IMPLEMENTING SCHOOL-WIDE COLLABORATIVE LESSON RESEARCH IN QATAR

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ABSTRACT

To develop and nurture Qatari teachers' capacity to teach mathematics through problem-solving, a 3-year professional development project was implemented in which the participants engaged in Collaborative Lesson Research (CLR), an enhanced version of Japanese lesson study. During the first year, the four Professional Development Specialists from Qatar University engaged in CLR to gain first-hand knowledge of teaching through problem-solving and CLR. In Years 2 and 3, teachers from 4 Qatari schools participated in the project. This paper reports the findings of the research that examined the viability of this innovative project design. Overall, the participants gained much insight into teaching mathematics through problem-solving and CLR. The results also confirmed the significance of knowledgeable others for teacher learning in CLR. The findings also revealed some challenges for the future scaling up efforts in Qatar such as the lack of resources in Arabic.

Keywords: Collaborative Lesson Research, Mathematics teaching.

Introduction

School education in Qatar in general, and mathematics education in particular, has been going through a major reform since 2001 when the Supreme Education Council (now Ministry of Education and Higher Education) launched a comprehensive education reform initiative. Many independent schools have been established, and an assessment system has been designed and implemented. Furthermore, world-class curriculum standards in four subjects, including mathematics, have been developed (Zellman, Constant, & Goldman, 2011).

Despite these changes, Qatari students' mathematics performance in international studies continues to lag behind their peers across the globe. Even though a major emphasis of the Qatari mathematics standards is problem-solving, many teachers are finding it difficult to develop and foster students' problem-solving capacity. To address these challenges, Qatar University College of Education and the International Math-teacher Professionalization Using Lesson Study (IMPULS) at Tokyo Gakugei University implemented a 3-year professional development project for Qatari primary and preparatory school teachers starting in the 2014-15 school year. In this QU-IMPULS project, Collaborative Lesson Research (CLR), an expanded and improved form of lesson study (Takahashi & McDougal, 2016), was used to increase Qatari teachers' capacity to teach mathematics through problem-solving. This paper reports the findings from the study that examined the project participants' learning.

Mathematics education in Qatar: Trends and issues

In the 2011 Trends in Mathematics and Science Study (TIMSS), Qatari 4th graders' average performance was ranked 44th among the 50 participating education systems, and 8th graders ranked 33rd among 42 participating systems (Provasnik et al., 2012). Their average scores, 413 and 410 respectively, were far below the cut point for International Benchmark of Intermediate, 475, for both grades. In the 2012 Program for International Student Assessment (PISA), Qatari 15 year-olds average performance in mathematics was ranked 63rd of the 65 participating countries and economies (OECD, 2014). Although Qatari students' average mathematics scores improved slightly in the 2015 TIMSS, their ranking among the participating systems was virtually unchanged, 41st out of 48 in Grade 4 and 28th out of 37 in Grade 8 (Provasnik et al., 2016).

In addition to these disappointing performances in international studies, a recent national report on the national educational assessment in Qatar showed that the mean score for students remains less than 40 (Ministry of Education and Higher Education, 2017). Moreover, the

Social and Economic Survey Research Institute (SESRI) at Qatar University conducted a study to investigate Qatari students' motivation towards education. The results revealed that although students generally exhibited positive attitudes towards mathematics in general (73% from governmental schools and 91% from other schools), only 11% of students in the government schools and 19% of students in other schools plan for future work in the field where mathematics is an essential subject in that field (SESRI, 2012). This study explains why the number of students enrolled in Biology, Chemistry, Physics, and Mathematics at Qatar University declined from well over 1300 students in 1999 to less than 400 in 2011. Furthermore, Said and Friesen (2013) found that the number of students enrolled in science courses in Grade 12 has become less than half since the mid-1990s. They suspect that this decline may be due to cumulative negative experiences at schools, whether due to uninteresting content, poor teaching, or various other factors.

Brewer et al. (2007) argued that Qatar needed much stronger results from its primary and secondary education system in the form of a standards-based system consisting of rigorous standards, a standard-aligned curriculum, assessments, professional development, and data use. However, Zellman et al (2011). point out that teachers in Qatar rarely have professional development opportunities. Although ministry inspectors regularly visit classrooms for inspections such as curriculum use—they do not visit classrooms to support teachers in improving their teaching. Thus, even though world-class standards were released in 2005, and the expectations for teachers and school leaders have been available as "National Professional Standards for Teachers and School Leaders", the actual classroom instruction does not appear to have changed. Schools in Qatar require a systematic supporting structure for teachers to implement standards into their classrooms.

