in turn, on enriching teachers' knowledge relevant for teaching (Shulman, 1986; Munter & Correnti; 2017; Hill, Ball, & Schilling, 2008).

A simple diagram of this process is shown in Figure 1. Acquiring richer knowledge for teaching leads to improving instructional practice leads, in turn, to improved student achievement. I first define each element of this framework, beginning with student achievement, and then unpack in more detail the top box, Enriching Knowledge for Teaching.

Figure 1

A Case for Providing Learning Opportunities that Enrich Knowledge for Teaching



Improving Student Achievement

For this study, I define improving student achievement as enriching students' conceptual understanding of important mathematics. Although educators do not fully agree on the instructional practices that yield deeper understanding, professional facilitators in the U.S. do agree there will be no change in students' mathematical understanding without improving instructional practices (Kennedy, 1999; Ball & Forzani, 2011).

Improving Instructional Practices

Professional facilitators often set their proximal goal as improving teachers' current instructional practices (Kennedy, 1999). Whether a slight improvement or a complete overhaul of practices, mathematics educators generally agree that teachers need support to implement classroom instruction that supports students' conceptual understanding (NCTM, 2000). To help students improve their conceptual understanding, the kinds of instructional practices will differ significantly from traditional classroom practices in the U.S. (Lampert et al., 2010; Munter, 2014; Stigler & Hiebert, 1999).

Teachers are likely to need new kinds of knowledge if they are to make substantive changes toward practices more aligned with conceptual understanding (Lampert et al., 2010; Munter, 2015; National Research Council, 2001). Although other factors influence teachers' instructional practices (e.g., changes in teachers' beliefs), I focus in this study on enriching teachers' knowledge.

Enriching Teacher Knowledge

Shulman (1986) argued that teachers need a unique kind of knowledge to teach well and that improving teaching requires enriching this knowledge. In particular, knowledge needed to improve teaching in each subject area requires enriching knowledge relevant to teaching this subject. For example, asking good questions in history classrooms requires different kinds of knowledge than are needed to ask good questions in mathematics classrooms.

Influenced by Shulman's work, Ball et al. (2008) examined the knowledge implicated in teaching mathematics. Their work produced a framework that describes types of essential mathematical and pedagogical knowledge for teaching mathematics. Called mathematical knowledge for teaching (MKT), Ball et al. (2008) referred to the mathematical content knowledge unique to teaching as specialized content knowledge. In this study, I attended to specialized content knowledge plus three types of pedagogical knowledge identified in the MKT framework: knowledge of content and students, knowledge of content and teaching, and knowledge of content and curriculum.

Content and Facilitation of Professional Learning Opportunities

Unpacking the top box in Figure 1 requires describing the content of the knowledge teachers must acquire *and* the nature of the professional learning opportunities[1] needed to acquire this knowledge (Kennedy, 2016). Both are needed to understand the potential contributions of instructional circles to teachers' practices.

The Content of Professional Learning Opportunities

I selected MKT for my framework because, in part, it has been shown empirically to relate with features of teaching associated with students' conceptual learning (Darling-Hammond & Mclaughlin, 1995; Borko et al., 2010; Knapp, 2003; Yoon et al., 2007; Jacob et al., 2017; Ball & Bass, 2002; Jacob et al., 2010; Dick, 2017). Empirical studies have also shown a relationship with different types of MKT and the nature of teachers' instruction (Hill et al., 2008, Ball et al., 2008; Kazemi et al., 2009; Heck; 2012; Copur-Gencturk, 2015; Ennis 1994; Remillard, 2018; Davis & Krajcik, 2005; Davis et al., 2015; Grossman et all., 1990). The four types of MKT in my framework are the following.

Specialized content knowledge

Content knowledge uniquely relevant for teaching mathematics is called specialized content knowledge (SCK) (Ball et al., 2008). SCK is the mathematical knowledge that goes beyond the common content knowledge needed by others (Ball et al., 2008, Markworth et al., 2009). Examples of this type of knowledge include helping teachers understand why multiple solution methods are viable, explaining why algorithms work mathematically (i.e., why invert and multiply works when a fraction is divided by another fraction), and understanding common student errors (Flores et al., 2013).

Knowledge of content and students

Knowledge of content and students (KCS) combines knowing about students and knowing about mathematics (Ball et al., 2008, p. 401). Central to this knowledge is understanding possible student conceptions and misconceptions of the classroom task. This is similar to the knowledge teachers demonstrate when they anticipate how primary grade students might solve addition and subtraction problems (Franke & Kazemi, 2004).

Knowledge of content and teaching

Knowledge of the content and teaching (KCT) allows teachers to represent the content to make it comprehensible for others (Shulman, 1986). For example, teachers utilize this knowledge when they use the advantages and disadvantages of different mathematical representations to sequence a lesson, asking thought-provoking questions, and use multiple representations to solve a problem. Teachers also use KCT to choose representations and sequences of mathematics problems that students will find engaging (Ball et al., 2008; Shuilleabhain, 2016).

Knowledge of content and curriculum

Knowledge of the content and curriculum (KCC) is the knowledge required to understand the intention of the curriculum and then adapt the curriculum to students' needs (Remillard, 2014) without altering the key mathematical ideas. Under KCC, I also include horizon content knowledge which Ball et al. (2008) describe separately as the "awareness of how mathematical topics are related over the span of mathematics included in the curriculum" (Ball et al., 2008, p. 403). Understanding the mathematics students should know before learning a new mathematical topic is critical when utilizing other forms of knowledge, such as KCS and KCT.

The Facilitation of Professional Learning Opportunities

Research has shown that for a professional learning opportunity to be beneficial for teachers, the opportunity must do more than present appropriate content. Teachers need to engage with the opportunity for a sufficient length of time. Perhaps most importantly, they must find it relevant to their classroom practices (Desimone, 2009; Darling-Hammond et al., 2009; Kazemi & Franke, 2004).

Relevance to the teachers' classroom

Seminal reviews of effective professional learning opportunities claim that *active learning* is one strategy for connecting teachers' learning to their classrooms (DeSimone, 2009; Grossman et al., 2009; Darling-Hamming et al., 2015, Yoon et al., 2007). Active learning can be conceived as investigation pedagogies and enactment pedagogies (Grossman et al., 2009; Gibbons, Kazemi, and Lewis, 2017). Pedagogies of investigation involve studying classroom artifacts like student work, whereas pedagogies of enactment include "planning for, rehearsing, and enacting high-leverage teaching practices" (Gibbons et al., 2017, p. 414). Through the process of going back and forth between these two activities, teachers can develop teaching practices aligned with richer conceptual understanding (Grossman et al., 2008; Lampert et al., 2013).

Analyzing records of practice also can situate learning in teachers' classrooms (Borko, 2008). Many different artifacts can be used, such as student work, lesson plans, and videotapes of lessons. Using student work samples helps teachers translate directly what they learn into their practice (Kazemi & Franke, 2004; Borko et al., 2008). Lesson plans can be examined carefully to help teachers represent content in ways students can understand and can help teachers better anticipate student thinking (Melville, 2017; Melville & Corey, 2017; Takahashi, 2004; Watanabe, 2002

Developing communities of practice

Teachers can engage more deeply with professional learning opportunities when experienced within communities of practice than as individual activities (de Jong et al., 2019; Patton & Parker, 2017). Communities of practice are developed as teachers learn to respect each other as professionals by listening to each other's ideas and valuing everyone's contributions. Communities of practice can take different forms such as professional learning communities, lesson study, and teacher workgroups. These forms often utilize teacher conversations to engage teachers in collaborative learning.

Professional learning communities often focus on helping teachers learn about and improve their KSC and KST. To do this, professional learning communities provide ways for teachers to become "professional" teachers through reflection and dialogue (Dufour & Eaker, 1998). Lesson study, for example, affords teachers opportunities to engage in teaching, planning, and reflective practices (Takahashi et al., 2006; Watanabe, 2002; Takahashi, Watanabe, & Yoshida, 2006). Teacher workgroups often focus on helping teachers develop a deeper understanding of students' mathematical thinking (Kazemi & Franke, 2004). All three forms of communities of practice are built around teacher conversations that often examine teaching in a supportive yet challenging way, therefore allowing for teachers to improve key aspects of their knowledge for teaching (Borko, 2008; Horn et al., 2017).

An additional benefit of communities of practice is the deprivitization of practice. Making teaching a public object of study rather than a private practice allows teachers to collectively reflect on teaching methods, plan lessons, and take coordinated action for further study (Dufour & Eaker, 1998; Little, 2002). Through the deprivitization of practice, teachers can converse more critically to identify gaps in their own knowledge for teaching. Research has shown that the deprivitization of practice can more readily happen through developing communities of practice (de Jong et al., 2019).

Duration of professional learning opportunities

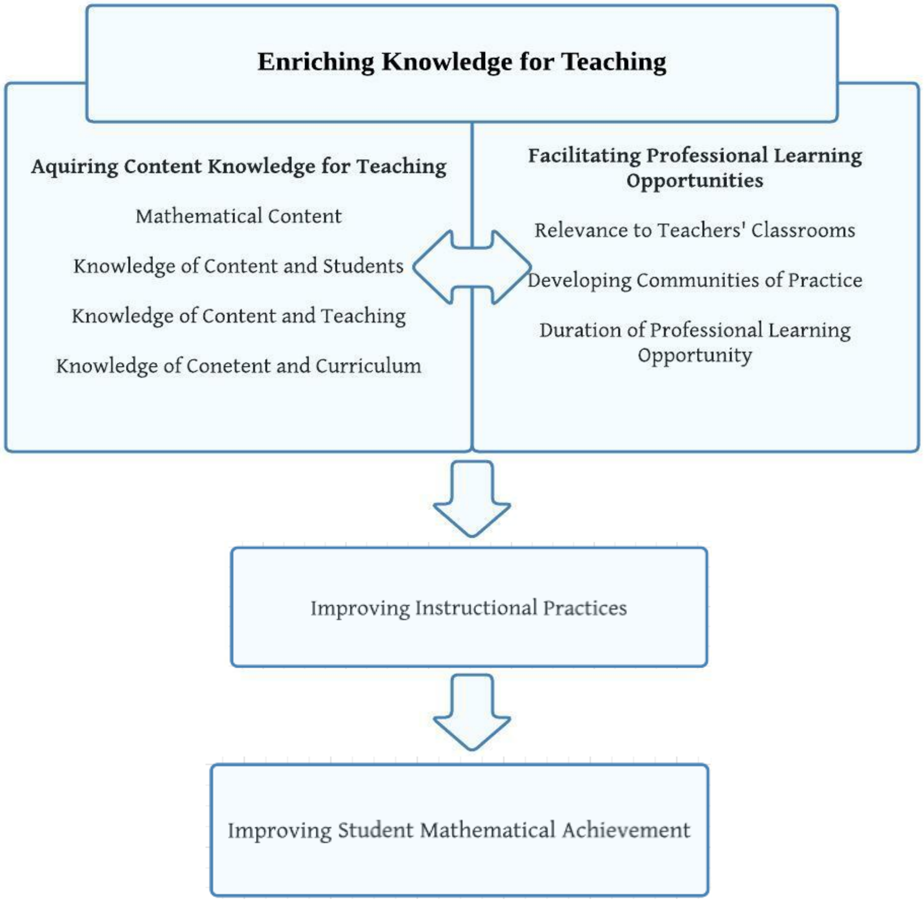
Applying knowledge acquired during professional learning opportunities is more likely to influence teaching practices if the professional learning opportunity is ongoing and intensive (Desimone, 2009; Pellegrini et al., 2018; Prast et al., 2018; Kraft et al., 2021; Borko et al., 2008). Even professional learning opportunities that focus on adjusting, rather than overhauling, teachers' instructional practices are more likely to be successful if teachers are given ample time to reflect on how to implement their newly acquired knowledge (Gibbons & Cobb, 2017; Borko et al., 2008).

Summary of the Theoretical Framework

The framework I will use to examine the professional learning opportunities in instructional circles is summarized in Figure 2. The top two side-by-side boxes were created by unpacking the top box in Figure 1. I will use these boxes as a lens through which to consider potential teacher learning during instructional circle sessions.

Figure 2

Framework for Enriching Knowledge for Teaching Through a Professional Learning Opportunity



Teacher Learning in Japan

Because instructional circles occur in Japan, there may be parallels to other forms of teacher learning in Japan. The most studied form of teacher learning in Japan is lesson study. Reviewing several aspects of lesson study provides a backdrop against which features of instructional circles can be described more distinctly

Lesson study is the most popular form of professional learning for teachers in Japan. Every teacher in Japan participates in this professional learning program as a form of assessment, as well as professional learning. Lesson study is unique to the field of professional learning because it is used a vehicle by the Ministry of Education and other central educational institutions to illustrate major instructional themes they want to push for the year. Previously, these instructional themes have included how to center problem solving as a common form of lesson (Hiebert, personal communication, August 2022), and how to incorporate active learning into lessons (Melville, 2017). A main purpose of lesson study is to help teachers develop core instructional practices usually identified through sources outside of the classroom.

Another key feature of lesson study is that it is designed for teachers to collaboratively develop a lesson through a connected series of sessions that last around 6-8 weeks. Even though a well-developed lesson plan is not the goal of lesson study (Murata, 2011; Shimizu, 1999), teachers use the preparation of a lesson plan as a catalyst for discussions around different instructional practices and student learning (Melville & Corey, 2021).

Methods

Participants

Participants were members of two instructional circles, one study instructional circle, and one research instructional circle. Both circles included educators from Saitama prefecture in Japan. In the research instructional circle, five elementary school teachers (grades 1, 4, 5, and 6), a district math coach, and sometimes a university professor of mathematics education attended. In the study instructional circle, there were between five and six elementary school teachers (grades 3-6), a district math coach, the superintendent of the local district, and sometimes a university professor in attendance. Three of the participants in the study instructional circle were new to this type of professional learning opportunity. In contrast, everyone in the research instructional circle had previous experience attending either a research or study instructional circle. Each of the participants in both groups had at least three years of teaching experience.

