

Development of program for “Global Lesson Study” in mathematics education

Development
of program for
GLS

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Received 28 February 2021

Revised 18 June 2021

13 August 2021

Accepted 16 August 2021

Abstract

Purpose – The purpose of this exploratory study was to develop Global Lesson Study (GLS) defined as an international collaborative lesson study through international exchange of teachers using ICT. Its purpose is to nurture teachers from different countries with intercultural competence to conduct lesson study.

Design/methodology/approach – We developed an initial program for GLS in the subject of mathematics education between elementary school teachers in Japan and Singapore. The qualitative analysis of activities at each stage of the Pilot GLS was conducted from two perspectives: (1) intercultural competence for lesson study and (2) teacher's competency for subject instruction.

Findings – Through GLS, a new lesson was created that was only possible with discussions from teachers from different locations. It was clarified that GLS was not only useful for training teachers with intercultural competence for lesson study but also has led to the improvement of teacher's competency for subject instruction in mathematics.

Originality/value – The GLS is a new attempt in the sense of developing a high-quality lesson study method for creating new lessons as well as improving qualities and abilities of teachers through international exchange.

Keywords Lesson study, Mathematics education, Intercultural competence, Singapore, Japan

Paper type Research paper

1. Introduction

1.1 Research purpose

Through the rise of globalization coupled with advances in Information and Communication Technology (ICT), societies face a diversification and radical changes in their existing social norms and values. Institutions of schooling and education across many cultures have been forced to respond to these changes that are both pervasive and inexorable. And even though Japan has itself long been described as a relatively uniform or monolithic society, the number of registered foreigners living and working here has been increasing. Commentators have therefore predicted that the nation will experience an “inner internationalization” resulting in a more multicultural society in near future (Kagata, 2011). Indeed, there are already visible outcomes of this effect as shown in the increasing number of schools that have enrolled children with foreign roots (Ota, 2014). In response, the Japanese government has emphasized



International Journal for Lesson &
Learning Studies
Vol. 10 No. 4, 2021
pp. 317-330

© Emerald Publishing Limited
2046-8253

DOI 10.1108/IJLLS-02-2021-0015

This work was supported by JSPS KAKENHI Grant Number 19K02690.

Conflicts of interest: The authors declare no conflicts of interest regarding the publication of this paper.

the importance of aiming for internationalization of education, globalization of teachers working in schools and acquisition of international experience for teachers whenever there is an opportunity (Tanaka, 2014). Among Japanese researchers and practitioners of global education, new priorities have likewise appeared. For example, knowledge of Education for Sustainable Development (ESD) and global citizenship education are regarded as necessity for nurturing “Intercultural Competence” and “Global Citizenship” (Nishiyama *et al.*, 2015).

While it is important for any society to prepare its people to be active in global society for the future, teachers in Japan themselves need to have exposure to rich intercultural experiences such as overseas educational activities. However, there is a limit to the number of teachers who can go abroad and be involved in overseas educational activities due to time and financial constraints. Thus, in-service training for teachers should provide such important experiences for as many teachers as possible while they are in Japan to obtain multicultural experiences in education.

Culture can be interpreted in multiple ways. This research follows Scollon and Scollon (1995)’s definition that culture is “any aspect of the ideas, communications, or behaviors of a group of people which give them a distinctive identity and which is used to organize their internal sense of cohesion and membership” (p. 127). As Ebaegu and Stephens (2014) confirmed, in the education system, culture itself influences over the form of pedagogy, classroom practice and teachers’ professional development. Multicultural experiences, therefore, would be a good opportunity for teachers to reflect on their pedagogy or classroom practice.

We believe that classroom practice is central role of teachers in schools. Among many different strategies available for teachers, we focus on Lesson Study as it is common worldwide and recognized as an effective strategy (Stiegler *et al.*, 1999). In this research, we positioned Lesson Study as a collaborative space where teachers can demonstrate multicultural abilities through the process of developing a new lesson in the lesson study with teachers from various cultures and countries. We aim to develop teachers with intercultural competencies for Lesson Study and to explore its effect. Also, through lesson studies with teachers of other cultures, it is expected that the skills of teaching will be improved through research discussion with others who are trained from a different cultural perspective.