QU-IMPULS project

Collaborative lesson research and teaching through problem-solving

Stigler and Hiebert (1999) introduced a Japanese lesson study to a worldwide audience. A major reason lesson study attracted so much attention from mathematics educators internationally was because videotaped Japanese mathematics lessons from the 1995 TIMSS reflected so many features of exemplary mathematics lessons, and Japanese lesson study was credited as the main mechanism that transformed Japanese mathematics instruction. Stigler and Hiebert (1999) labeled Japanese mathematics lessons as "structured problem solving" (p. 27) lessons, and Japanese mathematics educators call it *mondai kaiketsu gakushuu*, or teaching through problem-solving (TtP). A TtP lesson typically consists of 4 stages: (1) posing of the problem, (2) independent problem solving, (3) sharing and critical discussion of students' solution strategies, and (4) summarizing (Shimizu, 1999). According to a survey conducted by the Japan Society of Mathematical Education (JSME), virtually all Japanese teachers consider TtP to be an effective way to teach mathematics (JSME, 2001). Japanese mathematics

educators developed TtP through lesson study, and they continue to develop their expertise in implementing TtP in their classrooms by continuously engaging in lesson study.

The QU-IMPULS project utilized Collaborative Lesson Research (CLR) to help Qatari teachers develop and enhance their capacity to teach mathematics through problem-solving. After a broad review of the literature, Seleznyov (2018) noted that there is no internationally shared agreement on the critical components of Japanese lesson study. CLR, on the other hand, has a clear definition, and it is more similar to Japanese school-wide lesson study, *jyugyou kenkyuu*, than many other lesson study implemented in projects outside of Japan. CLR was created to help teachers outside of Japan who want to bring the success of *jyugyou kenkyuu* to their schools (Takahashi & McDougal, 2016). CLR has the following 6 components, details of which are discussed in Takahashi and McDougal (2016).

- Clear research purpose
- *Kyouzai kenkyuu* (study of materials for teaching)
- Written research proposal (lesson plan)
- Live research lesson and discussion
- Knowledgeable others
- Sharing results

There are several advantages to implementing CLR in Qatar schools. First, it allows teachers and schools to deepen their understanding of the curriculum and standards through *kyozai kenkyuu*, which helps them create better lesson research proposals. Through CLR, teachers have opportunities to see life lessons that use problem-solving to develop new ideas. They also have the chance to practice designing, teaching, and reflecting on these lessons with the support of their colleagues and IMPULS personnel as knowledgeable others. Thus, CLR provides a framework to examine and learn from teaching materials. In essence, through CLR, teachers can understand curriculum better, design units and lesson plans intentionally, observe lessons to better understand how students learn and discuss how to improve student learning.

Theoretical framework and project design

The QU-IMPULS project design was based on the cumulative knowledge of lesson study among IMPULS and other Japanese mathematics educators. The theoretical framework was consistent with the framework proposed by Lewis, Perry, and Hurd (2009). Figure 1 shows the framework, adapting Lewis et. al. (2009).

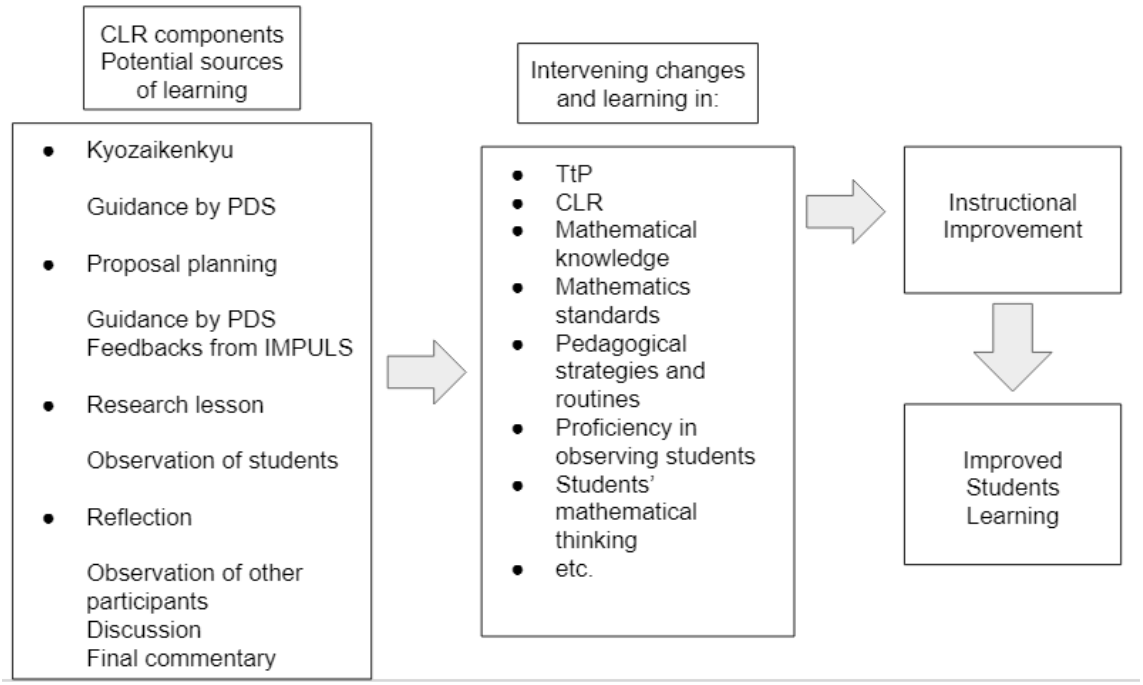

Figure 1 Theoretical framework for QU-IMPULS Project, adapting Lewis et al. (2009)