Setting

Both instructional circles were located on the northern side of Saitama prefecture, in which the participants worked at nearby schools. The two instructional circles differed in the learning goals and the participants, but their approaches to help teachers improve their instructional practices were similar. The study instructional circle included elementary school teachers who felt that mathematics was not their strong content area of teaching. The research instructional circle included teachers who enjoy teaching mathematics and wanted to investigate how instructional tasks and/or questions could improve student thinking and learning. The overarching structure was similar for both types of instructional circles, however, the types of teacher knowledge the teachers focused on slightly differed.

Both instructional circles typically met once each month during the 10-month school year in one of the participant's schools. The covid-19 pandemic created a different setting for the instructional circles. During the covid-19 lockdowns, teachers met remotely using zoom. When asked, teachers did not indicate any substantive changes to the content or the content facilitation in instructional circles as a result of using zoom.

Data Collection

Data were gathered through an ethnographic approach using the educational ethnographic guidelines outlined by Eisenhart (1988): participant observations, interviews, artifact collection, and researcher introspection.

Participant Observations

I was invited to these instructional circles by contacts made while conducting a previous study in Japan. Zoom allowed me to attend all ten monthly sessions that constituted a one-year professional learning cycle. My role was similar to the participating teachers who were not presenting a problem of practice during the session. I asked clarifying questions about the presented lesson and engaged in discussions about different approaches to solve the teachers' problem of practice. Each session lasted about 90 minutes. I recorded each session with the participants' consent.

Interviews

Interviews were conducted with the participants of each instructional circle after the full cycle was completed. The purpose of the interviews was to learn more about the history of instructional circles and how the instructional circles are viewed from the participants' perspectives. The interviews were conducted and recorded virtually through zoom. Each interview was semi-structured and lasted approximately 45 minutes. The interviews were conducted in Japanese. I am fluent in Japanese, so only the evidence presented was translated into English.

Artifact collection

I collected the written agenda created for each professional learning opportunity session. Sessions began with a teacher presenting an instructional problem, and the agenda included this problem. In addition, the agendas provided administrative data such as which teacher was going to present and the dates of the meetings. I also collected lesson plans brought to the group, snapshots of relevant textbook pages, and blackboard plans teachers brought to share with their colleagues. Before each session, teachers communicated using a group messaging service (line) to coordinate topics, confirm meeting times, and solicit additional topics of study from the teachers who were not presenting a problem of practice. I collected the records of these conversations.

Data Coding

Guided by the framework for enriching knowledge for teaching, I searched for instances that depicted each of the four types of MKT and each of the facilitation features I described earlier. I counted as an instance a discussion episode that focused on a single mathematical idea or a single problem of instructional practice.

Data Analysis

My analyses produced qualitative descriptions of instructional circles—the nature of learning opportunities that could support teachers learning of MKT and the facilitation features that increased the relevance and the potential of these opportunities. The analysis involved three phases. In the first phase, I found instances from the video recordings of each instructional circle session. In the second phase, I designed the final interview protocol based on preliminary findings from the first phase, I interviewed the participants, and I analyzed the interview transcripts. In the third phase, I analyzed artifacts to refine interpretations of findings from the first two phases and add new findings. Because I want to answer the same questions for both instructional circles, the analysis was identical for each type.

Analysis of Video Recordings

I re-watched all the video recordings of the sessions of the instructional circles to look for instances that describe the ways teachers develop their MKT, and the facilitation features present in instructional circles. After I re-watched all of the instructional circle sessions, I looked for common themes across the instances for similarities and differences. I then formulated questions for the interviews to clarify aspects of instructional circles that remained unclear after watching the individual sessions.

Interviews

The interview questions were designed to clarify structural aspects of instructional circles that I was unable to observe, while other questions were used to learn about teachers' motivations for attending instructional circles. The interview protocol provided specific prompts rather than leaving questions open-ended. From my previous experience, I was afraid that some educational practices seem so familiar and natural to Japanese educators that they would not comment on them unless explicitly asked (Melville & Corey, 2017). For example, educators can determine if other teachers *kyouzaikenkyuu* (instructional materials research) is sufficient and well done, but when asked "what makes kyouzaikenkyuu sufficient and well done?" The teachers had a hard time defining something that seemed overly familiar to their teaching practices.

Artifacts

I collected artifacts, such as student work, lesson plans, board work plans, textbook samples, and transcripts of previously taught lessons, to provide a richer description of the instances that depict the categories of my framework. The artifacts are used to provide insight to the materials that the teachers use during the professional learning opportunities, and as an example of the preparation teachers engage in when participating in instructional circles.

Expert Feedback

Since my experience with instructional circles was limited to these two circles, it was difficult to know whether they were representative examples of instructional circles across Japan. To determine the ways in which the circles were unique, I reviewed my claims with Japanese colleagues from Nara prefecture and Kumamoto prefecture who are experts in mathematics education in Japan and have extensive knowledge about instructional circles. Because these professors work in different regions in Japan, they could also address regional biases in my descriptions.

Findings

I will first present an overview of the instances from each instructional circle session. I begin by presenting the instances that show the content that was addressed during the study group, and then the research group. I then describe in more detail the learning opportunities by presenting several examples from each type of knowledge within the MKT framework. I then present an overview of the instances that contain essential facilitation features from the study instructional circle, and then the research instructional circle. Finally, I provide a more detailed description of several of the examples that show how instructional circles provide different ways to facilitate professional learning opportunities.

Table 1

Content Addressed in the Study Instructional Circle

Session and Presenting Teacher	Specialized Content Knowledge	Knowledge of Content and Student	Knowledge of Content and Teaching	Knowledge of Content and Curriculum
1 Teacher 1	Teachers discussed the differences in	Discussed possible student misconceptions	Discussed different strategies to	Teachers discusses reasoning

	representation and mathematical understanding behind 74 * 8 and 8 * 74	and how to help them understanding the meaning of the problem when switching positions when multiplying	help the students move from one representation to another	behind why the textbook presented the problems in a specific order
2 Teacher 2	Teachers learned about the similarities of fractional division and decimal division	Discussion about how to connect students' prior understanding of decimal division to transfer using that in fractional division	Discussion about how the lesson changes depending on what representation students develop during individual time	Discussion about whether students would actually develop strategies shown in the textbook for this lesson
3 Teacher 3	The teacher asked the other teachers help him better understand the concept of area in a given situation	A discussion about how students may think about area differently than the teachers	Discussion about how understanding the mathematics from your students' perspective can illuminate different challenges	No Evidence Found in this Session
4 Teacher 5	No Evidence Found in this Session	Discussion about how to help students who need help to stay sitting. Earlier grades learning how to do individual work	Teachers offered ideas of how they were able to find success in helping kids who get bored, or accomplish the task early	No Evidence Found in this Session
5 No Teacher	Session was cancelled	Session was cancelled	Session was cancelled	Session was cancelled
6 Teacher 1	Discussion about different ideas behind a fraction	Teachers presented different aspects of fractional	Discussion about how to help students understand the	Teachers discussed how the textbook assumes this

	dividing a fraction	division that have been difficult for students to understand	meaning and purpose behind fractional division	topic is going to be as easily understood as other topics
7 No Teacher	Session was Cancelled	Session was Cancelled	Session was Cancelled	Session was Cancelled
8 Teacher 4	No Evidence Found in this Session	Discussion about how to help students who are struggling with trying problem solving approaches in early grades	Teachers discussed building off of students' prior knowledge, in this case the counting scheme for Japanese is already reinforcing addition ideas	No Evidence Found in this Session
9 Teacher 3	Teachers looked at how the different solution methods in fractional division are similar mathematically	Discussion about possible student misconceptions when looking at decimal division	Knowledgeable Other reinforces the idea behind asking good questions will allow for students to stay engaged in the lesson and be less confused	Discussion about why the teacher changed the lesson task found in the textbook to something more complicated
10 Teacher 4	No Evidence Found in this Session	Teachers discussed how to help students with their online learning during the pandemic	Strategies for helping students engage in mathematics during an online course	No evidence found for this category during the session

As shown in Table 1, the sessions do not form a sequence of topic-related activities that build toward professional learning of a larger mathematical concept or a special instructional practice. Rather, each session is driven by the problem of practice presented by an individual teacher.

Table 2

Content Addressed in the Research Instructional Circle

Session and Presenting Teacher	Specialized Content Knowledge	Knowledge of Content and Student	Knowledge of Content and Teaching	Knowledge of Content and Curriculum
1 Teacher 5	Used a compass and straightedge to develop and understand multiple solution methods to constructions of shapes	Developed multiple solution strategies to using a compass and straightedge that students may use	Looked at how using a compass and straightedge reaffirms different properties of shapes	No evidence found for this category during the session
2 Teacher 2	Moving from manipulative representations to more abstract representations of addition (e.g., 5+3)	How to help students understand the "+" is a combination of two quantities. "Counting on" versus "Counting All" strategies	Discussion about the phrase "Solve this problem". This doesn't express the desire for the students to work together.	Discussion about whether the textbook representation of adding fish to a fish tank support all the kinds of thinking for students
3 Teacher 3	Learned about how changing a simple problem (15 – 5) to a seemingly similar problem (15 – 3) can have a big effect on student thinking	What types of strategies are used when subtracting 15 – 5 as compared to 15 – 3.	Discussion about the language used when saying the operation of "subtract" versus using words like "take away"	Discussion about why the textbook chose to use manipulatives to represent this operation even though students could use paper and pencil
4 Teacher 2	Teachers learned about several ways to represent the approximation of the area of a circle	Discussion about whether students will fully understand the idea about the smaller pieces a circle	Discussion about using the idea of approximating the area of a circle instead of jumping	Discussion about a challenge problem given by the textbook that may be too challenging for

		is cut into will yield a more exact approximation	directly to the formula for finding the area	students to solve using only approximations
5	Session was cancelled	Session was cancelled	Session was cancelled	Session was cancelled
6 Teacher 4	No evidence found for this category during the session	Discussed the possible implications about giving students water to begin to estimate how much a bottle would hold	Discussion about how to make the thought-provoking question (*Hatsumon*) elicit the type of student thinking that is desired	No evidence found for this category during the session (Teacher used their own task)
7 Teacher 3	No evidence found for this category during the session	Teachers used student work to discuss possible ways to help student misconceptions	There was a discussion about productive struggle and how much do we want kids to struggle with mathematics	No evidence found for this category during the session
8 Teacher 1	Teachers discussed that different problems elicit different types of student thinking	There are possible different thought processes going on even though the solution method looks similar	Different solution methods may provide insight into different struggles students are having	No evidence found for this category during the session
9 Teacher 5	Used a compass and straightedge to develop and understand multiple solution methods to	Developed multiple solution strategies to using a compass and straightedge that students may use	Looked at how using a compass and straightedge reaffirms different properties of shapes	No evidence found for this category during the session

	constructions of shapes			
10 Teacher 6	Discussed deeper meaning of fractions	Different representations of fractions may be difficult for students to access.	Discussion about if students would be able to think about fractions in the way they are presented	No evidence found for this category during the session

Like in Table 1, Table 2 shows varying topics of focus. Notice, however, that in Session 9, Teacher 5 returned to the same topic they posed in Session 1.

To provide a richer picture of the professional learning opportunities, I will present examples for both the study and research instructional circles. I found few differences between the two instructional circles.

Instructional circle sessions are structured around teachers volunteering to present a plan for an upcoming lesson or a lesson they have already taught. During this presentation, teachers pose a specific problem of practice for which they would like advice from the other participants. The participants each take turns asking clarifying questions about the presented lesson, and then the teachers discuss the problem of practice. At the end of the instructional circle session, a mathematics education expert offers some concluding thoughts about the discussed ideas.

Opportunities to Enrich Knowledge

In the next sections, I present examples of professional learning opportunities to build mathematical knowledge for teaching. In each section, I focus on one type of knowledge. Because the types of knowledge are intertwined, it is impossible to completely separate them. Most examples offer opportunities to develop multiple types of knowledge, but I will foreground one type and, often, note that other types could be acquired as well. I will elaborate some of these by revisiting the same examples when foregrounding another type of knowledge.

Specialized Content Knowledge

During instructional circle sessions, I saw opportunities for teachers to enrich their specialized content knowledge (SCK). Mathematical content knowledge is one area in which the study instructional circle and research instructional circle had similar opportunities to learn, but the discussion topics were different.

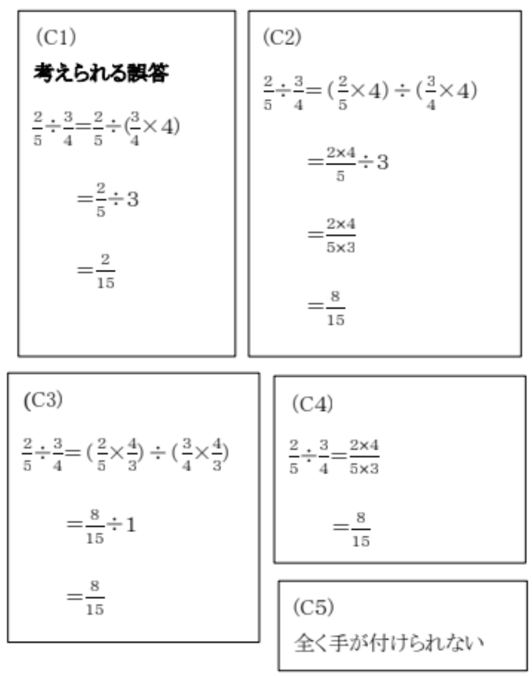
A professional learning opportunity for teachers to enrich their SCK comes from the second session in the research instructional circle group. A first-grade teacher posed a problem of practice about helping students understand the importance of showing the two quantities of 3 and 5 being combined (instead of just counted) to represent 3+5. The teacher suggested using manipulatives (blocks, circles on the whiteboard, etc.), then moving to a more abstract representation using numerical representations. Teachers began the discussion by considering the importance of the meaning of the + sign. One of the teachers talked about the importance of language when asking a thought-provoking question (a type of question that often begins Japanese lessons). The teacher said, "there is a difference between saying *add* the three blocks and the five blocks to find how many total blocks there are and *combine* the three blocks and five blocks to find how many total blocks there are". The teachers noted that using words like "combine" or "put together" reinforces combining quantities, whereas saying "add" or "how many are there total" reinforces solution methods like counting on or counting all. Teachers then described different understandings of what the + sign emphasizes. To some people, the + sign emphasizes the process, whereas to others it emphasizes the final group size. The idea that combining quantities is an action that reveals an appropriate meaning for the + sign for first-grade students was an opportunity in this instance for teachers to enrich their SCK.