1.2 What is intercultural competence in education?

Deardorff (2006) defined intercultural competence as the “ability to communicate effectively and appropriately in intercultural situations based on one’s intercultural knowledge, skills and attitudes” (pp. 247–248). This was based on four dimensions from Santerini (2010):

- (1) Attitude (openness, respect, curiosity, tolerance of ambiguity),
- (2) Knowledge and skills (cultural awareness, knowledge of one’s own and other cultures, observation, ability to evaluate),
- (3) Internal outcomes (adaptability, flexibility, empathy, the ability to see things from another’s point of view) and
- (4) External outcomes (situation-appropriate behaviors and communication).

In addition, Deardorff (2006) emphasized the pyramid structure of these dimensions, which implies the attitudes are starting point and fundamental to achieve appropriate intercultural competence and “this model of intercultural competence moves from the individual level of attitudes and personal attributes to the interactive cultural level in regard to the outcomes” (p. 255). It was believed that intercultural competence not only changes attitudes and consciousness toward different cultures and improves knowledge and skills related to

different cultures but also improves communication skills when interacting with different cultures (Santerini, 2010).

These four dimensions are almost similar to the contents described by Byram (2008) who defined the elements of intercultural competence as attitude, knowledge, interpretation and association skills, as well as discovery and interaction skills and described the gradual achievement of those abilities. Japanese researchers Nishiyama *et al.* (2015) have also advocated intercultural education that incorporates the elements of Bryan (2008).

In addition, the general provisions of the Japanese “Course of Study” for elementary schools, revised in 2017, lists qualities and abilities required in response to modern issues as follows (MEXT, 2017, p. 53):

(Qualities and abilities) while respecting diversity in globalization, to understand the territory and history unique to Japan that have been inherited to date, to respect tradition and culture and to work towards various goals while working with a variety of others.

Thus, according to the definition of Deardorff (2006), it can be said that Japan’s intercultural abilities can cover attitude, knowledge and skills and internal outcome, but does not mention how to deal with real issues by taking advantage of external outcomes— aspects attitudes, values and skills obtained through learning.

Even in Singapore, where various cultures intersect, qualities and abilities to be pursued in the policy documents and curriculum of the Ministry of Education are introduced as the twenty-first century competence. Among them, intercultural competencies are cited as Civic Literacy, Global Awareness, Cross-Cultural Skills (CGC), as well as Active Community Life, National and Cultural Identity, Global Awareness and Scio-Cultural Sensitivity and Awareness (Tan *et al.*, 2017; MoE, 2020, January 21). Compared to Japanese students and teachers, it can be easily imagined that students and teachers in Singapore who always live in a cross-cultural environment have relatively better intercultural competencies.

On the other hand, one issue was raised in the report of the Central Education Council under Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) in August 2012 regarding teacher training in response to globalization. That is, even though MEXT mentions “teacher themselves need to acquire a global perspective and way of thinking” (MEXT, 2012, p. 25), it is not clearly stated what the specific qualities and abilities are.

Advocacy for teacher education and teacher training—based on indicators such as (1) improving language skills, (2) increasing number of people studying abroad and (3) increasing experience of activities overseas—is carried out. But, due to time and money constraints described in previous section, only small number of teachers benefits from this. Also, many people misunderstand that simply obtaining language skills is equal to understanding different cultures.

1.3 Previous research on lesson study and improvement of abilities

Since “*The Teaching Gap*” by Stigler and Hiebert (1999) was published, Jugyou Kenkyuu or Lesson Study from Japan has spread far and wide internationally in schools. Two main trends of studies on Lesson Study are (1) teaching methods, including improvement of teacher’s pedagogical expertise (Rock and Wilson, 2005) and (2) improvement of teacher’s subject expertise (Fernandez, 2008). Results of all these studies have shown that Lesson Study has contributed to improving teacher’s skills and abilities through its processes involving collaborative planning and solving educational issues.

Also, it was shown that improvement of qualities and abilities for subject teaching can be achieved through global educational experience (Sakai *et al.*, 2019). This improvement was believed to be triggered by “Dilemma causing confusion” (Taylor, 1994). In other words, teachers can obtain new perspectives toward subject teaching by being exposed to unfamiliar

pedagogies of other cultures—Dilemma in GLS—that is outside of existing “framework to interpret experiences (Mezirow, 1991)” for them.