Because CLR, or lesson study in general, is a new idea in Qatar, this project was divided into 2 phases. In Phase 1 (Year 1), 4 professional development specialists (PDSs) from QU engaged in CLR themselves so that they understand both TtP and CLR. They first participated in the workshop on TtP, including the observation of a public research open house at Japan School of Doha (JSD) where they observed teaching and post-lesson discussion of a research lesson for a combined class of Grades 3 and 4 students (9 and 10-year-olds). The lesson was a part of the school-wide CLR at JSD. Then, the 4 PDSs formed 2 two-person teams and each team taught two sets of 4-day research lesson series. For the first set of 4-day research lessons, the teams were provided with suggested lesson plans that were developed by Japanese teachers as the starting point. For the second set of 4-day lessons, each team developed its lesson plans. In this way, each PDS had an opportunity to plan, teach, observe, and discuss 4 research lessons using TtP. Their first-hand experiences in CLR and TtP were hoped to enable them to provide more immediate and frequent support of teachers than IMPULS personnel who visited Qatar only 4 or 5 times a year.

For Phases 1 and 2, the CLR research theme was set as "fostering students' ability for problem-solving and reasoning by using Teaching through Problem Solving." As the planning teams planned their research lessons, they were asked to use the lesson proposal template (see Appendix A). This template guided the teams' *kyouzai kenkyuu* and the writing of research lesson proposals.

In Phase 2 (Years 2 and 3), the focus was on establishing a few cohorts of teachers from each of the four schools the PDS worked with so that they may become the model schools for school-wide CLR in Qatar. The 4 PDSs led the cohort groups through CLR steps at their respective schools, while IMPULS personnel provided intensive support for the content specialists and schools as knowledgeable others. In addition, JSD hosted Public Research Lessons in the fall of each year to provide the participating Qatari teachers' opportunities to observe both TtP and CLR in action.

The first year of Phase 2 began with a workshop introducing CLR and TtP at each of the 4 participating schools. These workshops were conducted by IMPULS personnel, and the focus was on helping Qatari teachers understand the process of CLR, with a major emphasis on *kyouzai kenkyuu*, as well as giving them some concrete image of TtP by engaging them in problem-solving. After this introductory workshop, participating teachers engaged in 4 cycles of CLR during the remainder of the school year. During the second year of Phase 2, each school team also engaged in 4 cycles of CLR. The 4th research lesson by the team from one of the schools was held as a public research lesson during a Lesson Study Forum held at QU.

In each cycle, a PDS led his or her school's lesson planning team with *kyouzai kenkyuu* and the preparation of a lesson proposal. They were encouraged to complete a draft of a proposal at least a week before the visit by IMPULS personnel. One IMPULS personnel provided comments on the draft proposal, making suggestions for clarifying, modifying, and generally improving the lesson proposal. The planning team, with the support of their PDS, then revised their lesson proposal before the day of the lesson.

On a research lesson day, participating teachers from the school and other educators engaged in the following activities:

- Pre-lesson discussion
- Observation of the research lesson
- Post-lesson discussion
- Final comment by knowledgeable other
- Writing a reflection journal

During a pre-lesson discussion, the planning team explained what their research focus was and why they chose the particular focus using the lesson proposal. Other observers had opportunities to ask clarifying questions about the research lesson. Finally, observers were reminded of the importance of carefully observing students' work based on the team's research focus.

After the research lesson, the participants engaged in the post-lesson discussion. The post-lesson discussion usually followed the following format:

1. Reflection by the teacher
2. Reflection by other members of the planning team
3. Sharing of observed data by other observers

4. Discussion

During the first year of Phase 2, this discussion was facilitated by one of the IMPULS personnel. During the discussion, a major point of emphasis was to base our discussion on observed data instead of simply stating our ideas and beliefs. It was also emphasized that we are not evaluating the teacher but examining the lesson carefully based on how students responded to the lesson. In the second year, the PDSs took over the role of the facilitator.

Finally, visiting IMPULS personnel provided the final comment. During the final comment, the knowledgeable other often used his notes and photographs taken during the lesson using a free application, Lesson Note. Thus, he demonstrated both how to observe a lesson and base his comments on observed data.