In the ninth research instructional circle session, there was an opportunity for teachers to enrich their SCK around using mathematical tools to further students' conceptual understanding. The presenting teacher presented a lesson about finding missing parts of shapes when given the midpoints and some vertices using a compass and straight edge. The problem of practice was how to help students use a compass and how to improve teachers' questioning while students are using a compass. The group members discussed how they could tell whether a regular hexagon could be fully constructed using only a compass if only half of the hexagon was given. The discussion involved some teachers showing their solution methods to the other teachers, while others asked them clarifying questions about their solution methods. Once the teachers agreed the problem could be solved, they explored multiple solution methods. After working for about ten minutes, teachers moved to using a compass to reaffirm the properties and definitions of regular polygons. An opportunity for teachers to enrich their SCK began when they studied multiple possible solution methods and discussed why these solution methods are viable.

During the second study instructional circle session, teachers had an opportunity to enrich their mathematical understanding about fractional division. In particular, the professional learning opportunity supported teachers' learning of the common conceptions and misconceptions of dividing a fraction by a fraction. The presenting teacher was worried about forgetting important mathematical concepts or not helping students recognize those important concepts. Another teacher stated that from his experience, it is important to understand the mathematics behind each of the possible solution methods to prepare for any situation that can arise during the lesson. He explained that he had a similar question when he first began participating in the study instructional circle group, so he is passing on the advice he received. The group then talked about how to connect fractional division with decimal division so that the teachers could understand how to help their students build off prior knowledge. After learning about the connections with decimal division, they went over the mathematics behind each of the possible student solutions they identified (see figure 3).

Figure 3

Artifact About Possible Student Solution Methods for Fractional Division



The teachers talked, not only about the mathematics behind the solution methods, but also about the benefits of the different solution methods. For example, they compared the solution method of $\frac{2}{5} \div \frac{3}{4} = (\frac{2}{5} \times 4) \div (\frac{3}{4} \times 4)$ and $\frac{2}{5} \div \frac{3}{4} = (\frac{2}{5} \times \frac{4}{3}) \div (\frac{3}{4} \times \frac{4}{3})$ to see the mathematical benefits of developing one strategy over another. The presenting teacher expressed her hopes that her students could produce different solution methods. During this instructional circle, teachers had an opportunity enrich their SCK by talking about why the multiple solution methods are viable and what to do if students present a common misconception. This example also contains opportunities for teachers to enrich their horizon content knowledge (HCK) through making connections between fractional division and decimal division, and their knowledge of content and students (KCS) by learning how to build on students' current understanding of division. These will be elaborated in later sections.

These examples show opportunities for teachers from both types of instructional circles to enrich their SCK through various activities. During the research instructional circle, the teachers talked in detail about the meanings of the addition sign, implications their word choices could have on student thinking, and how to use a compass and a straight edge in different ways to solve a task. In contrast, the study instructional circle broadened their understanding of how to help students build on their prior knowledge of division with decimals to guide their learning about division with fractions. The study circle also talked about different solution methods, and how to guide students who are struggling towards one of the possible solutions. Although the problems of practice were similar, the research instructional circle talked in greater detail about a specific problem while the study instructional circle looked at the problem more broadly.

Knowledge of Content and Students

In the ninth research instructional circle session presented earlier (using a compass to find missing side lengths of polygons), there was an opportunity for teachers to enrich their KCS through increasing their knowledge about students' understanding of mathematical tools. The presenting teacher asked how he could get his sixth-grade students to use a compass in a way that would enhance their understanding of regular polygons. There was a twenty-minute discussion about whether the compass was a viable tool to improve students' understanding of regular polygons. Some teachers felt that sixth-grade students would not understand the ideas of congruent sides and equal angles through use of a compass, whereas other teachers thought it would reinforce those concepts. In response to this problem of practice, there was no clear decision among the teachers on whether to use the compass in the lesson.

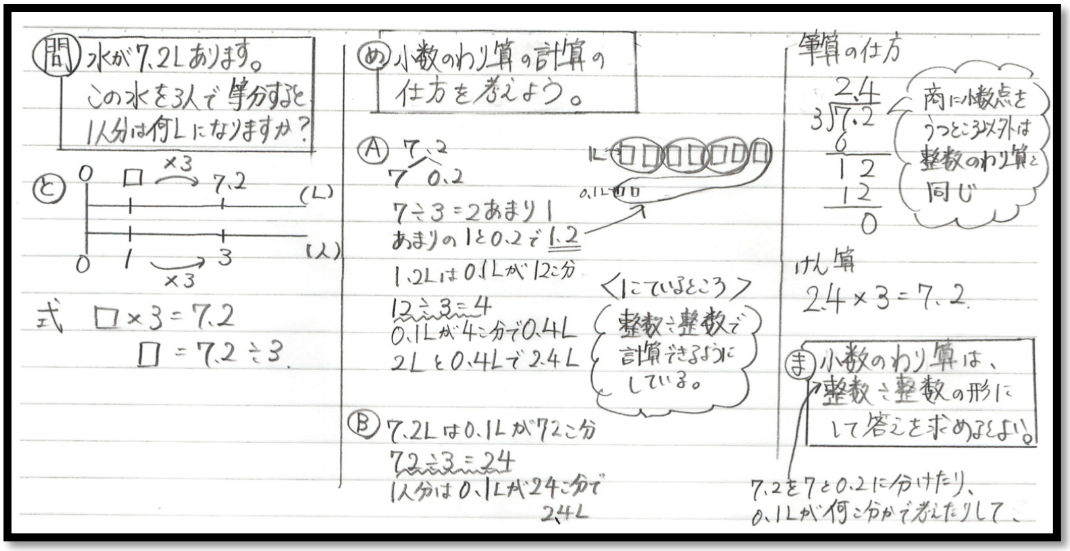
The knowledgeable other in the group (the district's math coach) stated that the discussion represented great kyouzaikenkyuu, or instructional materials research, but getting the students to understand is still a challenging endeavor. After the knowledgeable other's comments, the teacher who presented his problem was left to decide what to do about using the compass in his lesson. This professional learning opportunity contains opportunities for teachers to enrich two components of KCS: (a) teachers could improve their knowledge of how mathematical tools could promote students' understanding during the discussion of whether a compass could reinforce students' concepts of equivalent lengths of segments or whether students would only view the compass as a tool for drawing circles; and (b) teachers could improve their knowledge of student misconceptions during the discussion of the ways in which students might not use the compass correctly.

In the tenth session of the research instructional circle, there was an opportunity for teachers to improve their KCS and their knowledge of content and teaching (KCT) simultaneously through investigating a common misconception when adding fractions. I will describe the KCS opportunity here and the KCT opportunity in a later section. Teachers considered the task of adding fractions for the first time, specifically $\frac{3}{5}+\frac{4}{5}$. The presenting teacher asked for advice about how to help students when they present an incorrect solution, such as $\frac{3}{5}+\frac{4}{5}=\frac{7}{10}$. Teachers examined how it might be helpful for all students to see this common misconception, so they learn what not to do and why this does not work. Other teachers suggested using guiding questions or hint cards that could help correct students' thinking. The discussion about which teaching strategy was better for students lasted fifteen minutes. Even though several ideas were given for the teacher to consider, there was no resolution to the teacher's problem.

During the ninth session in the study instructional circle, there was an opportunity for teachers to enrich their KCS related to helping students make connections to prior knowledge by examining dividing a decimal number by a whole number. As shown in figure 4, the teacher's board work plan included two possible student solution methods to the problem 7.2 ÷ 3.

Figure 4

Artifact Used for Discussion During the Ninth Session of the Study Instructional Circle



The teacher expressed concern that students would be unable to produce the second solution method. If he explicitly encouraged that solution method, his students might not be ready to understand it. The teachers talked about how students were likely to think about division and how prior knowledge of multiplicative relationships could help them solve this problem. One teacher said, “some students might see that 3.6 is half of 7.2, since 3.6 divided by 3 is more accessible to the students, they then could simply double their answer”. The presenting teacher had not thought of that possible solution method but found it interesting because the textbook originally had 3.6 as the dividend.

The teachers then talked about possible misconceptions that students could have when solving. The first misconception described was forgetting to replace the decimal in the second solution method (marked *b* in figure 4) after taking it out. The solution method had the students solve 7.2 ÷ 3 by solving 72 ÷ 3 and then reinserting the decimal into the answer. The presenting teacher was worried that students would not see the connection between multiplying the 7.2 by 10 then needing to divide the answer by 10 to represent a multiplication by 1. Another misconception teachers examined was not realizing that 1.2 could be divided by 3. Teachers talked about helping the students multiply by 10, then divide by 10, to show they can treat 1.2 similarly to 12 when dividing. These discussions about possible students' misconceptions and how to help students through them provided teachers with opportunities to enrich their KCS.

In the same session, the presenting teacher asked how he could conduct this task without confusing the students. The knowledgeable other reinforced the idea that asking these types of questions when preparing for a lesson is what should be done to make a lesson great. The discussion about this particular solution method and whether it was accessible for his class of third graders lasted for over thirty minutes of the hour-long session. This discussion provided teachers with an opportunity to enrich their KCS by talking about students' perseverance and what prior knowledge they need, as well as how they are going to use this knowledge in the future.

During the eighth session in the study instructional circle, teachers had an opportunity to enrich their KCS. In the line chat among the teachers, a teacher new to instructional circles asked if they could explore her problem of practice even though it was not her turn to present a problem. The other teachers agreed, and the next session began with her question, "what can I do about students who are struggling to engage in problem solving?" This question was mostly about a first-grade classroom in which students were having a challenging time persevering while solving problems. The session began with teachers discussing classroom management, but quickly moved to ideas about helping students build on what they already know. The knowledgeable other talked about how learning to count in Japanese is more conducive to helping students add quantities and develop number sense than learning how to count in English. The knowledgeable other shared how Japanese children learn about numbers and develop number sense naturally when learning to count. He explained, "when counting past 10, we say 10 then 1, 10 then 2, and so on. When kids count higher than one ten, they say two 10's then 1, two 10's then 2. In contrast, in English kids say 'eleven' which does not help students develop their number sense like 10 and 1." These insights provided opportunities for the teachers to enrich their KCS through improving their understanding of how students develop number sense, and to rely on that knowledge when making future mathematical connections.

I inferred from my observations that student thinking is at the forefront of teachers' minds when engaging in the presented problems of practice. I found the instructional circle sessions filled with opportunities for teachers to build their knowledge of student thinking. For example, in the instructional circle session about using a compass to help students understand regular polygon relationships, the teachers talked about how students might think about the examples when using a compass. They wondered whether the students would recognize that compasses are used to create side lengths of equal size and not just circles. In the second study instructional circle session focused on introducing fractional division, the teachers talked about the students' current understating of multiplicative relationships and how to develop student understanding based on their prior knowledge (multiplicative relationships). In the session on adding 5 + 3 = 8, the teachers examined students' potential understandings and suggested how the presenting teacher could help students use these understandings when explaining their solution methods. The teachers in this session talked about different representations and the meanings they likely have for the students. For example, students can use blocks to represent 5+3, but that is different from using numbers to represent 5+3. In these examples, the problems of practice were not explicitly about student thinking. Still, the teachers used how students think about the mathematics and potential misconceptions students might have as explanations and reinforcement of possible solutions to the problems of practice.

Knowledge of the Content and Teaching

During the instructional circle sessions, teachers had an opportunity to improve their KCT around asking thought-provoking questions and using multiple representations to solve a problem.

Revisiting the ninth session in the study instructional circle in which the teachers discussed problems of practice around the problem $7.2 \div 3$, there were opportunities for teachers to enrich their KCT by learning how to ask better thought-provoking questions during the discussion section of the activity. A teacher wanted to know how to improve his *hatsumon,* a term used for the thought-provoking question, to launch the task or move students thinking forward. He presented his lesson plan in the form of his board work plan (see figure 4). Teachers in Japan frequently develop board work plans which show how they expect the chalkboard to look at the end of the lesson. He included two potential student solution methods signaled by a and b. He said, "I'm worried that students might not be able to skillfully explain their thinking in a, that no students will think about the solution method for b, so I will have a hard time asking questions using the students' words to tie these solution methods together."

One piece of advice the presenting teacher received from the other teachers was to focus on the point of the lesson. First, they asked him, "what do you want your students to understand?" They questioned whether all students should learn both methods, and if it is good enough to know just one solution method. The knowledgeable other said, "some students will say that solution method a is easier, while some students will say that b is easier. I don't think it is important that they need to connect both, but the kids that use a should be able to explain a and the kids that do b should be able to explain b". The presenting teacher then agreed and noted understanding both methods was not part of the lesson goals. They then worked on thought provoking questions that could be asked for each solution method. One teacher said, "students know how to divide 6 into three groups, then they will be able to divide the 1 into three groups, but they might get stuck dividing 0.2 into three groups, they might not see that 1.2 can be divided into three groups easily". Another teacher said, "if students were using solution method b, then part of the hatsumon should ask where the decimal point went, and what to do if no decimal point was reinserted."

