

Changes in qualities and abilities of Japanese teachers through participation in Global Lesson Study on mathematics

Takeshi Sakai

Kyoto Women's University, Kyoto, Japan

Hideyuki Akai

Kyushu Lutheran College, Kumamoto, Japan

Hiroki Ishizaka and Kazuyuki Tamura

Naruto University of Education, Naruto, Japan

Yew-Jin Lee and Ban Heng Choy

*National Institute of Education, Nanyang Technological University,
Singapore, Singapore, and*

Hiroaki Ozawa

Naruto University of Education, Naruto, Japan

Abstract

Purpose – The authors aim to determine the effects of Global Lesson Study (GLS) – a two-year, one-cycle program defined as “international cooperative lesson study through international exchange among teachers using ICT” – on intercultural competence for lesson study based on pre- and post-survey conducted for Japanese teachers.

Design/methodology/approach – In accordance with the GLS program, mathematics lesson studies on mathematics between Japanese and Singaporean elementary school teachers were conducted over a two-year period. Questionnaire surveys on intercultural competence for lesson study was conducted using 7-point Likert scale and descriptive questions with Japanese teachers ($N = 5$). Analysis of Wilcoxon's signed rank test and correlation analysis were conducted.

Findings – Followings are identified as the effects of GLS for Japanese teachers: (1) Japanese participants felt improvement of their competence in areas of attitude, internal outcomes and outward impact. (2) Participating in a GLS led to the improvement of Japanese teachers' qualities and abilities for subject teaching related to mathematics education. (3) Improvement of intercultural competence for lesson study was related to each other, and GLS led to improvement of these competences. (4) It was meaningful to have a two-year period to assimilate and adjust to independent experience of the host and guest.

Originality/value – The GLS led to teacher empowerment among this sample, not only as cooperative research, but also at the individual level of teachers where participants continued to develop lessons based on the GLS learning after study completion. This has important implications for the implementation and dissemination of the GLS.

Keywords Lesson study, Mathematics education, Intercultural competence, Teacher perception improvement

Paper type Research paper



1. Introduction

1.1 Overview of this research

This study aims to determine how Japanese teachers' intercultural competencies for lesson study (defined in [section 1.3](#)) were changed through the Global Lesson Study (GLS) between

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Japan and Singapore. GLS is defined as “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” (Sakai *et al.*, 2021) and have been developed through a pilot GLS conducted between elementary school teachers in Singapore and Japan. Our study focuses on a full two-year cycle of the GLS introduced by Sakai *et al.* (2021) as one of international lesson studies among teachers of different cultures using ICT. One cycle of the GLS consists of two years where host and guest schools change roles between the first and second year (Sakai *et al.*, 2022a, b). This research will contribute to presenting a new modality for teacher education in a society where ICT is further developed and international collaboration is deepened.

1.2 Research purpose

The prevalent use of information and communication technology (ICT) has facilitated international exchanges among teachers and researchers of different cultures and regions, thereby seeding ideas of a global network for lesson study. For example, through an online cross-cultural lesson study conducted between primary mathematics teachers, there were improvements in the teachers’ mathematical knowledge for teaching (MKT) and technological pedagogical content knowledge (TPACK) (Huang *et al.*, 2021b; Sakai *et al.*, 2022a). However, intercultural collaborative lesson study without much use of ICT between German and Japanese teachers identified some difficulties such as “sharing data and culture,” “visualizing methodology and process” and “responding to research questions and answers” (Yoshida *et al.*, 2021).

Recently, a variety of online lesson study models have been found to positively impact teaching and learning (Huang *et al.*, 2021a). While the standard lesson study model assumes that teachers prepare and observe instruction in person, the use of digital tools, such as video conferencing and cloud services, can open up new ways of conducting lesson study and supporting teachers’ professional development (Hrastinski, 2021; Suh *et al.*, 2021). Furthermore, it has been suggested that incorporating digital tools into an online teacher education program based on lesson study can lead to the development of a collaborative community among teachers (Weaver *et al.*, 2021). Thus, in the context of the COVID-19 pandemic and adoption of safe-distancing measures in many regions, examining lesson study approaches with the use of ICT may have many significant benefits and lessons for implementation.