During Year 2, the 4 PDSs began to play more and more of the leadership roles including the facilitation of the pre-and post-lesson discussion and making summarizing comments at the end of the post-lesson discussion. This gradual release of the leadership roles was designed to develop the capacity of Qatari professionals so that CLR would continue to spread throughout Qatar.

Research Questions

This inquiry was conducted to examine the viability of the 2-phase program design in helping the participants gain an understanding of TtP and CLR. In particular, we were interested in the following three questions:

1. What did the participating Qatari teachers learn about Collaborative Lesson Study (CLR) and Teaching through Problem Solving (TtP)?
2. Which CLR components did the participants perceive to be helpful for their learning?
3. What factors hindered/promoted the implementation of CLR and/or TtP in Qatari schools?

Methodology

Participants

The first group of participants was the 4 professional development specialists (PDSs) affiliated with Qatar University. These PDSs each worked with teachers at one school site. The second group of participants was teachers from 4 independent schools, 2 primary schools, and 2 preparatory schools, located in Doha. Primary School AM is a girls school (Grades 1 - 6), and 18 teachers participated in the opening workshop. Primary School IS is a boys' school (Grades 1 - 4), and 4 teachers who taught Grades 3 and 4 participated in the opening workshop. Preparatory School MA is a girls school (Grades 6 through 9), and 6 teachers participated in the opening workshop. Finally, Preparatory School DP is a boys' school (Grades 6 through 9),

and 9 teachers participated in the project. Thus, altogether, 37 teachers participated in the opening workshop. However, for a variety of reasons, only 30 teachers (AM, 11 teachers, IS, 5 teachers, MA, 6 teachers, and DP 8 teachers) completed the project. All teachers from Primary Schools AM and IS and Preparatory School MA was female while all teachers from Preparatory School DP were male.

Data Sources

The primary data source for this case study was the final survey conducted in May 2017 (see Appendix B). This survey was completed by all 34 participants, 30 teachers, and 4 PDSs. In addition, the participants completed daily reflections after each research lesson at their respective schools during Phase 2. The IMPULS personnel also took various research memos during their visits.

The reflections after the research lesson and the free-response items on the final survey were analyzed to identify themes. While the reflections were translated into English so that they could be analyzed by the IMPULS team, the final survey responses were analyzed by the researcher from QU whose first language is Arabic.

Findings

Research Question 1: What did the participants learn?

Question 6 on the final survey (see Appendix B) asked the participants how much they learned about different aspects of mathematics teaching and lesson study. The items in the survey are the intervening changes and learning anticipated in the design framework. There were 20 items for the participants to respond on a 5-point scale from "Not at all (1)" to "A lot (5)." Overall, all 20 items received either 4 or 5 ratings from more than half of the teacher participants. The following 7 responses received the highest rating of 5 from at least a half of the participants (the number inside the parentheses indicate the number of teacher participants (N = 30) who gave the rating of 5):

(b) How to support students' problem-solving ability. (19)
(e) Collecting data on student thinking to inform instruction. (15)
(f) Strategies for making students' thinking visible. (15)
(q) Strategies for working effectively in a lesson study group. (16)
(r) Analyzing written student work/responses. (16)
(s) Analyzing and interpreting verbal student comments. (17)
(t) How to lead less study. (16)

Items (b), (e), (f), (r), and (s) are directly related to TtP, one of the major foci of the project. On the other hand, items (q) and (t) are about implementing lesson study effectively. In

contrast to these items, items (d), (h), (m), and (n) received the highest number of either 1 or 2 ratings from teacher participants:

(d) How lesson study is conducted in another school. (6)
(h) Ways to build connections among educators at multiple levels of the education system. (5)
(m) Differentiating/offering support for struggling learners. (4)
(n) Cultural influences on mathematics teaching and learning. (6)

However, as noted above, even these items also received ratings of 4 or 5 from more than half of the participants.

The 30 teacher participants' responses to Question 1 on the survey are consistent with these findings. Many participants thought their participation in lesson study helped them teach mathematics through problem-solving. They also felt that their participation in the project helped them trust their students' ability to learn mathematics and solve problems. Many of them felt that they improved their ability to analyze students' responses to mathematics problems, and they are encouraging their students to tackle novel mathematics problems using what they have learned previously.