For example, international cooperative distance lectures and seminars among undergraduate and graduate students in Japan, Germany and Thailand have successfully improved students’ scholastic abilities to teach mathematics much more than they are conducted separately in each country (Moriya *et al.*, 2016). Furthermore, it was clarified that the experience of collaborative lesson making at a secondary school in Thailand by Japanese undergraduate students led to a reconsideration of the mathematics education in Japan (Nakamura *et al.*, 2018). However, issues such as international experience have been limited to studying teaching materials and more importantly, actual lesson practice has not been conducted remain to be improved. Other problems included shortness of time for sharing and relative inexperience of student teachers who were participating.

As another example of Lesson Study by in-service Israeli and Japanese mathematics teachers through observation of lessons, it has been reported that productive discussions took place when Israeli teachers watched Japanese videos and came into contact with culturally far lessons, resulting in some dissonances that promoted reflective thoughts and actions (Schwartz and Karsenty, 2020). However, in this research, international experience was limited to observing lessons and activities like collaborative lesson making with studying teaching materials together were missing.

Even though there are studies like these, there are few studies focusing on new lesson development by creating contents and methods together incorporating perspectives of different cultures. The GLS conducted in this study, therefore, is a new attempt in the sense to develop a high-quality lesson study method for developing a new lesson as well as improving qualities and abilities of teachers and is expected to be effective.

To clarify the domain of this research, we briefly mention about adaptation of the Lesson Study in Singapore. As well as other countries, feasibility of Lesson Study in Singapore is questioned by some researchers. Among them, e.g. Lim-Ratnam *et al.* (2019) indicated that the Lesson Study is a sociocultural teacher practice, being “organic” to the Japanese education culture. Also, in the examination-oriented education system in Singapore, the short-run and immediate results of academic ability would be more favorable or attractive than the long-run effects supposed to be achieved in the Lesson Study. In addition, according to Lim-Ratnam *et al.* (2019), it was mentioned that indispensable elements of the Lesson Study are (1) existence of learning community of practice among teachers and (2) teachers’ professional development through research. Based on the above conditions and due to the cultural difference between Japan and Singapore, it was concluded that indigenization of these two elements would be big challenge in Singapore.

However, teachers of the Host school selected for this pilot study have been conducting their own lesson reviews internally. Therefore, when the Japanese researchers and teachers have approached to the faculty member at the National Institute of Education, asking for possible primary schools for exchange activities, they are willing to participate in this international collaboration from the beginning. Also, the aim of this research is not to clarify the acceptability of the Lesson Study in Singapore as their school culture in general, but, to analyze any change of the teachers’ pedagogy or classroom practice, facing multicultural experience such as the GLS. Given a condition that the partner Singaporean school in this research had already accepted the Lesson Study as a subject based learning community and research based professional development, the GLS was conducted as explained in the next section.

1.4 Definition of Global Lesson Study

Based on the discussion about intercultural competence and lesson study mentioned above, we expect teachers with intercultural competence for lesson study required in the field of education are teachers who can:

- (1) Flexibly understand contents and methods of education in different cultures through communication with teachers of different cultures (Intercultural Communication) and
- (2) Proactively and collaboratively develop new lessons that are integrated and expanded other cultures' contents and methods of education into those of own culture (Intercultural Creativity).

Also, with the intercultural competence of [Deardroff \(2006\)](#), the specific intercultural competence for lesson study of such teachers is defined as follows:

- (1) Attitude
 - Openness, respect and curiosity toward contents and methods of education of the other cultures (Attitude #1).
 - Tolerance for ambiguity about difference in contents and methods of education (Attitude #2).
- (2) Knowledge and Skills
 - Awareness toward contents and methods of education of other cultures (Knowledge and Skills #1).
 - Understanding of contents and methods of education in own and other cultures (Knowledge and Skills #2).
 - Observation and ability to evaluate contents and methods of education of other cultures (Knowledge and Skills #3).
- (3) Internal Outcomes
 - Adaptability, flexibility, empathy and the ability to see things from another's point of view toward proposals and suggestions from the other cultures.
- (4) External Outcomes
 - Situation-appropriate behaviors and communication during lesson studies.

Intercultural competence for Lesson Study as mentioned above is related to the Intercultural Communication of teachers with intercultural competence for lesson study that is expected.