To promote international collaboration between educators such as during GLS, a strong intercultural competence is necessary. First raised by Byram and Zarate (1998), the term intercultural communicative competence was developed in the context of foreign language learning. This represented the ability to mediate between self and others from different cultures through foreign language learning, to turn an “outside” perspective on oneself, to rethink and, if necessary, remake one’s own behavior patterns and values. Byram (2008) further stated that when different values and modes of behavior come into contact with each other, it can be expected to be not only binary but also multidimensional in nature, which heightens the difficulties to communicate and learn from different others.

In contrast, Deardorff and Jones (2012), while accepting Byram’s assertion that language fluency is necessary to acquire intercultural competence, acknowledge that a high degree of fluency is not always necessary. Instead, Deardorff (2009) describes intercultural competence as more about intercultural competence in behaviors than in communication. In fact, Deardorff defines intercultural competence as the “ability to communicate effectively and appropriately in intercultural situations based on one’s intercultural knowledge, skills and attitudes” (Deardorff, 2006).

Therefore, the GLS program aims “to understand different interpretations of teaching materials and teaching methods through international exchange among teachers using ICT, and to create lessons of new value by integrating and developing them in education in each country” following Deardorff (Sakai *et al.*, 2021). We envision that teachers from different cultures will not only gain an understanding of different teaching materials and methods, but will also enhance their professional competencies through the GLS. Since the GLS emphasizes formation of effective and appropriate modes of behavior as posited by Deardorff (2006, 2009), we considered it appropriate to discuss the acquisition of intercultural competence based on his definition in this study.

1.3 Intercultural competence for lesson study

Sakai *et al.* (2021) redefined intercultural competence for lesson study by adding outward impact as intercultural creativity to the four elements of intercultural competence proposed by Deardorff (2006, 2009): attitude, knowledge and skills, internal outcomes and external outcomes. The followings elaborate the five elements of intercultural competence for lesson study based on Sakai *et al.* (2021):

Attitude

- (1) Openness, respect and curiosity towards contents and methods of education of other cultures
- (2) Tolerance for ambiguity about difference in contents and methods of education

Knowledge and skills

- (1) Awareness towards contents and methods of education of other cultures
- (2) Understanding of contents and methods of education in own and other cultures
- (3) Observation and ability to evaluate contents and methods of education of other cultures

Internal outcomes

- (1) Adaptability, flexibility, empathy, and ability to see things from another’s point of view towards proposals and suggestions from other cultures

External outcomes

- (1) Situation-appropriate behaviors and communication during lesson studies

Outward impact

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

In our previous studies (Sakai *et al.*, 2022a, b), progress of one year of GLS between Singaporean and Japanese teachers was analyzed qualitatively from the perspective of intercultural competence for lesson study. In the discussions between primary teachers from Singapore and Japan – two countries with different instructional content and methods – we observed that teachers exchanged and integrated instructional ideas based on their disciplinary understanding and use of representations specific to their context. In addition, we could characterize GLS as a Plan-Do-Check-Act (PDCA) cycle from our findings. It was also suggested that the program has a potential as action research through exchange of research and classroom practice and as a “GLS package” in context of international educational cooperation.

Sakai *et al.* (2022a) reported that such GLS has led to changes in how teachers plan lessons to get their students share ideas before integrating their ideas to bring forth the main teaching point. These new lesson plans would not be conceived with in-school research in Singapore only.

However, previous studies have been limited to the analysis based only on interpretation of what was observed. How individual teachers were transformed in this context was not fully analyzed. Furthermore, most Japanese teachers use only Japanese in daily life including teaching in school and tend to emphasize “being Japanese” in their teaching (Wier, 2010). In addition, it has been pointed out that there is insufficient consideration for different cultures when working with students of foreign nationality (Takahashi, 2020). These remarks suggest that Japanese teachers have less experience in cross-cultural education than their Singaporean counterparts, who work with students from diverse cultural backgrounds. Given that participating in GLS is relatively novel for Japanese teachers, this paper focuses on their experiences and attempts to identify their transformations in this process.