As mentioned earlier, in the tenth research instructional circle session about the multiple representations of adding fractions, teachers also had an opportunity to understand the learning development students' progress through when learning how to add fractions. This was mostly done when teachers were talking about whether it could be beneficial to show the students the misconception of $\frac{3}{5}+\frac{4}{5}=\frac{7}{10}$. The discussion around this teaching strategy of presenting common misconceptions to help the students be aware of mistakes could enrich teachers' instructional practices, or KCT.

Another example in which teachers had an opportunity to enrich their KCT after improving their KCS was in the second research instructional circle, their discussion centered around solutions to the addition problem $3+5=8$. After discussions about the different representations of the problem, the teachers talked about supporting students from the "counting all" strategy to the "counting on" strategy when solving this problem. The teachers discussed that representations involving manipulatives or pictures of the quantities being combined could lead to a "counting all" situation, whereas abstracting the representations through using numbers could help the students move to the "counting on" strategy.

Knowledge of Content and the Curriculum

There are two main ways that conversations during instructional circles could have enriched teachers' curricular knowledge. The first focused on why the textbooks selected the activities for the lessons, and the second situated the current lesson goals in the national standards.

To understand the curricular context of teachers' conversations, it is important to know there are only six curricular programs in elementary schools in Japan. Each program undergoes an extensive evaluation process by the ministry of education to get approved. There are slight differences in the tasks used or the order in which some of the topics are taught but, overall, they match the national curriculum standards.

During the fourth session in the research instructional circle, teachers had an opportunity to enrich their knowledge of content and curriculum (KCC). The presenting teacher was worried that the representations provided in the textbook would not help the students derive the algorithm for finding average (see figure 5). There are two different representations of finding average in the textbook, one with cubes stacked at various heights and the other with glasses of orange juice filled to different heights.

Figure 5

Artifact from the Textbook Activities for Finding Average

The presenting teacher was pleased the students would leave this lesson knowing that finding the average was akin to making all the amounts equal; however, he was worried these activities did not connect to the algorithm for finding the average and to the mathematical meaning of average. He worried that the students would pour orange juice from one cup to another in small quantities back and forth until the cups were equal but not recognize the averaging concept. To represent the algorithm, students should pour the cups into one container and then split it equally between them. The other teachers in the circle also worried that students would only move one cube at a time rather than making one big pile and then splitting it evenly. The conversation moved to finding questions that would direct the students to make a larger quantity and then split that quantity evenly. The teachers were concerned the students would think the method of combining and splitting was not efficient and would revert to the equalizing method. The teachers then decided to find a different context in which students would use a solution method that could eventually be represented by the standard algorithm. By examining the textbook problem carefully, the teachers had an opportunity to learn in what ways they might question, and then improve, curricula material. Notice that this learning opportunity relied on another type of knowledge—knowledge of content and students (KCS).

During a number of instructional circle sessions, teachers tried to understand the implications of changing the task found in the textbook. Another example is shown in figure 3. The presenting teacher changed the task in the textbook from 3.6 ÷ 3 to 7.2 ÷ 3. He did this because he wanted to push students to think about the operation on the entire number (7.2) and not as an operation on the number's separate parts (3 and 0.6). During the conversation about helping students develop a solution method to solve this problem, the teacher was asked by others to describe the intent of the original problem in the textbook. Would changing the problem changed the intent of the curriculum? The teachers looked at the sequence of problems in the textbook to see whether the presenting teacher was taking out important scaffolding for future problems. When they found that the teacher's proposed replacement problem was in line with the textbook's conceptual flow, they returned to focus on his specific problem of practice. Even though understanding the curriculum design was not the focus of the problem of practice, the teachers created an opportunity to further their understanding of the curriculum to make more informed decisions about the lesson.

Facilitating Professional Learning Opportunities

Instructional circles are structured in ways that place teachers at the center of the learning process by asking them to select the topics of study. I observed when reviewing the research on professional learning opportunities that particular features are believed to be especially useful for helping teachers connect the content of the opportunity to their own classrooms. My observation of instructional circles suggests these features are often addressed through the circle's structure. The following tables describe instances of how instructional circles achieve relevance due to their structure.

Table 3

Facilitation Features from the Study Instructional Circle

Session and Presenting Teacher	Relevance to Practice	Developing Communities of Practice	Duration of Professional Learning
1 Teacher 1	The discussion was situated within Teacher 1's classroom because the problem of practice was introduced through a lesson plan prepared for an upcoming lesson	Teacher 1's practice was deprivatized through the use of a lesson plan they prepared that provided insights into their decision making about instructional decisions. Every participant was given ample time to provide feedback and ask questions.	50 minutes
2 Teacher 2	The discussion was situated within Teacher 2's classroom because the problem of practice was introduced through a lesson plan prepared for an upcoming lesson	Teacher 2's practice was deprivatized through the use of a lesson plan they prepared that provided insights into their decision making about instructional decisions. Teacher 2 was treated like a professional and given full autonomy over any decision made about the lesson	50 minutes
3 Teacher 3	The discussion was situated within Teacher 3's classroom because the problem of practice was introduced through a lesson plan prepared for an upcoming lesson	Teacher 3's practice was deprivatized through the use of a lesson plan they prepared that provided insights into their decision making about instructional decisions. Teachers were given time to provide feedback and ask questions about the lesson plan	45 minutes

4 Teacher 5	The discussion was at a more general level for relevance to classrooms	Teachers were able to brainstorm possible ways to answer the instructional problem. Every teacher was asked their opinion.	50 minutes
5 No Teacher	Session was cancelled	Session was cancelled	Session was cancelled
6 Teacher 1	The discussion was situated within Teacher 1's classroom because the problem of practice was introduced through a lesson plan prepared for an upcoming lesson	Teacher 1's practice was deprivatized through the use of a lesson plan they prepared that provided insights into their decision making about instructional decisions. Teachers were given time for questions and feedback.	50 minutes
7 No Teacher	Session was Cancelled	Session was Cancelled	Session was Cancelled
8 Teacher 4	The discussion was situated within Teacher 4's classroom because the problem of practice was introduced through competed student work and transcripts of the lesson that had already occurred	Teacher 4's practice was deprivatized through her the use of their students work and transcript of the lesson that they had taught prior to the professional learning opportunity. Other teachers were able to ask questions and provide feedback based on the snapshot of the class provided.	60 minutes
9 Teacher 3	The discussion was situated within Teacher 3's classroom because the problem of practice was introduced through a snapshot of the board work plan	Teacher 3's practice was deprivatized through her the use of the boardwork plan, which shows their reasoning and planning for possible student representations and how they are going to introduce the problem and conclude the lesson. Teachers provided feedback on the lesson holistically.	50 minutes
10 Teacher 4	The discussion was situated within Teacher 4's classroom because the	Teacher 4's practice was deprivatized through her the use of a lesson plan they	55 minutes

	problem of practice was introduced through a lesson plan prepared for an upcoming lesson	prepared that provided insights into their decision making about instructional decisions	

Table 4

Facilitation Features from the Research Instructional Circle

Session and Presenting Teacher	Relevance to Practice	Developing Communities of Practice	Duration of Professional Learning
1 Teacher 5	Teachers used a lesson plan to situate their discussion within Teacher 5's classroom	Teacher 5's practice was deprivatized through providing reasoning behind instructional decisions. All teachers provided insight and feedback.	50 minutes
2 Teacher 2	Discussion was situated within a teacher's lesson plan for the upcoming lesson	Teacher 2's practice was deprivatized through providing their reasoning for their instructional decisions. All teachers provided feedback. Teacher 2 was allowed to make final instructional decisions about the lesson.	45 minutes
3 Teacher 3	Discussion was situated in Teacher 3's classroom by using a lesson plan and textbook information for the upcoming lesson	All participating teachers provided feedback and asked clarifying questions. Teacher 3's practice was deprivatized through talking about their knowledge about different strategies students build on when adding.	50 minutes
4 Teacher 2	The discussion was situated within Teacher 2's classroom by talking about an instructional problem for an upcoming lesson	All participating teachers commented on their own understanding about approximating the area of a circle and why it is important for student development. All of the teachers' practice was deprivatized through discussing openly their	60 minutes

		own understanding about the topic.	
5	Session was cancelled	Session was cancelled	Session was cancelled
6 Teacher 4	The discussion was situated within Teacher 4's classroom because they presented a lesson plan for an upcoming topic	Teacher 4's practice was deprivatized through the discussion about this lesson. There was some negative criticism in this session that was taken as advice and improved the lesson.	50 minutes
7 Knowledgeable Other	The discussion was designed around a national conference about how to help kids persevere when challenged. Generally relating to the classroom	This discussion developed a community of practice within a community of practice. It was a report on a national conference with helps tie all of the teachers understanding together	50 minutes
8 Teacher 1	The discussion was situated in Teacher 1's classroom because they used a transcript and student work from a lesson that had already occurred to describe their problem of practice	Teacher 1's practice was deprivatized through them proving a snapshot of what occurred during an actual lesson. There was also a video recording of the lesson to allow for teachers to provide better feedback.	55 minutes
9 Teacher 5	The discussion was situated in Teacher 5's classroom through the problem of practice being established through the teachers studying an upcoming lesson plan that the teacher provided	Teacher 5's practice was deprivatized through the teachers looking closely at a lesson that they planned. There was also some criticism that the lesson was boring for students and needed to be fixed	50 minutes
10 Teacher 6	The discussion was situated in Teacher 6's classroom because the problem of practice was derived from a lesson plan for an upcoming lesson	Teacher 6's practice was deprivatized through providing rationale behind instructional decisions. All teachers were given the opportunity to ask questions and provide feedback.	50 minutes

Relevance to Practice

Instructional circles included both pedagogies of enactment, which are activities that plan for, rehearse, and enact high-quality teaching practices, and pedagogies of investigation, or activities involving studying classroom artifacts. Teachers brought a lesson plan, a board work plan, or student work to situate the problem of practice within their classroom. This structure encouraged a pedagogy of investigation—teachers discussed how to improve or ask clarifying questions about the classroom artifact. The same structure also encouraged a pedagogy of enactment—teachers then helped the presenting teacher plan future instruction.

One example of how the structure helped teachers engage in both pedagogies occurred during the seventh research instructional session (see figure 6). In figure 6, CI is the statement and work of the first student, CII represents the second student's work, and so forth. These examples were shared by the presenting teacher to highlight the student thinking that appeared in the lesson and to show the results of their interactions with students. After they looked at the lesson, the teachers discussed implications for the next lesson using the information in figure 6. In this case, instructional circles engaged teachers in both types of pedagogies included in actively learning.

Figure 6

Artifact of Examples of Student Responses Used During Instructional Circles

ＣⅠ：整数にして計算する。
×２．４が２４なら計算できる。
８０×２４＝１９２０　<u>１９２０円</u>

ＣⅡ：２ｍ，２．５ｍ，３ｍ，の代金から，０．１ｍ分の代金を考え，
２．４ｍの代金を求める。
２ｍのとき　８０×２＝１６０（円）
２．５ｍのとき　８０×２．５＝２００（円）
３ｍのとき　８０×３＝２４０（円）
０．５ｍで４０円上がるから，０．１ｍなら，４０÷５＝８で
８円上がる。
２．４ｍは，２．５ｍより０．１ｍ短いので，２００－８＝１
９２円になる。

ＣⅢ：０．１を単位として考える。
０．１ｍの値段が分かれば，それを２４倍すれば２．４ｍの値
段が分かる。
０．１ｍの値段を求める。　８０÷１０＝８（円）
２．４ｍの値段を求める。　８×２４＝１９２（円）

During instructional circles, student work was used infrequently. Instead, the instructional circles focused on discussing anticipated problems of practice and future lessons; they rarely reflected on previous lessons or looked at past student work. In only a couple of instances were student solution methods brought to discuss (see figure 6). Even in these instances, the focus was planning a future lesson based on what they could learn from the student examples.

Developing Communities of Practice

Instructional circles are structured in ways that seem to develop communities of practice. I observed teachers taking on different roles when participating in these instructional circles, both over the entire cycle and even within one session. In most sessions, teachers listened and offered advice, but every participating teacher presented a problem of practice in at least one session.

I learned during interviews that the circle leader is drawn from former participants. The leader is responsible for communicating when the sessions are being held, identifying the teacher who will present the problem of practice at each session, and facilitating the sessions. The circle leader changes only at the end of an entire cycle or one year. One participant said during his interview that he started as a participating teacher. He became the circle leader and then, as he furthered his education, he was asked to fill the knowledgeable other role. I asked another teacher about his motivation for participating in the instructional circles, and he said, "even as the expert, I still learn a lot about teaching and student thinking when I come to the instructional circles." Continuously improving as a community of practice appears to be not just for the participating teachers, but for the leaders of the circle as well.

Another way the teachers in the instructional circles form a community of practice is through their constant deprivitization of practice. I observed teachers presenting their problem of practice nested in the context of their prepared lessons or already taught lessons. Teachers critically discussed aspects of the lesson and pointed out areas that needed improvement. Critical comments were not directed toward the teacher but rather toward the lesson and the plan. For example, in the instructional circle involving the discussion around students' compass use, the knowledgeable other said the lesson was "tsumaranai" or "boring" for students because there were no interesting connections to the students' lives. These kinds of criticisms were common during the conversations. However, they were not meant as a criticism of the teacher's ability, but rather intended to push the teacher to think more deeply about different aspects of a problem of practice.

Communities of practice are developed within instructional circles because members appear to value all participants' ideas and comments. I observed that all participants had time to express their ideas, and all appeared to be comfortable doing so. The knowledgeable other did not lecture, or present ideas expected to be immediately accepted by others. It appeared that *all* participants saw these sessions as opportunities to learn from each other.

I asked a university professor who participated in the research study circle how much he was paid to participate in an instructional circle session. He said he did it for free. When I asked him why he would do it for free, he explained that he continues to learn about teaching mathematics and hear innovative ideas from teachers, which benefits him even as a professor. This concept of constant improvement and treating others respectfully has roots in Japanese culture (Melville & Corey, 2021).