Although all 20 items in Question 6 received high ratings from all participants, we also noticed that there are some differences in responses between teachers from primary schools and those from preparatory schools. The average ratings for the teachers from primary schools ranged from 4.25 to 4.88 while the average ratings for the preparatory school teachers ranged from 2.62 to 4.00. While none of the primary school teachers gave the rating of 1 or 2 to any of the 20 items, at least one preparatory school teacher was giving the rating of 1 or 2 in all but item i, anticipating student responses. Moreover, item f, which is about strategies for making students' thinking visible was one of the 5 highest rated items for the primary school teachers, but it was the second lowest-rated item by the preparatory teachers. On the other hand, item p, which is about developing units and lessons, was the 5th highest rated item (tied with the item i about anticipating student responses) by the preparatory teachers, but it was the 5th lowest rated item among the primary teachers. Table 1 shows the 5 highest and 5 lowest-rated items for these groups of teachers.

Table 1: 5 highest and 5 lowest rated items on Question 6 by school levels

Levels	5 Highest Rated Items (in order)	5 Lowest Rated Items (in order)
Primary	(f), (b)/(e)/(s), (q)	(n)/(j), (m)/(d), (p)
Preparatory	(t), (b), (r), (s), (i)/(p)	(d), (f), (h), (n)/(m)

Question 7 on the final survey asked the participants to rank up to five items from Question 6 that they believed would be professionally most useful as they looked ahead. All 20 items

were included in at least one teacher's ranking. The following 3 items were picked by the most teacher participants as the most useful idea:

(a) Mathematics content. (6)
(e) Collecting data on student thinking to inform instruction. (9)
(f) Strategies for making students' thinking visible. (6)

The participating teachers have rated items (e) and (f) highly in terms of how much they perceived to have learned from the project. Although item (a) was picked as the most useful idea by 6 teachers, only 4 other teachers have picked this item in their top 5 useful ideas. 3 items were picked as one of the 5 most useful ideas by more participants than this item was – items (i) (13 participants), (l) (15 participants), and (t) (12 participants). Item (l), which is about students' mathematical reasoning, was picked as the most useful idea by only 1 teacher, but altogether, 12 teachers picked it as one of the most useful ideas as they look ahead. All but 1 of the 12 teachers who included item (t) in their 5 most useful idea was rated as their 5th most useful idea.

Given Question 7 was asking the participants about the usefulness of the potential learning through the project participation, we did not expect too many teachers would select the items related to implementing lesson study as one of the 5 most useful ideas. As anticipated, items (d), (h), (k), and (o) were not picked by any teacher as one of the 5 most useful ideas. Interestingly, item (q) about strategies for working effectively in a lesson study group, was picked by 4 teachers. Items (q) and (t) were other items that related directly to lesson study, and they received the highest rating in terms of the amount of learning from more than half of the teacher participants. However, only a much smaller number of teachers included them in their 5 most useful ideas.

Research Question 2: What are the sources of the participants learning?

Question 9 asked the participants how much they learned through each of the 7 possible sources of learning in the design framework on a 5-point scale from "Not at all (1)" to "A lot (5)." Among the teacher participants, the average ratings on the 7 activities were rather high, ranging from 4 to 4.5. The three highest-rated activities were items (c), (e), and (g) (the numbers in the parentheses indicate the average rating and the number of teachers who gave the ratings of 4 or 5):

(c) Lesson plan feedback by IMPULS. (4.4, 21)
(e) Collecting data on student thinking during research lesson observation. (4.5, 23)
(g) Final comments by IMPULS professors. (4.5, 25)

Although 25 out of 28 teachers rated item (g) either 4 or 5, there was one teacher who rated it as 1, Not at all. This rating was the only rating of 1 by all of the participants on the 7 items.

The items that received the lowest rating by the teacher participants were items (a) and (f) (the number in the parentheses indicates the average rating).

(a) Developing lesson plan. (4.0)
(f) Post lesson discussion. (4.2)

Research Question 3: What are perceived challenges?

Question 3 on the survey asked the participants to identify challenges to using lesson study in their schools. By far the two most commonly mentioned issues are the overcrowded curriculum/standards and students' weakness in mathematics in general and problem-solving in particular. These ideas were also frequently mentioned in the participants' daily reflections. The teacher participants often wondered if teaching through problem-solving is appropriate for all levels of students, in their daily reflection, on the final survey, and during the post-lesson discussion. They also mentioned time as another challenge in implementing lesson study. They felt they needed more time to become more familiar with the idea of teaching through problem-solving, examining curriculum, and plan research lessons. One challenge mentioned by PDSs several times throughout the project is the difficulty of conducting *kyozai kenkyuu* as a part of lesson planning. One specific issue they mentioned was the lack of resource materials in Arabic. Although many teachers are comfortable with English, it nevertheless posed challenges to investigate teaching materials in depth.

Despite these challenges, some of the participants indicated that their views about teaching and learning mathematics have changed in several ways. In particular, several teacher participants mentioned that they are giving students time to think mathematically and incorporate their ideas in-class discussion to enhance their mathematics learning. Some are thinking more about student-centered mathematics learning environments instead of teacher-centered approaches.