Our findings will be useful not only for modifying the GLS program and providing important support for disseminating the GLS, but also for gaining insights into how teachers perceive about a novel experience. Thus, the followings are our two research questions:

- RQ1. What changes in intercultural competence for lesson study were perceived by Japanese GLS participants?
- RQ2. What are the characteristics of the process of achieving change in intercultural competence for lesson study through GLS?

2. GLS and intercultural competence for lesson study

2.1 Program of the GLS

A program for a single year of GLS consists of five stages: (1) starting up, (2) pre-lesson conference, (3) recording and observing the demonstration lesson, (4) post-lesson conference and (5) closing (Refer to Sakai *et al.* (2021) for details). A two-year cycle of GLS was implemented by repeating this twice, swapping the host. Brief descriptions of the contents and methods at each stage are shown below:

- (1) *Starting up*: Selecting and proposing grades and units for GLS implementation (Host)
- (2) *Pre-lesson conference*: Review and propose of lesson plan(s) (Host) → Compiling a comment sheet (Guest) → Online meeting (Host and Guest) → Revision of lesson plan(s) (Host)
- (3) *Recording and observing of the demonstration lesson(s)*: Conducting and recording of demonstration lesson(s) (Host) → Uploading movies and pictures of student notebooks (Host) → Watching videos and analyzing lesson(s) (Guest) → Compiling a comment sheet (Guest)
- (4) *Post-lesson conference*: Online meeting (Host and Guest) → Summarizing results and issues (Host and Guest)
- (5) *Closing*: Summarizing revisions (Host and Guest) → Improving the program (Host and Guest)

In Sakai *et al.* (2021), we indicated that lesson study is positioned 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. Therefore, this study does not focus on the differences between the lesson studies of each country or how the lesson studies of other countries can be transferred to one’s own country, but rather on the process of creating new lessons in this “Collaborative Space” as the common platform of the GLS.

Lesson study has been introduced in many countries beyond Japan and each country has followed its own history of development, and issues have been pointed out (Moriya *et al.*, 2016; Nakamura *et al.*, 2018; Schwarts and Karsenty, 2020). Even in Singapore, as pointed out by Lim-Ratnam *et al.* (2019), it is not easy to ensure (1) existence of learning community of practice among teachers and (2) teachers' professional development through lesson studies. However, Singaporean host school and Japanese guest school that participated in this study have been smoothly conducting lesson studies within their schools and have already formed a relationship to fulfill both conditions (Sakai *et al.*, 2021).

2.2 Pre- and post-survey on intercultural competence for lesson study

In order to clarify which elements of intercultural competence for lesson study were improved through two-year GLS, seven survey items based on Deardorff (2006, 2009) with a 7-point Likert scale were adopted in a pre- and post-survey. Six items corresponded to each of the five elements mentioned above and developed to capture subtle differences in participants' perceptions. For knowledge and skills, two items were set up to distinguish between those related to instructional content and instructional methods. The final item (7) was related to overall evaluation of intercultural competence for lesson study.

<Survey Items>

- (1) *External outcomes*: Ability to communicate with teachers from other countries who have different languages, cultures and values.
- (2) *Attitude*: Concern about working with teachers from other countries who have different languages, cultures and values.
- (3) *Internal outcomes*: Ability to work with teachers from other countries with different languages, cultures and values while respecting each other's ideas.
- (4) *Knowledge and skills (Instruction contents: IC)*: Ability to understand what is learned in education in other countries with different languages, cultures and values.
- (5) *Knowledge and skills (Instruction methods: IM)*: Ability to understand teaching methods used in education in other countries with different languages, cultures and values.
- (6) *Outward impact*: Ability to create lessons that make use of good points of education in other countries with different languages, cultures and values, as well as education in your own country.
- (7) *Overall evaluation*: Having qualifications and abilities of teachers as personnel with intercultural competence for lesson study from judgment of the overall results.