Duration of Instructional Circle Sessions

The duration of the instructional circle sessions was 45 – 60 minutes. In both types of instructional circles, there were norms about time allocation that were practiced by all who participated. Teachers were all given time to express their ideas and questions about the problem of practice, and the final word was given by the knowledgeable other. Teachers listened to each other and were cognizant of how much time they had already used sharing their ideas.

The duration of the cycle of instructional circles normally spans the academic year. Each year, teachers are given different responsibilities, and encouraged to invite colleagues to join the circles, although they are welcome to do so throughout the cycle.

Additional Facilitation Features

I noticed some features that were not part of my initial framework but that could be critical in shaping the professional learning of participating teachers.

Teachers' Problems of Practice

Problems of practice structure every session of instructional circles. I use the term "problem of practice" to describe the questions and concerns that the teachers would like to improve on during the instructional circle session. The problem of practice came from teachers own instructional needs. These are often identified through lesson study or other lessons they taught that were observed by an expert teacher (Yoshii, personal communication). This is different than lesson study in which the teachers are working towards developing a common lesson.

In obvious ways, bringing one's own problem to a group increases the relevance of what this teacher learns, but there appear to be ways in which other teachers find relevance through this structure. During their interview, one teacher claimed that the benefits for the non-presenting teachers are twofold. First, sometimes teachers are in the same grade level and will teach the same lesson, which is a more immediate benefit for those teachers. Second, the knowledge gained about that one specific lesson can transfer when teachers prepare other lessons.

Grain-size of Discussions

Instructional circles provided a way of thinking about how teachers can engage in discussions about mathematics and lesson tasks that is different than common U.S. practices. Teachers in instructional circles discussed mathematics at a very fine grain size. In the following examples, notice that the grain size was partially determined by the very specific problem of practice posed by the teacher. One example occurred during research instructional circle session #2. The problem posed to the group was “what manipulatives should be used to better elicit student thinking?”. In response to this problem, teachers discussed, for about 10 minutes, the differences between using blocks versus goldfish as manipulatives when adding 3+5. They spent this time analyzing how using manipulatives affects student thinking. The teachers also looked at the implications of the vocabulary they used when introducing the idea of combining two quantities. They examined the effects on student thinking when using the operative word “combine”, “put together”, “add”, or “sum.”

The fourth session in the research circle provided another example of the fine grain size with which teachers talked about mathematics and mathematical problems. When discussing how to help students develop the algorithm for finding the average, teachers discussed the implications for student thinking of pouring liquid from one cup to another cup. Teachers discussed and analyzed the different possible strategies in great detail. By sharing suggestions for how students might think in this situation, teachers created opportunities to acquire KCS; by examining ways to adjust the problem, teachers created opportunities to acquire HK; and, by discussing different moves the teacher might make and what the likely consequences would be, teachers created opportunities to acquire KCT.

Expert Feedback

I sent my initial results to professional educators in Kumamoto prefecture and Nara prefecture. They confirmed my overall understanding of the instructional circles but said that some instructional circles meet every two to three months depending on their needs. The experts also explained they do not view instructional circles as having a year-long cycle, but rather providing ongoing professional learning opportunities for teachers. The participants and leadership might change, but there is never a beginning or end to the professional learning opportunity. They did confirm that in Kumamoto and Nara prefectures, teachers followed a similar structure of the presentation of a problem of practice and subsequent discussion to enrich teachers' mathematical knowledge for teaching (Yoshii, personal communication, March 2022; Ninomiya, personal communication, March 2022).

Discussion

I observed how instructional circles provide opportunities for teachers to enrich their mathematical knowledge for teaching by using facilitation features that researchers have described as important in other settings. For example, recall that in the second study instructional circle session, the teacher presented a problem of practice about helping students remember important conceptual aspects of the division of fractions. She used a record of practice (her lesson plan) to deprivitize her practice and reveal her thinking to her colleagues, while engaging in a pedagogy of enactment. Through these facilitative features of the professional learning opportunity, the teachers had an opportunity to enrich their knowledge of content and students (KCS).

As an observer, I found the nature of instances to be particularly interesting and informative because they recognize the importance of enriching the same types of mathematical knowledge for teaching identified earlier using the same facilitation features, but they do so in a way that differs from many professional learning opportunities described in the literature I cited earlier to establish my theoretical framework. I will review some of these differences, first for MKT and then for the facilitation features.

Mathematical Knowledge for Teaching: Grain-Size of Discussions

The discussions of all four types of MKT (specialized content knowledge, knowledge of content and students, knowledge of content and teaching, and knowledge of content and the curriculum) were carried out at a fine grain size. Teachers focused on the details of the mathematics, of students' thinking, of teaching moves, and of tasks and questions suggested in the curriculum. Teachers spent most of one session, for example, considering the best word to use to introduce first graders to the concept of combining quantities as the meaning for the "+" sign, or considering the best task for introducing the mean average to students. Similar examples could be identified in almost every session. These examples are similar to aspects found in lesson study because both types of professional teacher learning programs focus on the specific details of teaching.

Features that Enhance Professional Learning Opportunities

Developing Communities of Practice: A Different Interpretation of Communities of Practice

When observing an instructional circle from an outside perspective, the teachers exemplify the aspect of a community of learners. Teachers gather together voluntarily to help others and themselves improve their teaching practices. However, upon further investigation, how teachers were able to develop this understanding was through a unique method of deprivitizing practice. During instructional circles, teachers would present their own thinking in form of a lesson plan or board work plan. Teachers would also open their classroom to other teachers through providing a transcript of student responses to the lessons that they had previously taught. These methods of deprivitization of practice differ from the usual methods of other teachers watching a classroom lesson by viewing a recording or observing in person.

Relevance through Teachers Presenting their Own Problems of Practice

A strong recommendation in the literature is that professional learning opportunities have relevance to teachers' classroom practices (Desimone, 2009; Darling-Hammond, 2009; Kazemi & Franke, 2004). Instructional circles uniquely accomplish this through its structure. As I noted earlier, presenting a problem of practice ensured that the session would be relevant for the presenting teacher. Other participants indicated that they found relevance through imagining how they could translate the discussion around the problem being examined to their own problems.

Another feature that could increase the relevance for teachers was mentioned in the previous section. It was common for group members to avoid agreeing on a solution to the problem presented. They saw their role as offering ideas based on their previous experiences and teaching philosophy. The individual teacher was left to decide on a final solution. Thinking through the series of suggestions with your own students in mind would inevitably bring the discussion back to your classroom.

Duration of Professional Learning Opportunities: A Different Interpretation of Duration

One commonly recommended feature of professional learning opportunities found in the literature is intensive and ongoing (Desimone, 2009; Pellegrini et al., 2018; Prast et al., 2018). This feature is believed to increase the probability that teachers will acquire and use the content of the learning opportunity. The argument is that acquiring challenging knowledge and skills takes time, and through a sustained professional learning opportunity, teachers can acquire MKT (or other challenging content), can study an instructional practice, can implement the learned practice, and can reflect on that implementation (Kraft et al., 2021).

Instructional circles offer another perspective about the intensity and duration of a professional learning opportunity. The average instructional circle session lasted about 50 minutes. Each session focused on a different problem of practice and so offered an opportunity to learn something different. The duration of these sessions was less than those called for by U.S. researchers and educators (Desimone, 2009; Pellegrini et al., 2018; Prast et al., 2018).

One reason for this shorter professional learning opportunity in instructional circle sessions is that their goals were relatively small, concise, and highly focused. It is clear that instructional circles are not hoping to change teachers' beliefs or overhaul their teaching practices. Instead, they focus on a very specific teaching problem. Another reason for instructional circles' brevity is that, although teachers offer multiple suggestions and have lengthy discussions about small grain-size issues, the goal is not to reach consensus about the best solution to the problem of practice. Rather, the goal is to provide the teacher with ideas so they can move toward solving the problem when they study their lesson plan again, after the session.

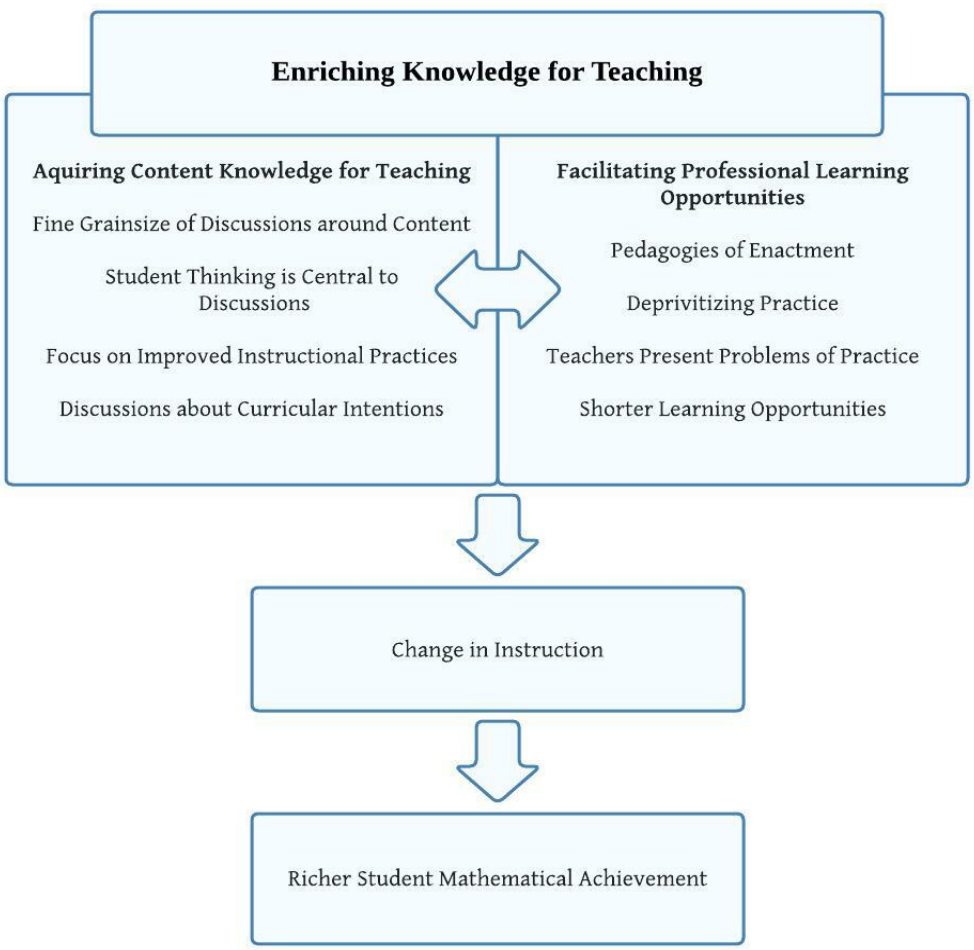
The duration of instructional circles is one area that differs from lesson study. During instructional circles, the sessions are spread out and focus on separate tasks; whereas, during lesson study, they meet regularly during a six to 8 week period and focus on one task. This signals that the duration of the professional learning opportunity could depend on the purpose of the activity and outcomes desired.

Instructional Circles' Framework for Enriching Knowledge for Teaching

Based on the findings and descriptions above, it is now possible to specify further the framework presented in Figure 2 to show how instructional circles support teachers' professional learning opportunities to enrich their knowledge for teaching.

Figure 7

Framework for Enriching Knowledge for Teaching Through Instructional Circles



Limitations

As an observer, I saw opportunities for teachers to enrich their mathematical knowledge for teaching during instructional circles. However, what I presented does not capture everything that occurred in instructional circle sessions or all the opportunities that were created. In addition, I did not investigate whether teachers learned from these opportunities or if their practices changed because of what they learned. I deliberately used the word *opportunity* often while presenting my results to remind the reader I focused only on opportunities to learn, not actual learning. In addition, the study was limited to identifying learning opportunities created during the instructional circle sessions, not opportunities that occurred while teachers were preparing for circle sessions or reflecting later on circle session discussion.

Implications

Implications for Practice

The purpose of this paper was to investigate the type of opportunities Japanese teachers had to enrich their mathematical knowledge for teaching. There are cultural underpinnings that influence the creation, maintenance, and efficacy of instructional circles. From this international comparative study, I cannot claim that instructional circles could be transplanted into different cultures and expect them to work in a similar fashion. On the other hand, I do think that features of instructional circles that create special kinds of professional learning opportunities could give educators in other countries new ideas about how to adjust professional learning opportunities in their own countries to better accomplish their own teaching goals. Hopefully, professional learning facilitators can use information presented in this article to expand their toolboxes and adapt to the needs of their teachers.

Implications for Research

Many aspects of instructional circles warrant further study. One area for future research would be to address directly the potential limitations of instructional circles as a cultural practice. Specifically, how could instructional circles, or select features, be adapted to work in other countries and what kinds of supports would be needed for these features to work well. A focus of this research should be the challenges teachers face when trying to engage in these practices. In other words, under what conditions do instructional circles achieve local professional learning goals? And what kinds of support do they need in local contexts to be effective?

Another area for future research would be to specifically look at how instructional circles impact teachers' knowledge. Because the sessions focus on specific, well-defined topics, it would be possible to assess participating teachers' learning during the session. Comparing the effect of a session on the presenting teacher's knowledge with other participating teachers would offer some insight into the comparative usefulness of these sessions for different teachers. This study looked at the opportunities to learn in instructional circles; however, understanding what teachers learned and how much their learning changed is a topic of future research.

Extending research on the acquisition of participating teachers' knowledge, it would be possible to study how instructional circles impact teachers' classrooms. What changes do different teachers make to their teaching practices after the instructional circle sessions? Is it possible trace these changes back to knowledge they acquired during the sessions?

Accumulating more information about the learning opportunities for Japanese teachers and how these affect their practices could open new kinds of learning opportunities for teachers in other countries. If these opportunities are responsible, in part, for the kind of conceptually oriented teaching reported in Japanese classrooms, this research seems warranted.