Discussion

Overall, the findings suggest that the project was well received by the participants, and they gained insights into both CLR and TtP, suggesting the viability of the design framework. In particular, the results from this inquiry confirm the critical roles knowledgeable others play in teacher learning. Takahashi (2014) discussed different ways knowledgeable others in Japan facilitated teacher learning, and the current case study suggests that future implementations of Japanese lesson study outside of Japan should seriously consider the roles of knowledgeable others in their designs.

Designing a mathematics lesson in which students are given opportunities to learn through problem-solving is a challenging task. The Qatari teachers who participated in this project also expressed the challenges of TtP while appreciating it at the same time. Their responses to the questions on the final survey seem to show that many of them are paying more attention to

students' thinking and trying to incorporate students' ideas in their mathematics lessons than they used to. The fact that many teacher participants picked "strategies for making students thinking visible" as something professionally useful is clear evidence of these participants valuing their students' reasoning.

21 out of 27 teachers rated the support by QU specialist during the lesson planning as either 4 or 5 on the 5-point scale (3 teachers did not answer this question). We suspect that spending the first year of the project fully immersed in TtP and CLR themselves helped them to be more effective as they guided the planning team at their respective schools. This finding suggests that any future effort to implement CLR or TtP should focus on developing the capacity of a few leaders who have first-hand knowledge of both ideas.

On the other hand, the fact that the participating teachers did not think they learned as much from developing lesson plans or post-lesson discussion as other aspects of CLR raises some concerns. For post-lesson discussion, we suspect it might be because it often ended with observers simply sharing what they observed. A similar phenomenon in some US lesson study implementation has been reported (e.g. Takahashi, & McDougal, 2016). This might be due to, in part, our emphasis on observed data during the post-lesson discussion.

The issue of challenges in developing lesson research proposals is also a common one across the world (Khokhotva, 2018, Quaresma et al., 2017, Takahashi, et al., 2005, Watanabe et al., 2008), but it also has a facet that is unique to Qatar. As mentioned above, English poses a significant challenge for some Qatari teachers. Unfortunately, there are few resources written in Arabic that can be useful during *kyozai kenkyuu*. The project provided an English-translated Japanese mathematics textbook series that might be used during this phase of CLR. However, many participants find it difficult to make full use of the textbook series, and oftentimes, QU specialists had to find resources (in English) for them. Lewis and Perry (2017) found educators who were provided with a tool kit to support their lesson study deepened their understanding of fractions more than those who simply engaged in lesson study without the tool kit. Thus, the development of Arabic resources to support lesson study in Qatar may be an important factor for future success.

The difference in Question 6 responses between the primary school teachers and the preparatory school teachers was a surprise. We anticipated what teachers learn would be influenced by the topic and the design of research lessons, which in turn affect the post-lesson discussion. However, with each teacher having opportunities to observe and discuss several research lessons, we did not anticipate the difference between the primary and the preparatory teachers. We also experienced some issues of the commitment of the school administration with one of the preparatory schools. Thus, oftentimes, participating teachers had to leave in the middle of the post-lesson discussion because their schedules were not adjusted for the project activity. This issue requires additional investigation.

Implications to Institutions of Higher Education and Future Research

Institutions of Higher Education (IHEs) are responsible for teacher preparations throughout the world. In addition, many IHEs throughout the world are also involved in the professional development of in-service teachers. Supporting teachers' life-long learning is a critical mission of IHEs. As a part of their efforts to support teacher professional development, Japanese lesson study has become a popular tool employed by many IHEs. The current report has a few implications for those who are considering the use of lesson study to support teacher professional development.

First, as stated earlier, Seleznyov (2018) reported that there is no internationally shared knowledge of critical components of lesson study. Many projects employ "modified" lesson study, but it is not often clear what modifications were made and why. We cannot simply transplant a learning activity developed in culture into a different culture and expect the same results. Adaptations are necessary, but adaptations should be made based on a clear understanding of the original activity. The current study shows that the use of CLR with a clear definition is a useful tool for teacher professional development.

The design of the project also affirms the critical importance of IHE personnel's understanding of CLR and TtP. The current project dedicated the first year to help QU specialists to experience CLR and TtP first-hand so that their understanding of both practices was well-grounded in their own experiences. When the project schools were engaged in their first cycle of CLR during the second year of the project, one of the specialists wondered why the teachers appeared to be catching on to the idea of TtP much more quickly than they did during the first year of the project. We believe that it was because the participating teachers were able to get ongoing and direct support from the specialists about both TtP and CLR while the specialists were able to receive support remotely in between the visits by IMPULS personnel. Thus, IHE personnel must be well-versed in a particular pedagogical idea they want to promote but also in CLR.