Based on such intercultural competence for lesson study, it is also expected to develop a new lesson as indicated as Intercultural Creativity. Therefore, we define newly developed lesson as follows:

- (5) Outward Impact
 - Based on the proposals/suggestions from the other cultures, new contents and methods of education integrated and developed with own culture as a New Style/Product of lesson study.

Regarding "communication with teachers in different cultures," teachers can utilize ICT such as e-mail and on-line conference system like Zoom or Google Hangouts without physical traveling.

Also, for "flexibly understanding the contents and methods of education in different cultures," teachers can learn a new perspective for interpreting teaching materials and instruction methods by exchanging ideas. This may lead to an understanding of different values of education and is considered related to the attitude, knowledge and skills, and internal outcomes of intercultural competence for lesson study defined above.

Furthermore, with regard to “proactively and collaboratively develop new lessons that are integrated and expanded other cultures’ contents and methods of education into that of own country,” teachers can develop, implement and exchange teaching materials and instruction methods adjusted for their culture based on new perspective, resulting in developing a new lesson that fuses and expand different cultural contents and methods of education. This is considered as the outward impact mentioned above.

In this research, we, therefore, define “international collaborative lesson study through international exchange of teachers using ICT to understand different interpretations of teaching materials and instruction methods, and to create lessons with new values that have been integrated and developed in education of both countries,” as Global Lesson Study (GLS). A diagrammatic representation of the theoretical framework of this research is shown in Figure 1.

By implementing GLS, teachers can improve their intercultural competences for lesson study while staying in their own countries and may further improve their qualities and abilities for subject teaching. Since this is still a pilot study, verification of the above-mentioned expected results will be carried out through qualitative analysis. Therefore, we extracted the scenes where the majority of participants were corresponding to each element that was defined as above for inter-cultural competencies for lesson study and added consideration. Specifically, we qualitatively evaluate the changes and transitions of contents of communication and interaction among teachers involved in GLS.

2. Method of research

2.1 Participants of pilot Global Lesson Study

Singapore—an advanced education country with a high level of teacher specialties while some similarities and differences in its traditional culture compared to Japan—is selected as a partner of this pilot GLS. It would be beneficial for teachers of both countries to know each other’s interpretations of teaching materials and instruction methods.

Since 2015—before the idea of GLS—we have been conducting exchange activities with two primary schools in Singapore each focusing on Mathematics and Science. Since the teachers of elementary schools where we visit in Singapore have been regularly conducting subject-based lesson studies internally, they were willing to learn ideas from teachers of other country by accepting researchers and school teachers from Japan to join class observations and discussions afterwards. Also, teachers of both Host and Guest visit each other and are interested in education of each side. Here, all teachers from Singapore and Japan joining this Pilot GLS are specialized in Mathematics. Therefore, a learning community and research-based professional development can be considered already developing gradually between the

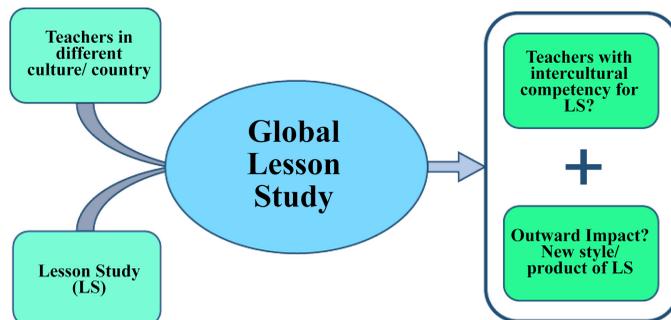


Figure 1.
Theoretical framework
of this research

Host and Guest through Mathematics. Among the two schools, we then started discussing with one school focusing on Mathematics to bring simple exchange activities up to international lesson studies as GLS since very similar mathematical contexts are instructed somewhat differently.

In this project, university faculties are in responsible for planning and managing exchange of teachers between two countries. They also coordinate dates and time and provided interpretation and translation as needed for the GLS to make teachers feel no anxiety to join the GLS. However, they did not directly involved in discussions such as contents of after-class discussion and simply observed the GLS from the third party's point of view and provided feedback as needed to teachers on how to discuss based on observation and analysis of change.