Chapter 2

PROFESSIONAL LEARNING THROUGH JAPANESE INSTRUCTIONAL CIRCLES

Instructional circles are a professional learning opportunity enacted in Japan that supports the development of teachers' high-leverage teaching practices. Most studies of Japanese education point to lesson study as the main form of professional learning for Japanese teachers. However, based on my experiences living in Japan and interacting with Japanese teachers, I learned that instructional circles are another professional learning opportunity that might contribute significantly to Japanese teachers' practices.

Beginning more than 20 years ago, reports about Japanese students' consistently scoring in the top five countries in the world in mathematics were released as part of the TIMSS studies (McKnight, 1987; Hiebert et al., 2005, McFarland et al., 2017; Hussar et al., 2020). The form of teaching seen in the videos captured many of the high-leverage teaching practices promoted in the U.S. and other countries (Ball & Forzani, 2010; Fernandez & Yoshida, 2012; Takahashi, 2006; Takahashi & Yoshida, 2004). More than that, these practices are associated with the consistently high performance of Japanese students on international comparisons (Murata, 2011; Stigler & Hiebert, 1999; Hiebert et al., 2005).

As interest in Japanese teaching practices grew, and as researchers described the professional learning opportunities that might explain the pervasiveness of these practices, astute observers could conclude that "lesson study" was responsible for these practices (Murata, 2011; Watanabe et al., 2008; Takahashi, 2006; Takahashi & McDougal, 2016; Melville; 2017). Based on the information I present in this article; I believe more than one form of professional learning has contributed to Japanese teachers' practices. In this article, I describe how another form of professional learning -- instructional circles -- provides rich professional learning opportunities for participating teachers.

What Research Says about Professional Learning Opportunities

The effectiveness of professional learning opportunities depends on their content and how the content is facilitated, *what* teachers' study, and *how* they study it (Van Es et al., 2014; Kazemi et al., 2009; Kennedy, 2016). In this paper, I focus on the way in which professional learning opportunities are facilitated, on how teachers are engaged in studying teaching.

Several facilitation features of professional learning have consistently been labeled as important for effective professional development. Following these recommendations, professional learning opportunities should: (a) be intensive and ongoing (Kraft et al., 2021; Smith et al., 2020), (b) deprivitize teachers' practices (de Jong et al., 2019); (c) be relevant to teachers' classroom practices (Desimone, 2009; Darling-Hammond et al., 2009; Kazemi & Franke, 2004); and, (d) be content oriented (Desimone, 2009; Smith et al., 2020; Kennedy, 2016; Darling-Hammond et al., 2009).

Research on professional learning opportunities is quite U.S. centric. I have experienced professional learning in Japan and observed learning opportunities that attended to the same principles identified in the previous paragraph but applied in quite different ways. Before presenting what I found, I would like to describe briefly two forms of professional learning in Japan and then step back to ask what can be learned from educational practices in other countries.

Two Forms of Professional Learning in Japan

Lesson study (jugyou kenkyuu) has become the most frequently described form of professional learning in Japan. Lesson study is an activity used for professional development, the evaluation of teachers, and conducting action research in classrooms (Lewis, 2016; Melville & Corey, 2021; Fujii, 2014; Lewis, 2009; Takahashi & Yoshida, 2004). By engaging small groups of teachers in planning and teaching a research lesson, lesson study intends to enrich teachers' knowledge of teaching through investigation and practice.

The focus of this paper is another, rarely-studied form of professional learning in Japan. The Japanese refer to it as *kenkyuukai* or *benkyoukai*. I translate it *instructional circles.* Instructional circles are somewhat informal gatherings of small groups of teachers to discuss instructional practices. These circles are oriented to analyzing specific practices and sharing advice rather than collectively designing a lesson or learning about a specific instructional method. Local teachers and educators voluntarily attend instructional circle sessions that usually meet once per month. Japanese teachers have described them as important professional learning activities that serve an essential function quite different from lesson study.

There are two types of Japanese instructional circles as suggested by the two different words. One type, *benkyoukai,* I translate as *study* instructional circle; the second type, *kenkyuukai,* I translate as *research* instructional circle. In the study instructional circle, teachers are learning how to teach mathematics more proficiently, whereas teachers in the research study circle delve more deeply into nuances of mathematical tasks and the implications for student thinking. The structures for these two varieties of instructional circles appear to be similar, but the discussion topics may vary in content and depth. I will use instances from both instructional circles to highlight the ways they accomplish similar professional leaning goals to those often espoused in the United States.

What Can We Learn from Other Countries?

There are two significant reasons to study other educational cultures. The first is to discover different instructional practices that may work better than those one's own community currently employs. The second is to become more aware of one's own practices that might be hidden because they are so common and taken for granted (Stigler, Gallimore, & Hiebert, 2000; Hiebert & Stigler, 2017). Learning about practices in other countries can prompt one to realize there are alternatives that were not seen before. In this paper, I aim to describe practices that accomplish both goals. I focus on how teacher learning was facilitated in instructional circles but also share an observation about the nature of the mathematics content that was studied. I discuss ways in which instructional circles can offer a different perspective on how professional learning opportunities can be designed and implemented.

How I Learned About Instructional Circles

I first learned about instructional circles when I was invited to participate while in Japan on a different research project. The instructional circle was in Saitama prefecture in Japan and, depending on the session, included from four to six elementary school teachers, a district match coach, the superintendent of the local school district, and sometimes, a university professor from Saitama University. The teachers worked at different schools but were close geographically. I learned these meetings typically occur once a month during the 10-month school year. Teachers gather at one of the local schools to conduct their meetings.

I was invited to participate in the instructional circles via Zoom. Because of the time difference, I woke up at 4:00 am to participate via Zoom. Because of COVID-19, all of the teachers met via Zoom which allowed this unique opportunity. As a Japanese speaker, I was able to participate without any translation assistance. With permission of the teachers, I recorded all of the sessions in which I participated and collected all materials that were used during the sessions. After I reviewed the video recordings, I interviewed some of the teachers to understand what they view as beneficial to their own practices through their participation in instructional circles.

Descriptions of Professional Learning Opportunities in Instructional Circles

To share what I learned about instructional circles; I will present several vignettes. Although these examples do not capture the full range of learning opportunities for teachers, they illustrate common goals, practices, and norms.

Vignette 1 – Instructional Circle Discussion about Subtraction in First Grade

This first vignette takes place in a research instructional meeting, where teachers were interested in examining how changes to the task suggested in the curriculum could affect student thinking during the lesson. Notice the structure of the instructional circles, the detailed depictions of the instruction, and how the leader of the group encourages others to provide their ideas and opinions. This vignette features three teachers: Mr. Uesugi (U), the leader of the instructional circle group, Mr. Yamamoto (Y), the presenter of the lesson, and Ms. Sato (S), a participating teacher. At the end of the discussion, Mr. Shigehara, the district level math coach, offers a concluding comment.

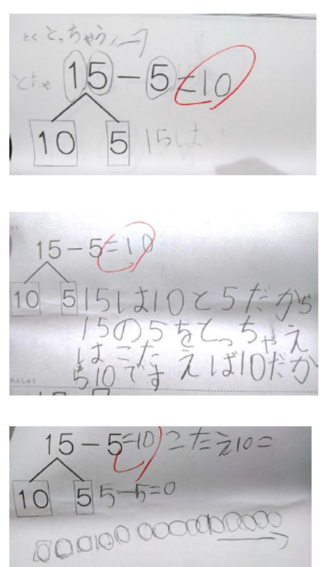
U: Okay, so today we are going to hear from Mr. Yamamoto about a lesson that he taught already. Go ahead.

Y: I have two points of data to talk about. Previously we talked about subtraction in my class, but today we expanded their [my students'] understanding and had a goal to subtract a number from one larger than 10. I want to improve my proposal about the development of the problems 15 – 5 and 15 – 3. I thought that if I use blocks or other physical objects then I worry that kids will only use a "counting all" method. If possible, I wanted to first present an equation. Then kids can decide on their own to use blocks to explain their patterns for solving the problem. So, I tried to do this using the black board and printouts with the students. There are a few things I would like feedback on and want to discuss further. First, let's look at the Development of 15 – 5. First, I reviewed some things the students already know, 5 – 3 and 5 – 5. Then I presented them with today's problem with the following statements, "What is 15 – 5? Let's talk about how we can solve this problem. Does it look doable?" The students then had time to work on the problem by themselves and came up with three different methods to solve the problem.

[Mr. Yamamoto then directed the other participants to look at the handout where he provided the different student solution methods].

Figure 8

Student Work Presented to the Other Participants About Different Solution Methods for 15 – 5.



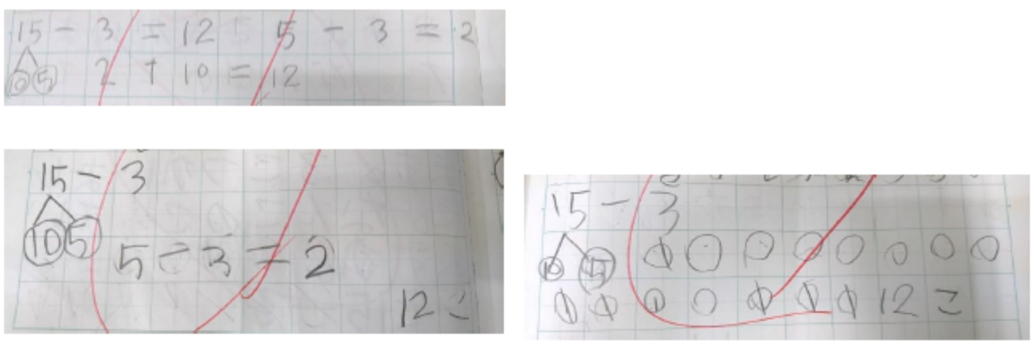
Y: As you can see, the students used a printout [say what a printout is] to separate the 15 into 10 and 5. Then they used that information to solve the equation provided. Some students drew circles on their paper to help them figure out the arithmetic.

Y: After the students presented their ideas to the entire class, we talked about why we separate the 15 into 10 and 5. If we separate 15 into 10 and 5, then subtracting 5 from 5 is an excellent method to solve this problem. However, I wanted them to still understand that this process can be done using blocks, so I invited a few students to come up to the board to represent the equation using blocks. Students then used blocks to solve 17 – 7. During the conclusion of this problem, about half of the students felt comfortable solving the problem using different methods.

Y: Next we moved to 15 – 3. We followed the same structure when solving 15 – 5. The students developed three different solution methods to solve this problem as well.

Figure 9

Student Work Presented to the Other Participants About Different Solution Methods for 15 – 3.

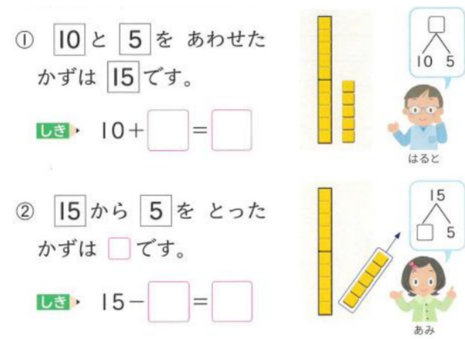


Y: In addition to these three methods, there were some students who used circles to solve it and came up with 12, Then during the conclusion of this problem, I ran out of time.

Y: In the textbook, they do the addition before the subtraction, 10 + 5 = 15, but I did not do that part with my students because I was concerned about time. From here, I am wondering about the use of blocks as manipulatives like they use in the textbook. Should I have used the manipulatives first? Or was the equation first fine?

Figure 10

Photo from Textbook Used in the Instructional Circle



U: Thank you for sharing. Now we will move onto how you all are thinking about the questions Mr. Yamamoto posed, as well as questions you may have as well. I will start with a question that I had. What helped you decide to take out the addition problem that is included in the textbook?

Y: Previously, students would only work with the number line when constructing larger numbers. In this problem, they are working on $10 + 5$ and $15 - 5$ simultaneously with blocks. On page 44. I wanted to go to the equation representation first, instead of modeling with blocks, so I left this activity out.

U: Oh, I understand. I was also wondering why use the representation $15 - 5 = 10$ here, because honestly, the problem $15 - 3$ seems more natural [a more natural approach when building on students' prior knowledge].

[In the next part of the dialogue, the speakers used the Japanese pronunciation of numbers. For example, saying 12 in Japanese is jyuuni or 'ten two']

Y: I think that what the textbook wants to do is get close to showing the composition of the number. Like 12 (ten two) is ten and two; 15 (ten five) is ten and five. [They use the elongation of the numbers to help students make the connection.]

U: So, you are saying they are reinforcing the composition of numbers as a solution method?

Y: Yeah, I think so.

U: The problem would then become, if I have 10 acorns and then 5 acorns how many acorns would I have together if they are combined? And hopefully, they can see the relationship with the pronunciation. More than the calculation, the act of combining these two numbers is what is important, right?

Y: I think that's correct. The textbook does this very well. Then after moving on to subtraction, it focuses on how you can undo that composition of numbers.

U: I think that this idea of using the pronunciation of the numbers and their composition of parts is very interesting. Like, with addition, I have 10 and 5 and put them together, I have ten five (15). Likewise, if I have ten five (15), then take away the part that is 5, then I only have the 10 portion left, in both mathematics and pronunciation. This model is helping the students move away from counting strategies when adding or subtracting.

Y: Yes, the lesson before this one, they really focused on the decomposition of numbers like 12 and 17 to really help the kids understand that aspect before today's lesson about tying it into the process of subtraction.