Finally, although the participating teachers' reflections and their responses to the final survey appear to indicate that their participation in the project has begun to influence their mathematics teaching, it is all based on self-reporting. Additional inquiries to examine the changes in teaching practices and students' learning must be conducted to fully assess the effectiveness of this project. Moreover, lesson study in Japan is not a one-time project. Rather, it is a part of ongoing efforts by Japanese teachers to continuously enhance their professional capacity. Thus, it is important to examine how such a culture may be nurtured through the leadership of IHEs.

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Appendix A Lesson proposal template

LESSON RESEARCH PROPOSAL FOR [*GRADE AND TOPIC*]

For the lesson on [date]

At [name of the school], [teacher's name] class

Instructor: [name]

Lesson plan developed by: [names]

Experienced lesson study practitioners use a variety of formats for presenting the thinking behind their research lessons, but this template identifies important considerations of lesson study.

Red italicized text briefly describes what the sections are for; ***all red text should be deleted during the preparation of the actual research proposal.***

Title of the Lesson: <a descriptive title>

Brief description of the lesson

Just a few sentences…

Research Theme

Fostering students' ability for problem-solving and reasoning by using Teaching through Problem Solving (TtPS)

Goals of the Unit

a) [include long-range goals as well as short-term ones] For students to become…
b) To help students understand…

Goals of the Lesson:

a) Students will understand …
b) Students will be able to…

Relationship of the Unit to the Standards

DELETE RED TEXT This section typically describes how this unit fits between the standards from prior grades and the standards for this or later grades. Do not quote standards in their entirety, but excerpt the relevant clauses or use strike-through to show which parts of a standard are and are not being addressed.

Related prior learning standards

Learning standards for this unit

Related later learning standards

Background and Rationale

DELETE RED TEXT Justify your choice of theme and topic. Frequently this is expressed in terms of a contrast between the current state of students (or students in previous years) and what you and your colleagues want to accomplish.

Research and Kyozaikenkyu

DELETE RED TEXT Describe findings from looking at various curricula and any other resources, and rationales behind the particular tasks, manipulatives, and design of the unit and lesson.

Unit Plan

DELETE RED TEXT Shows how this lesson fits into a larger unit. Briefly describes lessons before and after the research lesson. A typical unit maybe 10 days, including practice; this is what it might look like for a 4-day unit in which the research lesson is lesson #2:

Lesson	**Learning goals and tasks**
1	<description>
2	**The research lesson:** <brief description of this research lesson>
3	<description of a later lesson>
4	

Design of the Unit and Lesson

This section typically discusses:

- *how the research theme will be addressed during the unit;*
- *how the lesson has been designed to address the research theme and learning goals.*

Research lesson plan

The sections of this lesson plan are based on a typical problem-solving-based mathematics lesson, which may or may not be appropriate for your lesson. "Anticipated student responses," however, should always be included.

Steps, Learning Activities Teacher's Questions and Expected Student Reactions	Teacher Support	Points of Evaluation
DELETE THIS ENTIRE ROW OF THE TABLE This column shows the major events and flow of the lesson.	This column shows additional moves, questions, or statements that the teacher may need to make to help students.	This column identifies what the teacher will look for (formative assessment) and what observers should look for to determine whether each segment of the lesson is having the intended effect.
1. Introduction This section may review ideas from a prior lesson or discuss a simple problem designed to prepare students for work on the main problem.		
2. Posing the Task This section describes a problem or task as it will be presented to students. Give the exact phrasing of the hatsumon (key question) and the specific numbers used.	Indicate here whether the problem will be written on the board, posted, handed out as a worksheet, or glued into student notebooks.	
3. Anticipated Student Responses This section describes how students might respond to the problem, including incorrect solutions and places where students might get stuck. It can be helpful to tag different responses in some way, e.g. "R1" for Response 1, etc. R1: 2 + (3 * 5) [correct] R2: 3 * 5 = 15; 2 + 15 = 17	Here the plan might describe how the teacher will handle the different student responses, especially incorrect solutions, students who get stuck, or students who finish early.	
4. Comparing and Discussing This section may identify which student solution methods should be shared and in what order, or generally how to handle the discussion.	What are the ideas to focus on during the discussion?	
(If needed, repeat 2, 3, & 4 above for additional tasks.)		
5. Summing up This section may describe how the teacher will summarize the main ideas of the lesson. It may also include an assessment activity.		

Evaluation

This section often includes questions that the planning team hopes to explore through this lesson and the post-lesson discussion.

Board Plan

This section contains a diagram showing how to work on the blackboard will be organized. A good approach is to run a simulation of the lesson and then take a photo of the board.

Reflection

After the research lesson, the team should append to the original lesson plan a summary of major points from the discussion. This may be a few paragraphs in length and makes the final document ***much more valuable*** *to an outside audience.*

Appendix B Final Survey

Q0. Your Affiliation

Omitted to protect the identity of the participants

Q1. What do you think are the strengths/ benefits of using lesson study in your school?