2.2 Program for pilot Global Lesson Study

In GLS, the process of understanding and comparing contents and methods of education in partner country/culture is important. Therefore, it is necessary to have enough time and opportunities for discussion. For example, other than essential pre- and post-conferences for demonstration lesson(s), it is important to pre-arrange what to discuss, how to and what to record and how to share the recorded video and other materials. Furthermore, it is necessary to consider how to provide translation and/or interpretation between different languages.

We developed five stages of discussion with university professors and primary school teachers, including head teacher for mathematics in both countries. Those stages are: (1) start-up discussion, (2) pre-lesson conference, (3) recording and observing of the demonstration lesson, (4) post-lesson conference and (5) closing (summarization). [Table 1](#) shows the detailed contents and methods for each stage of GLS. [Table 2](#) shows the Pilot GLS program.

2.3 Pilot Global Lesson Study

Before the full implementation of GLS, it is necessary to clarify educational effects and issues of the program to some extent. Therefore, we conducted the Pilot GLS in 2018 with a primary school in Singapore as the “Host” school to conduct the demonstration lesson (Japan as the “Guest”) according to the program shown in [Table 2](#). In the following sections, we describe some details of learning contents for Stages 2–4. Since Stages 1 (start-up) and 5 (closing) are mostly formal and routine communication, we omit the explanation here.

3. Results of pilot Global Lesson Study

3.1 Discussion in pre-lesson conference

3.1.1 Proposal and confirmation of lesson plan. The pre-lesson conference was started by proposing a lesson plan from Host. The lesson objective is “Make two-step problems about areas of square and rectangles and solve them”.

The lesson starts with confirming the meanings of mathematical terms of “more than,” “shorter than,” “twice” and “three times”. Then, based on the presented rectangle (8 cm × 16 cm), students represent linguistically about relations of length and width. Students should describe as:

- (1) Length is 8 cm longer than width.
- (2) Length is twice of width.
- (3) Width is shorter than length by 8 cm.

Table 1.
Contents and methods
in each stage of GLS

Stage 1: Starting up

- Decide which school to be the host (host and guest switch their roles every year)
- Host proposes a schedule to guest (e-mail)
- Host selects grade and unit and proposes them to guest (e-mail)
- Conduct further e-mail conversations if necessary

Stage 2: Pre-lesson conference

- Host prepares a lesson plan and worksheets and proposes them to guest within a month of stage 1 (e-mail)
- Guest analyzes the lesson plan comparing with usual method used in guest school and prepares a list of questions and suggestions
- Hold an online/Internet conference before conducting the demonstration lesson(s) and discuss about current situation of students, nature/essence and value of teaching materials, important points of instruction and flow/development of lesson(s)
- Host finalizes the lesson plan and share it with guest (e-mail)

Stage 3: Recording and observing the demonstration lesson(s)

- Record the demonstration lesson(s) by several (at least two) video cameras. One camera (fixed) is for the whole flow and others are for close-up recording of description in notebooks and student activities
- University professors conduct a simultaneous interpretation/translation from Japanese to English (for lesson in Japan)
- Host uploads the movie(s) to a cloud storage and proposes a list of view point for lesson observation to guest
- Teachers of guest school watch and analyze the lesson(s) based on the list, prepare and share comments with host (e-mail)
- Conduct e-mail conversations if necessity

Stage 4: Post-lesson conference

- Teachers of host school read the comments, set points of discussion, and share with guest (by e-mail)
- Hold online/Internet meeting and discuss about the demonstration lesson(s)
- Host summarizes results and challenges in the demonstration lesson(s) and shares them with guest (e-mail)

Stage 5: Closing

- Review results and issues in the entire GLS process in each school, summarize points of improvement and share them (e-mail)
 - Host school finalize the modifications to the GLS program and share with guest (e-mail)
-

Next, one of four Helping Words sets (Figure 2) is distributed to each group. With these Words, students make two-step problems as a group activity.

To check whether created problems are solvable “two-step problems”, students actually solve them. They then hide the answer by folding worksheets, leave them for others to solve while switching tables to solve someone else’s problem. After this, exercises for similar problems as mastery and then reflection as consolidation were planned.

3.1.2 Discussion about lesson plan. After Guest reviews the lesson plan, an online discussion was conducted through via Google Hangouts as second pre-lesson conference.