U: I worry that when you write this as an equation first, then students are not making that connection between the pronunciation and the mathematical operation (for 1st graders).
U: Ms. Sato, you taught this lesson, what do you think about how it went?
S: Thank you, I was able to teach this lesson right before Mr. Yamamoto and so we planned a very similar lesson. One difference between our classes was that I had a student come up with a solution method in which they split 15 into 10 and 5, and then subtracted the 5 from the 10 instead of the 5. I found this very interesting.
U: That is very interesting! I wonder why they decided to do that. Does it matter though? If you use blocks, then the process is the same. Subtract, then add the left over portion to the unchanged value. When you get to 15 – 3, the process will feel very similar to those students.
Y: I was hoping I would have someone use that representation, but it did not come up in my class.
Mr. Shigehara: I don't see a problem with students doing it this way. They are still going through the process of decomposing and recomposing without using language to guide their thinking. In the next lessons, the problem becomes $13 - 7$, where students are supposed to subtract from the 10 after decomposing. The goals of this lesson, as they fall within the unit, is to learn how to decompose a number to make it easier for them to subtract. Therefore, if students are doing it either way, then that is okay.

How Instructional Circles Address Recommended Features of Professional Learning

In the vignette, we see a glimpse of the structure and topics that are found in instructional circles. I will use this vignette to show how instructional circles address key features of professional learning identified earlier: the duration of the professional learning opportunity, the deprivitization of teachers' practices, the relevance of learning opportunities to the teachers' own classroom situations, and the focus on content. I will reconsider each feature in light of how instructional circles illustrate them.

Intensive and Ongoing Professional Learning Opportunities

One commonly recommended feature of professional learning opportunities found in the literature is that they should be intensive and ongoing (Desimone, 2009; Pellegrini et al., 2018; Prast et al., 2018). Instructional circles offer another perspective on the intensity and duration of a professional learning opportunity. The average instructional circle session lasted about 90 minutes. Each session focused on a different problem of practice. The sessions were a month apart and independent of each other. They were not thematically connected. Therefore, it would be reasonable to interpret instructional circles as providing shorter and less connected learning opportunities than those called for by U.S. researchers and educators (Desimone, 2009; Pellegrini et al., 2018; Prast et al., 2018).

One reason for this shorter, highly focused professional learning opportunity in instructional circle sessions could be that the goals for each session were relatively small, concise, and highly focused. For example, in the vignette, Mr. Yamamoto's problem of practice was to understand the implications of presenting an equation before using manipulatives. The intent of the instructional circles sessions was not to prompt wholesale changes in teachers' practices or change their beliefs. Instead, teachers focused on a very specific teaching problem and considered small changes to a single lesson.

Another reason for instructional circles' brevity could be that, although teachers offered multiple suggestions and had detailed discussions about teaching, the group did not find it necessary to reach a consensus about the best solution to the problem of practice. In the vignette, Mr. Yamamoto was trying to select the best order of problems and choose the best representations that would encourage students' understanding of subtraction. Participating teachers viewed their role as providing Mr. Yamamoto with ideas to help him think about his problem in different ways so he could move toward a solution.

By providing this description, I do not contend that instructional circles are not intensive and ongoing, but they address this feature in a different way. Instead of defining a large topic of study (e.g., teaching from a student-centered approach) and working to achieve that goal over time, teachers in instructional circles continuously work on different problems of practice for shorter periods and accumulate small improvements over time. Thus, instructional circles could be considered intensive and ongoing, but they focus on incremental changes across many smaller grain-size topics rather than a large change on a single topic.

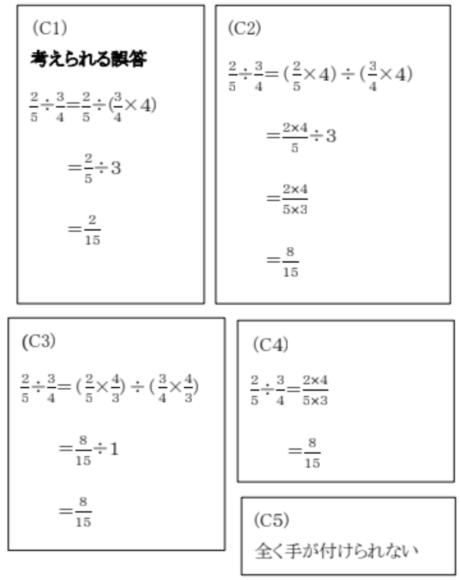
Deprivitization of Practice during Professional Learning Opportunities

The instructional circle sessions provided a method for teachers to deprivitize their practice that is not commonly found in the research literature. Problems of practice structured every session. The problem of practice came from teachers' own instructional needs. When a teacher presented their problem of practice, they let other teachers see their planning process, decisions about specific teaching practices, and sometimes the results of their lessons. Not only were their instructional practices made public, but gaps in their mathematical knowledge for teaching could have become apparent during their presentations. Thus, the teachers placed themselves in a vulnerable position with their colleagues.

An example of deprivitizing a teacher's practice, in addition to that in the vignette, comes from a session during which a teacher, Ms. Arakaki, presented a problem of practice about fractional division. She was worried that her own understanding of a fraction dividing a fraction would not be sufficient to explain different solution methods that students could explore (see Figure 11).

Figure 11

Teacher-Created Handout that Shows Possible Solution Methods of a Fractional Division Task



The other participants in the instructional circle were impressed that she produced so many different representations. One of them said, “I really hope my students would be able to think about fractional division using this method (C2).” One of the teachers, Mr. Horiei, then talked about Ms. Arakaki’s worry about helping students understand the principles behind the different solution methods. He explained how students had experienced these principles of division before, but in decimal division problems. He explained further that by helping the students make connections to their understanding of decimal division, they might better understand the fractional division problems.

In addition to revealing her own knowledge deficiencies, this interaction put Ms. Arakaki in a vulnerable position among her colleagues by making her instructional practices public. She provided everyone a detailed lesson plan for them to scrutinize. She asked her colleagues to find ways to help her improve her practices. Because she was willing to risk revealing her own weaknesses, she received direct and personalized feedback from her peers about the lesson and her instructional practices.

Instructional circles provide a different perspective on how to deprivitize teachers' practices. Normally, deprivitization of practice implies that teachers allow other teachers to observe and critique their teaching, either in person or through a video recording. However, instructional circles demonstrated other ways to make teaching public. Teachers distributed their lesson plans or board work plans and asked for advice from the other participants. They also proposed various ways of solving instructional problems in front of their peers and other experts in their field.

Relevance of Professional Learning Opportunities to Teachers' Classrooms

A strong recommendation in the literature is that professional learning opportunities connect with teachers' classroom practices to enable the implementation of new instructional practices (Desimone, 2009; Darling-Hammond, 2009; Kazemi & Franke, 2004). Instructional circles uniquely accomplish providing a practice-relevant professional learning opportunity through its structure. In obvious ways, bringing one's own problem to a group increases the relevance of what this teacher learns. For example, when Mr. Yamamoto brought his problem of practice of how to help students think about 15 – 5, the advice he received could be applied directly to his classroom. What about teachers who do not present their problem? While interviewing the teachers, they described ways in which they find relevance when engaging in discussions about others' problems. One teacher summarized the benefits of instructional circle discussions for the non-presenting teachers as twofold. First, sometimes teachers are in the same grade level and will teach the same lesson, so the discussion has an immediate benefit. Second, for teachers not at the same grade level, the knowledge gained about a specific lesson can transfer when teachers prepare their own lessons.

During the instructional circle sessions, the discussions led to many different ideas about how to approach a problem of practice. For example, during the session in which Mr. Yamamoto was wondering about how to help students think about 15 – 5 and 15 – 3, the teachers discussed the benefits of using 15 – 5 first because 5 – 5 is easier for the students, while other teachers argued that 15 – 3 was more natural because the concept of zero is often difficult for students. These debates touch on larger issues than just 15 – 5 vs. 15 – 3. Teachers indicated they were able to use these discussions to think about their own instructional problems.

Professional Learning Opportunities were Content Oriented

Instructional circles provide a learning opportunity for teachers in Japan to enrich their mathematical content knowledge through facilitation features that differ from those commonly found in the literature. The following vignette highlights how instructional circles use teachers' presentation of problems of practice to focus on content through fine-grained discussions of mathematics. This vignette features five teachers: Mr. Watabe (W), the leader of the instructional circle group, Mr. Shirokawa (S), the presenter of the lesson, Mr. Kishi (K) a participating teacher, Mr. Nakandakari (N), the knowledgeable other and superintendent of the local district, and Mr. Fukuda (F), another participating teacher.

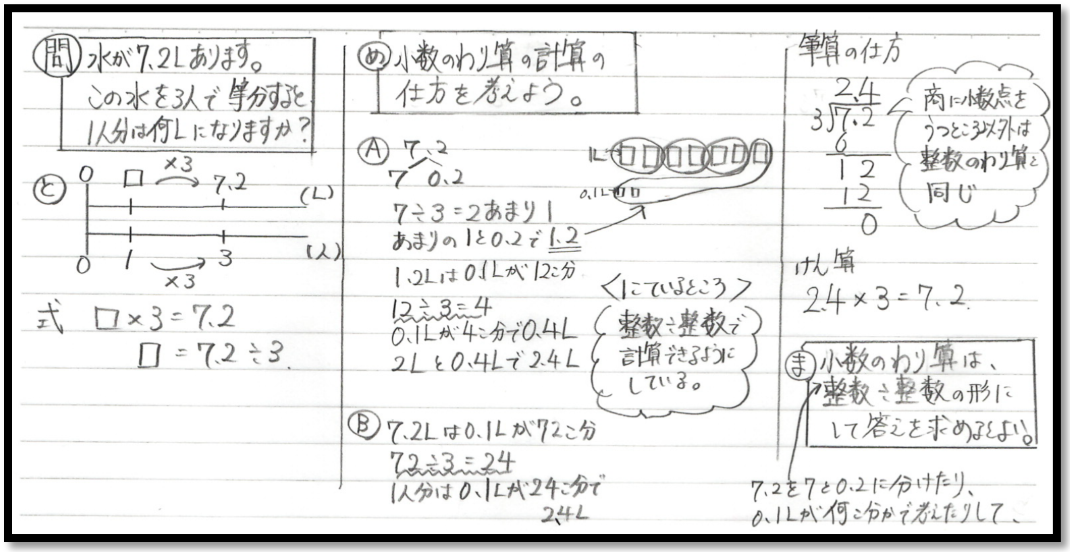
Vignette 2 – Example of Detailed Discussions of Mathematics

W: Okay let's go ahead and begin for today. Today, Mr. Shirokawa is going to be presenting a lesson he would like our insights on. Go ahead Mr. Shirokawa.

S: I attached my board work plan for the lesson if you could all look at that with me.

Figure 12

Teacher's Notebook Displaying His Board Work Plan for the Lesson.



This lesson is the sixth lesson within the unit plan. I would like your opinions on a few aspects of this lesson. This lesson is the first lesson of division with decimals. This lesson will have the students focus on thinking about the solution process.

S: The lesson task reads, "If 7.2 liters of water are divided equally among three people, how many liters will each person get? Let's think about different ways we can solve this problem."

For review, this lesson is for fourth grade. In the third grade, they learned about operations with decimals, but not division.

During their individual problem solving time, I expect solution method (A) and (B) will be developed by the students. These are the two solution methods that I found in the teachers' manual of the textbook.

I'm worried about the first solution method and how it will appear in the students notes. I also worry if I will be able to explain the solution method expertly and clearly, or if I will be able to use the correct mathematical language. The next thing that I am worried about is if my questions at the conclusion of the lesson are good enough. The last area of the lesson that I am worried about is if the students are going to be able to develop their understanding of division with decimals properly. If there is anything that you could teach me in these aspects, please do so. Okay, I'm done.

W: Thank you for talking about your lesson with us. Does anyone have any questions or aspects they would like clarification about? Specifically, Mr. Shirokawa is looking for help in the first solution method, his questions at the conclusion of the lesson, and the students' development of their mathematical understanding, right?

S: Yes, that's right. Thank you.

W: Or if you have other areas of the lessons you want to discuss first, that would be fine here as well.

K: Actually, can I go first? I'm thinking that for the solution method A isn't really about decimal division because they can just solve 72 divided by 3. Can't the students do that already? So maybe if you did an easier problem like 3.6 divided by 3 to help the students make the connection between that and 36 that might be better.

S: I changed the problem in the textbook from 3.6 to 7.2 because I felt that 3.6 was too easy for the students, but I don't know how to engage the students in this problem.

W: Like you said, $3.6 \div 3$ is easy, so you could start off the lesson with that one. Then change 3.6 to 7.2, then the students will see that simply separating then dividing won't work like it did earlier. So, then you could ask, "What should we do now?"

S: Ahh, I see.

W: You could say, "That will be the purpose of today's study." That becomes the *Kadai* [intellectual challenge of the lesson].

S: So, let me confirm, before I start the individual problem-solving time, I should connect the problem of the day back to the previous lesson; then, when students are unable to solve the problem the same way, it will create a need to study something new.

W: Yes, I think so.

S: I am wondering, if students start from the previous solution methods, then solution method B [see figure 5] won't come out. And that's not good, right?

Melville: Do you think that the solution method of just doubling the answer they found yesterday will be used by the students? Will they see the relationship between 3.6 and 7.2 as double, so the answer must be double?

W: Now that you say that that is a possible solution method I didn't think about. But the solution method *might* come out.

S: If it does come out, is that a good thing? Or a bad thing?

N (Knowledgeable Other): The solution method of doubling? I think if it comes out, great. Address it, then ask them to see if they can do it without doubling because there may be problems that they can't just double. Start there, let them know there are multiple solution methods, then have them focus on that.

F: In relation to solution method B. I think that it is important that students know that they can multiply by 10 to find the solution method. Sometimes, having a multiplier of 2, 4, or 8 will be sufficient. In the third grade students have to do the calculation of $25 * 36$. At first that calculation is hard, so they have a multiplier of 4 which makes it easier for the students to do the multiplication, then divide by 4 in the end. Using that method here, understanding that 7.2 is double 3.6 may lead to the solution method B more readily than starting from nothing. I think that would be a good development of the lesson.