Q2. In your mind, what are the essential features of lesson study?

Q3. What do you think are the challenges to using lesson study in your school?

Q4. Please describe how you hope to use lesson study for educational improvement in your school after this program.

Q6. [1] How much did you learn about each of the following during the IMPULS-QU Lesson Study Program?

[1] There was a numbering error, and there was no question 5.

	Not at all (1)	A little (2)	Some (3)	Quite a bit (4)	A lot (5)
a. Mathematics content	❍	❍	❍	❍	❍
b. How to support students' problem-solving ability	❍	❍	❍	❍	❍
c. Evaluating lessons on the basis of the written plans	❍	❍	❍	❍	❍
d. How lesson study is conducted in another school	❍	❍	❍	❍	❍
e. Collecting data on student thinking to inform instruction	❍	❍	❍	❍	❍
f. Strategies for making students' thinking visible	❍	❍	❍	❍	❍
g. Analyzing/studying curriculum materials	❍	❍	❍	❍	❍
h. Ways to build connections among educators at multiple levels of the education system	❍	❍	❍	❍	❍
i. Anticipating student responses	❍	❍	❍	❍	❍
j. Writing a useful lesson plan	❍	❍	❍	❍	❍
k. Organizational/structural supports for lesson study	❍	❍	❍	❍	❍
l. Students' mathematical reasoning	❍	❍	❍	❍	❍
m. Differentiating/ offering support for struggling learners	❍	❍	❍	❍	❍
n. Cultural influences on mathematics teaching and learning	❍	❍	❍	❍	❍
o. Organizing a successful post-lesson debriefing session	❍	❍	❍	❍	❍
p. Developing mathematics units and lessons	❍	❍	❍	❍	❍
q. Strategies for working effectively in a lesson study group	❍	❍	❍	❍	❍
r. Analyzing written student work/ responses	❍	❍	❍	❍	❍
s. Analyzing and interpreting verbal student comments	❍	❍	❍	❍	❍
t. How to lead lesson study	❍	❍	❍	❍	❍

Q7. Please select and rank in order of importance the five items from the previous question that you believe will be most professionally useful for you within the next year.

In order of importance, I anticipate I will find these 5 items the most professionally useful in the coming year:
_____ a. Mathematics content
_____ b. How to support students' problem-solving ability
_____ c. Evaluating lessons based on the written plans
_____ d. How lesson study is conducted in another school
_____ e. Collecting data on student thinking to inform instruction
_____ f. Strategies for making students' thinking visible
_____ g. Analyzing/studying curriculum materials
_____ h. Ways to build connections among educators at multiple levels of the education system
_____ i. Anticipating student responses
_____ j. Writing a useful lesson plan
_____ k. Organizational/structural supports for lesson study
_____ l. Students' mathematical reasoning
_____ m. Differentiating/ offering support for struggling learners
_____ n. Cultural influences on mathematics teaching and learning
_____ o. Organizing a successful post-lesson debriefing session
_____ p. Developing mathematics units and lessons
_____ q. Strategies for working effectively in a lesson study group
_____ r. Analyzing written student work/ responses
_____ s. Analyzing and interpreting verbal student comments
_____ t. How to lead lesson study

Q8: How did your views about teaching and learning mathematics change as a result of this IMPULS-QU Lesson Study Program, if at all?

Q9: In looking over all the activities during the IMPULS-QU Lesson Study Program, how much did you learn from each of the following?

	Not at all (1)	A little (2)	Some (3)	Quite a bit (4)	A lot (5)	N/A
a. Developing Lesson Plan	❍	❍	❍	❍	❍	❍
b. Support by QU specialist during the lesson planning	❍	❍	❍	❍	❍	❍
c. Lesson Plan Feedback by IMPULS	❍	❍	❍	❍	❍	❍
d. Teaching a research lesson	❍	❍	❍	❍	❍	❍
e. Collecting data on student thinking during research lesson observation	❍	❍	❍	❍	❍	❍
f. Post Lesson Discussion	❍	❍	❍	❍	❍	❍
g. Final Comments by IMPULS Professors	❍	❍	❍	❍	❍	❍

Q10: In looking over all the research lessons during the IMPULS-QU Lesson Study Program, name one that was especially meaningful to you, and why:

Title and date of research lesson:

The reason this stood out for me:

Q11: In looking over all the post-lesson discussions during the IMPULS-QU Lesson Study Program, name one that was especially meaningful to you, and why:

Title and date of post-lesson discussion:

The reason this stood out for me:

Q12: Was there a conversation among participants during the IMPULS-QU Lesson Study Program that stands out to you? Please describe, and provide reasons that this stood out for you:

Q13 Anything else you'd like to add?