Once Host explained their consideration in making lesson plan, discussion was conducted based on questions and suggestions from Guest, especially that two kinds of problems—“forward thinking” and “reverse (backward) thinking”—might be created from Helping Words. Teachers of both countries agreed that problems with forward thinking are easier to make for students than with reverse thinking. Next, Host came up with an idea to change the word of “7 cm” to “8 cm” in Set 2 considering it can be divided by 4 and Set 2 also have a word of “4 times.”

In the next part, Guest stated that some Japanese students often select a wrong mathematical equation depending on words used in the problem sentences without much thinking. Host shared their experience that some Singaporean students also have misconception of simply relating addition with “more” and subtraction with “less.” To improve students’ understanding about this, Guest suggested activities to share problems each group have made with the whole class and categorize them into forward and reverse

Stage	Date (approx.)	Appointment	Contents of GLS
Starting up	July 1st to August 1st	Host and guest	- Appoint host
	August 2nd	Host	- Schedule adjustment
	August 2nd	Host and guest	- Select and propose grade and unit for demonstration lesson
Pre-lesson conference	August 2nd	Host and guest	- Discuss about grade and unit selected
	August 3rd to September 2nd	Host	- Propose a lesson plan and worksheets
	September 3rd	Guest	- Check the lesson plan and worksheets
	September 3rd	Host and guest	- Discuss about the lesson plan and worksheet
Recording and observing the demonstration lesson	September 3rd	Host	- Finalize the lesson plan
	September 4th	Host	- Conduct the demonstration lesson and record
	September 4th	Guest	- Upload the recorded movie
	September 4th	Guest	- Watch the movie and analyze the lesson
Post-lesson conference	October 1st	Host and guest	- Discuss about the lesson conducted
	October 1st	Host	- Summarize the results and challenges
Closing	October 2nd	Host and guest	- Summarize improvement points
	October 2nd	Host	- Finalize modifications to the GLS program

Table 2.
The program timetable
for Pilot GLS

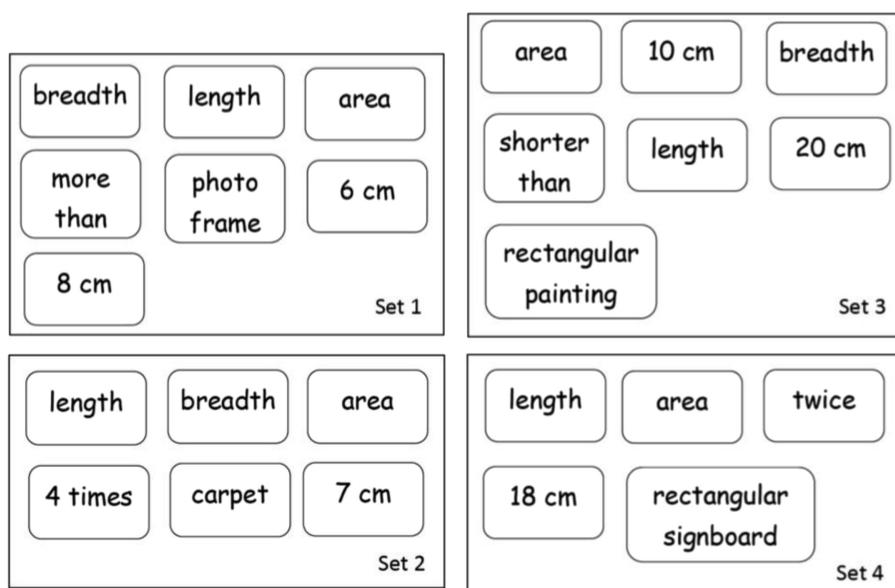


Figure 2.
Four sets of
Helping Words

thinking. However, Host replied that the learning to discriminate into forward and reverse thinking had already been instructed in domain of Numeracy at second grade, so this activity might not be necessary. Furthermore, there was a concern that it might be too difficult to make and solve two kinds of problem within a lesson time.

After exchanging thoughts, Host decided to revise its lesson plan so that Helping Words related with multiplication and division used in Set 2 and 4 will not be used. Instead, students will make two problems—forward and reverse thinking—with only Words related to addition and subtraction. Words related to multiplication and division will be used in the next lesson with similar activities.

As described above, based on the reality of students and the curriculum of their own country, Host understood the essence of Guest’s opinion and suggestion then came up with a new lesson plan.