S: Thank you so much. This also has a more fun feel to the problem if I introduce it like this.

The literature on teachers' professional learning recommends designing professional learning opportunities to be content specific (Kennedy, 2016; Desimone, 2009; Hill, Ball, & Schilling, 2008; Shulman, 1986). For instance, mathematics teachers should learn how to improve *mathematical* instructional practices rather than improve instruction at a more general level. Instructional circles not only fulfill that recommendation but do so at an even more specific level than envisioned by many professional learning providers.

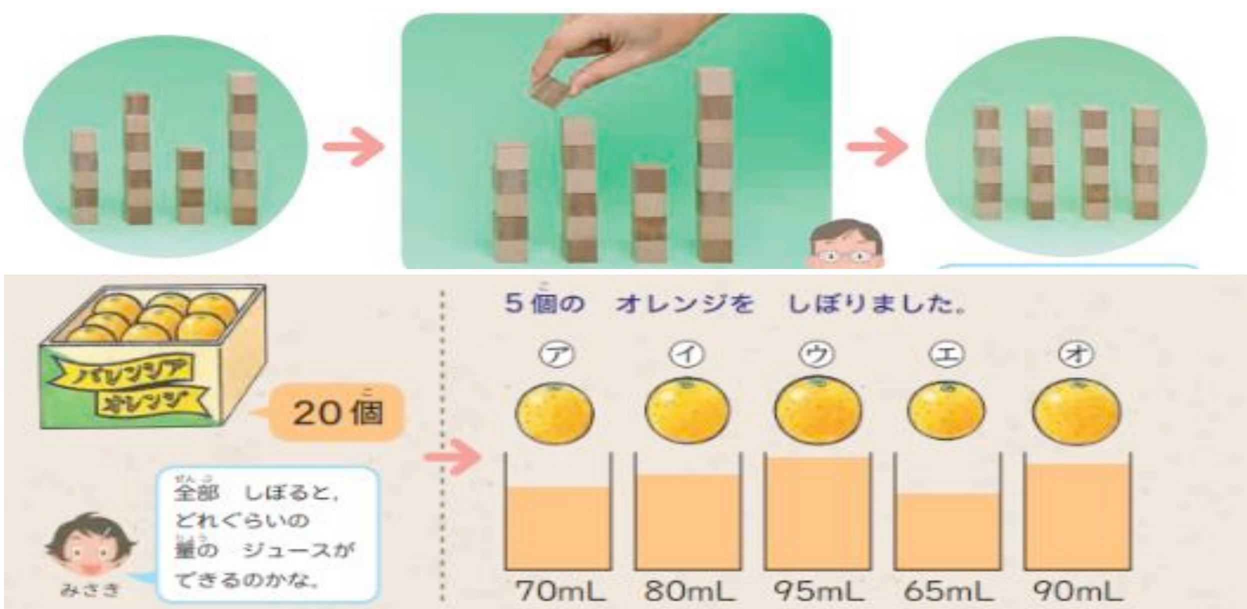
A first example is found in the preceding vignette. The conversation between Mr. Shirokawa and Mr. Watabe includes a detailed discussion about whether or not to change the 7.2 to 3.6 when dividing by three. They discuss possible mathematical implications of each scenario, while also focusing on the goal of the lesson. Mr. Shirokawa is concerned if he changes the problem, then the solution method B that he anticipated students would develop on their own given the original problem would not be considered if he changed the problem. Then the teachers discussed whether or not that was necessarily a detrimental side effect of changing the problem. Although it is a simple change in the calculation aspect of mathematics, they discussed deeply the implications that those changes could have on the lesson flow and the student understanding

A second example of detailed level at which mathematics is discussed can be seen in the first Vignette. Mr. Yamamoto and Mr. Uesugi discuss which subtraction problem (15 – 5 or 15 – 3) is more natural for building upon students' prior understanding. Mr. Yamamoto noted that because 5 – 5 equals zero, students would see that 10 is the answer to 15 – 5, but Mr. Uesugi stated that zero was a difficult idea and students might find it easier to solve 15 – 3. If they solved 5 – 3 = 2, they would have something to add back to the 10. Even though they acknowledged that both options are viable, they discussed the impacts that each problem could have on their students' thinking. This conversation reinforces the idea that small changes to the task can have important implications for student thinking, both positive and negative.

A third example of detailed mathematical discussions is taken from another session. Mr. Kawasaki, a presenting teaching, said he was worried about students being unable to connect the procedure shown in the textbook task with the algorithm for finding the average (see Figure 13). The representations used by the textbook include towers of blocks at various heights and cups of orange juice filled to various heights. The blocks are a discrete representation of finding the average, and the orange juice would extend that to a continuous representation.

Figure 13

Artifact from a Textbook Activity for Finding the Average



Mr. Kawasaki was worried these activities did not connect to the algorithms for finding average. He said that the action of pouring juice from one cup to another cup a little bit at a time does not lead students to the algorithmic strategy of adding the quantities together and then dividing by the number of quantities. One of the teachers, Mr. Horiei stated that finding the average by equalizing the amounts is a good first step into understanding the process; however, if students remember this activity, then those actions might be detrimental to their conceptual understanding of how to find the average. Other participants suggested different contexts in which finding the average might make more sense, like the height of the students or the shoe sizes of the students. As in other sessions, teachers were discussing the possible learning effects of different versions of one task in one lesson. The consistency of discussions at this small grain size was a striking feature of the content-orientation of instructional circles.

Enabling Features of Instructional Circles

I observed a number of characteristics of instructional circles that were especially informative. First, they provided a different perspective about what "ongoing and intensive" could look like in professional learning. Second, instructional circles provided different ways in which teachers could make teaching public, deprivitize their practice, and engage in collaboratively improving teaching. Third, due to the structure of instructional circles, teachers found every session relevant for their classrooms, both directly and indirectly. Last, the context in which teachers' discussions occurred were very specific, well-defined, small grain-size problems of practice. I believe these characteristics warrant special attention because they align with research-based recommendations for effective professional learning opportunities but they so in ways that open the possibilities beyond those usually described in the literature.

I noticed several aspects of instructional circles that were consistent throughout and appeared to enable teachers' discussions to function as I have described. These features include (a) shared understandings of instructional practices and classroom structures, (b) a mutual respect for each other shown by treating others as professionals, and (c) a common language specific to teaching mathematics that enabled clear communication.

Shared Understandings that Supported Professional Conversations

During my observations, I was struck by the conversations the teachers were *not* having. Teachers apparently assumed they were all using a similar instructional approach and shared a general understanding of the curriculum trajectory and lesson intent of different textbook series. Teachers did not talk about how they should teach to optimize student learning. Rather, they talked about student thinking. They asked how they could improve their questions or tasks to elicit more student thinking and guide student thinking toward well-defined learning goals. This kind of teacher talk is quite different than the types of teacher talk I have observed during professional learning opportunities in the United States.

Also, absent from teacher talk during instructional circles were conversations about the quality of textbooks. All six textbook companies that publish curricula for elementary school mathematics are vetted by the Japanese Ministry of Education and can be considered high quality materials. Therefore, the teachers know the textbooks they use follow the national standards. In addition, they share the assumption the materials will be high-quality as defined by the Ministry. Without these conversations dominating the professional learning opportunity, teachers could focus on other subjects, particularly their own day-to-day instructional problems. They used this time to delve deeply into their own instructional practices and create opportunities to enrich their knowledge for teaching.

Teachers are Treated as Professionals and have Mutual Respect for Each Other

The facilitation of the instructional circles positioned the teachers as professionals. The leader of the instructional circle made sure every teacher had an opportunity to talk about their insights and ask questions about the presented instructional problems. Everyone's input was valued and considered seriously by the other teachers. Teachers were positioned as experts in their craft through allowing everyone time to share their own understanding and experiences.

Being treated as professionals was also demonstrated by giving the presenting teacher autonomy for resolving their problem. As seen during the vignettes, the teachers never explicitly told the presenting teacher what to do. The presenting teacher was expected to learn from the conversations and then adapt the suggestions with their students in mind. This occurred in all of the instructional circle sessions I attended. Allowing the presenting teacher to work out their own solution was intentional. It provided another opportunity for the teacher to thoughtfully apply the suggestions of others to their own classroom.

Common Language of Mathematical Instruction

Educators have long noted a need for a "technical language of teaching practices" (Lortie, 1975, p. 73). Having a common language to talk about instructional practices allows teachers to pinpoint specific areas of their practice to talk about and study (Grossman, 2009; Lampert, 2000; Mesiti & Clarke, 2017). Lortie (1975) observed that the isolated nature of U.S. teachers has likely prevented the development of a common language for teaching.

Lortie's claim takes on new significance when observing Japanese teachers collaboratively address problems of practice using a shared technical language. Their teaching vernacular includes vocabulary that is special to teaching. It is not used in common language. For example, in Japanese, *shitsumon* translates to *question,* and *hatsumon* is also *question* but is used to describe the thought-provoking question to help students engage in an activity or to help students think about a topic differently. Even though *hatsumon* translates to question, non-educators in Japan will not understand this term.

Other examples of terms that support teachers' discussions of teaching include *kadai*, *matome,* and *banshou. Kadai* is the intellectual challenge students are trying to achieve. Sometimes *kadai* refers to the task that could help them engage with this challenge and sometimes it refers to the connections students need to make between the new idea and other areas of their mathematical understanding. *Matome* is used to describe the last part of the lesson during which teachers tie together the student representations and standard algorithms to fully address the *kadai. Banshou* is directly translated into "board work" which is part of common language, but used by teachers means a snapshot of the entire lesson including what students are predicted to contribute to the display. These snapshots are used to plan a lesson and to share with others what is planned including the student thinking that is anticipated. As illustrated earlier, teachers also use their *banshou* to share the plan for a lesson already taught.

The value of sharing a technical language for teaching was brought to life during the instructional circle sessions. It helped teachers define their instructional problems and reduced the ambiguity during the discussion of these problems. For readers who have participated in discussions of how to address particular instructional problems that do not have shared, unambiguous means, such as how to “improve problem solving,” the benefits of using well-defined terms with shared meanings should be clear.

Conclusion

The purpose of this paper is to introduce a type of professional learning opportunity available to Japanese teachers. Because it occurs in a culture different from that of most readers, it is useful to consider again the potential value of studies conducted in other cultures. Researchers can make two mistakes when interpreting the results of cross-cultural studies. One is to assume that what was observed in one culture can be transferred to another culture with the same results. The other is to assume that nothing can be learned because cultures are different. I do not claim that instructional circles could be transplanted into a U.S. culture and work in a similar fashion. There are cultural underpinnings that influence the creation, maintenance, and efficacy of instructional circles as practiced in Japan. On the other hand, features of instructional circles that create special kinds of professional learning opportunities could give educators in other countries, including the U.S., new ideas about how to adjust professional learning opportunities to better accomplish their own teaching goals. Professional learning facilitators can use the information presented in this article to expand their perspectives on professional learning and, perhaps, adapt some of the features to the needs of their teachers.

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Appendix A

INTERVIEW PROTOCOL

Note: This protocol represents the questions that may be asked during interviews. However, based on student responses, the researcher may choose to follow up on particularly interesting responses with other questions. These questions may not be explicitly listed here, but will not stray from the main ideas contained in these interview items

1. What is your name?
2. How long have you been teaching?
3. What grade are you currently teaching? How many times have you taught this grade?
4. How long have you been participating in instructional circles?
5. How did you learn about instructional circles?
6. What made you want to participate in this type of learning opportunity?
7. How long do you think you'll continue to participate in instructional circles?
8. What kinds of topics do you normally study during instructional circles?
    a. Pedagogical
    b. Mathematical
    c. Student thinking
9. What are your responsibilities as the presenter of the lesson to the group?
10. What are your responsibilities as not the presenter of the lesson?
11. What is the role of the knowledgeable other in these instructional circles?
12. What benefits do you feel come from having a knowledgeable other participate in these instructional circles?
13. Do you feel like zoom affects your ability to participate in these instructional circles?
14. What is the role of the knowledgeable other in instructional circles?
15. Why do you think the knowledgeable other is important?
16. What do you do to prepare for instructional circles? As a presenter? As a participant? (If the knowledgeable other, then ask them as a knowledgeable other?)
17. How did instructional circles start?
18. Is there a connection among all the instructional circles in Japan?
19. How are the topics selected?
20. What is the greatest benefit from participating in these learning circles?

21. Is there anything else that you would like to share with me about learning circles that you feel is critical for me to understand?

Appendix B

IRB APPROVAL

Institutional Review Board
210H Hullihen Hall
Newark, DE 19716
Phone: 302-831-2137
Fax: 302-831-2828

DATE:	January 7, 2021
TO:	Matthew Melville
FROM:	University of Delaware IRB
STUDY TITLE:	[1693034-1] Japanese Mathematics Instructional Study Circles
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
EFFECTIVE DATE:	January 7, 2021
REVIEW CATEGORY:	Exemption category # *(2)*

Thank you for your New Project submission to the University of Delaware Institutional Review Board (UD IRB). According to the pertinent regulations, the UD IRB has determined this project is EXEMPT from most federal policy requirements for the protection of human subjects. The privacy of subjects and the confidentiality of participants must be safeguarded as prescribed in the reviewed protocol form.

This exempt determination is valid for the research study as described by the documents in this submission. Proposed revisions to previously approved procedures and documents that may affect this exempt determination must be reviewed and approved by this office prior to initiation. The UD amendment form must be used to request the review of changes that may substantially change the study design or data collected.

Unanticipated problems and serious adverse events involving risk to participants must be reported to this office in a timely fashion according with the UD requirements for reportable events.

A copy of this correspondence will be kept on file by our office. If you have any questions, please contact the UD IRB Office at (302) 831-2137 or via email at hsrb-research@udel.edu. Please include the study title and reference number in all correspondence with this office.

INSTITUTIONAL REVIEW BOARD

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