3.2 Implementation, recording and observation of the lesson

At least two cameras are used for recording: fixed camera for recording with wide field of view chasing teacher’s movement and other(s) is for recording a close-up of activities and students’ notebook.

Host uploaded the video and pictures of the lesson, PDF data of students’ worksheets and reflections for sharing. Guest school observed them and summarized questions before the post-lesson conference.

3.3 Discussion in post-lesson conference

An online discussion with the same members as pre-lesson conference was conducted. At the beginning, Host explained that only a few groups created reverse thinking problems. Although students successfully solved those problems, they had difficulties creating questions with reverse thinking. To avoid repeating such situation, Host suggested introducing reverse thinking problem at the beginning of lesson to promote student’s understanding.

Guest proposed children to use small whiteboards for rearranging the Helping Words to create various problems (Figure 3). With this suggestion, Host came up with an idea to fix the first sentence as “the length of photo frame is 8 cm,” hoping students can manipulate the second sentence as “the breadth is 6 cm more than the length” (forward thinking) or “the length is 6 cm more than the breadth” (reverse thinking) for the Set 1 of Helping Words.

From this discussion, Host concluded that it is easy to make different problems through manipulation and decided to try it out in other classes.

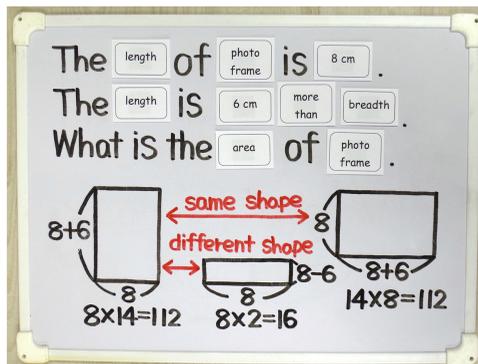


Figure 3.
Proposed way of using
Helping Words for
reverse thinking

Analyzing the uploaded data, Guest noticed that most groups did not draw figures in problem setting. Host also recognized that drawing figures is essential to help students conceptualize learnings about perimeters and areas. Therefore, Host agreed that if students had drawn figures, they could have noticed that the two statements “the breadth is 8 cm and the length is 6 cm more than the breadth” and “the length is 8 cm and the breadth is 6 cm more than the length” represented the same rectangle. By drawing figures, students can focus on making problems related to rectangles with different shape and size. This prospect is related to the suggestion from Guest as shown in [Figure 3](#).

A few weeks after post-lesson conference, Host reported through e-mail the result of practice in other classes with an improved lesson plan. According to the report, students successfully made different problems of forward and reverse thinking by using small whiteboards and Helping Words.

4. Discussion on pilot Global Lesson Study

Host presented a lesson theme with two-step problem with forward and reverse thinking using Helping Words. Discussion about making problems with forward and reverse thinking—usually not being conducted in Japan—is connected to “understanding contents and methods of education in different cultures flexibly” for teachers. Especially for Japanese teachers, we found “openness, respect and curiosity (Attitude #1)” and “awareness (Knowledge and Skills #1)” toward contents and methods of education among intercultural competence for lesson study strongly appeared.

For Japanese teachers, this imply that instead of simply solving questions with forward and reverse thinking, this activity makes possible the instruction to deepen understanding the difference between two values by thinking about the relationship between them. Therefore, conducting GLS with Singaporean teachers is expected to make their understanding of contents in mathematics education deeper.

On the other hand, making two kinds of problem based on forward and reverse thinking with Helping Words were not initially proposed by Host in pre-lesson conference. This can be concluded as a result of “External Outcomes” of discussion. During the discussion, Guest “flexibly understood contents and methods of education in different culture” about problem solving and problem making based on the theme of “two-step problems” and tried to “proactively and collaboratively develop new lessons that are integrated and expanded” with problems of forward and reverse thinking commonly seen in Japan. Analyzing the former part, Attitude #1 and #2 (Tolerance for ambiguity) as well as Knowledge and Skills #2 (Understanding) and #3 (Observation) of intercultural competence for lesson study are thought to be appeared. And for the latter part, “Internal Outcomes” appeared. Host, who accepts and reflects suggestions from Guest is, therefore, trying to “develop proactively and collaboratively new lessons that are integrated and expanded” for mathematics educations. Here, Knowledge and Skills #2 and #3 are in action.

These show that GLS could successfully promote development of teachers with intercultural competence for lesson study. The lesson plan presented in the pre-lesson conference was discussed six times within host school and was thought to be the best plan at that time. Yet, the Host found a new viewpoint through discussion with Guest. This discovery is, therefore, a result that could not be achieved only with internal discussions of one school. For teachers in Singapore, this means that GLS with Japanese teachers successfully lead to deeper understanding of contents and methods of mathematics education. The lesson plan corrected based on the pre-lesson conference, therefore, is an example of Outward Impact.

During post-lesson conference, Guest proposed an activity of actually manipulating Helping Words with small whiteboards that was unexpected for Host. This can be understood as a result of “External Outcomes” of Japanese teachers. Host then accepted this

suggestion and obtained the new idea of fixing the first sentence in a problem to improve lessons. This clearly shows that teachers in Singapore were trying to “flexibly understand contents and methods of education in different cultures” and “proactively and collaboratively develop new lessons that are integrated and expanded other cultures’ contents and methods of education into that of own country.”

These shows that “Attitude #1,” “Knowledge and Skills #2 and #3” and “Internal Outcomes” of “intercultural competence for lesson study” are in effect. And the modified lesson plan and actual lesson conducted after the post-lesson conference is an example of “Outward Impact.” This also provides some evidence that GLS can be used to promote development of teachers with “intercultural competence for lesson study”.

Furthermore, a comment that only a few groups drew figures of rectangles in problem making led to share recognition of the importance of drawing figures to help students solidify their learnings. Before the meeting with Japan, Host conducted five internal meetings to discuss about the lesson plan, where discussion focus on learning activity of making two kinds of two-step problems, but discussion about characteristics of those two problems was not conducted. However, when Japanese teachers pointed out that the value of this lesson is “these 2 problems can be one for forward thinking and the other for reverse thinking,” teachers of the Host shift their thinking from including all of addition, subtraction, multiplication and division to only use addition and subtraction. This results in making students focus on creating questions with forward and reverse thinking for sure. The use of multiplication and division are carried over to the next lesson. For teachers in Singapore, this means conducting GLS with Japanese teachers lead to break through a wall for deeper understanding about method of instruction in mathematics education.

From the analysis above, we found all components of intercultural competence for lesson study (i.e. Attitude, Knowledge and Skills, Internal Outcomes and External Outcome) are promoted and linked to the Outward Impact. We also found evidence that teachers participated in this Pilot GLS were able to “flexibly understand contents and methods of education in different cultures through communication with teachers in different cultures” and “proactively and collaboratively develop new lessons that are integrated and expanded other cultures’ contents and methods of education into that of own country” at each stage. Therefore, we are confident that GLS as an international and collaborative lesson study is useful for training teachers with “intercultural competence lesson study”.

In addition, it is considered that all teachers in Singapore and Japan can deeply understand about contents, teaching materials and methods of instruction in mathematics education and re-discover about students through GLS. Therefore, we wish to affirm that GLS will lead to improvement of teacher’s competency and skills about subject instruction as well.

5. Conclusion

5.1 *The effect of Global Lesson Study*

In this research, we developed a pilot program for GLS in mathematics education between teachers in Singapore and Japan and carried it out with a school in Singapore as a host. From the analysis of activities at each stage, we found three important results.

- (1) Components of intercultural competence for lesson study are promoted in each stage of the GLS, and all those together lead to the “Outward Impact.”
- (2) GLS is useful for training teachers with intercultural competence for lesson study.
- (3) GLS will lead to the improvement of teacher’s qualities and skills for subject instruction.

5.2 Future challenges

In a GLS between two countries, one cycle is a two-year span where each country is in charge of the host school for a year. In this paper, we introduced the case for a half cycle where Singapore became the host school for a year. The next challenge is, therefore, to verify the effect when Japan conducts this GLS as the host school.

Additionally, we only conducted qualitative analysis of the GLS by interpretation of practices in this paper. In the future, it is necessary to conduct some quantitative analysis about the effect of the GLS by using questionnaire items relate to not only teachers with intercultural competence for lesson study but also teacher's competency and skills about subject instruction. Also, it is necessary to verify whether the GLS can contribute to the remaining issues of lesson study in Singapore on creating learning community and on realization of research-based professional development.

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