As a general tendency, Japanese teachers are reluctant to communicate in English and have little experience in interacting and collaborating with non-Japanese speaking teachers. Therefore, these items were considered suitable subjects to verify the effects of GLS. For items (1) and (3) through (6), a seven-point scale – 1: completely unable, 2: unable, 3: somewhat unable, 4: undecided, 5: somewhat able, 6: able, and 7: fully able – is used. For items (2) and (7), a seven-point scale – 1: strongly disagree, 2: disagree, 3: somewhat disagree, 4: undecided, 5: somewhat agree, 6: agree, and 7: strongly agree – is used. Taking into account that this survey is conducted in Japan, these seven-point scales were created using Japanese terms.

For analysis of pre- and post-survey, the answered scale in items (1) to (7), other than item (2), are regarded as scores of each element of intercultural competence for lesson study. Since the item (2) is asking about teacher's concern level on international collaboration, selecting "1:

strongly disagree” actually means he/she is strongly willing to work together on GLS. Therefore, linear transformation is applied to make the selected scale matches to the score of other items.

For items (1) through (6), we also conducted a descriptive survey on reasons for the choices in 7-point scale.

Pre-survey was conducted at the beginning of GLS in the first year, and post-survey was conducted at the end of second year. These surveys were conducted with five Japanese teachers who participated. Teacher A is a male in his 40s with 19 years of teaching experience; Teacher B is a male in his 50s with 31 years of experience; Teacher C is a male in his 50s with 37 years of experience; Teacher D is a female in her 20s with 6 years of experience; Teacher E is a male in his 30s with 9 years of experience.

All participating Japanese teachers belong to the same elementary school attached to the private university. Unlike other public elementary school teachers, they will not be transferred to other schools. Only teacher A had experience working at an elementary school attached to a national university prior to working at current school. As for the grade levels teachers are in charge, they are randomly assigned different grade level every year as in other schools in Japan. In addition, a characteristic of Japanese elementary school teachers is that they do not teach only certain subjects, but in principle teach all subjects. Only teacher A has not assigned any class as a homeroom teacher, but instead has been performing school administrative duties and collaborating with an assistant language teacher (ALT) as a specialized foreign language teacher. Also, teacher B, while he teaches all subjects as a homeroom teacher, specifically selects the field of mathematics as his research field.

3. Actual practice of two-year cycle GLS

In accordance with the GLS program, first year GLS was conducted from June to September 2019 with school A in Singapore as the Host, and second year GLS was conducted from July to October 2020 with school B in Japan as the Host. For the details of GLS activities in each year, refer to papers by Sakai *et al.* (2022a, b). In this section, we briefly review the highlights of learning mathematics from two-year cycle of GLS.

3.1 Overview of 1st year GLS

At starting-up, a lesson for 5th grade on word problems on rate (flow of water) using problem 3 and problem 4 in Figure 1 was planned, and in pre-lesson conference, school A (Host) presented four expected solutions for problem 3 as shown in Figure 1.

School B (Guest) suggested a proposal based on the idea of “integration of key concepts”. Based on the content of discussion, an activity was added to consider the commonalities among the three expected solutions (solution 1 is based on wrong concept) and to think integratively as shown in the bottom table section of Figure 1 labeled “From Guest school”. Thus, the Singapore lesson plan, which was carefully constructed to anticipate children’s solving methods, was further improved by adding integrated activities based on the suggestions from Japanese teachers.

In the demonstration lesson, where slides were presented with ICT, students were able to accurately grasp the method for solving problem by relating the solution in problem 3 and problem 4. They were also able to improve their strategies through this. Class observation and class analysis were conducted by recording and sharing through a cloud service.

In post-lesson conference, the efficiency and effectiveness of Singapore’s typical approach was shared. On the other hand, necessity of providing support is confirmed for children who had wrong ideas such as solution 1 in Figure 1 and to understand the process of transformation from wrong to right ideas through teaching.

Finally, as a closing, participants reviewed the first year of GLS and shared following achievements and challenges.

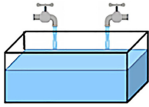
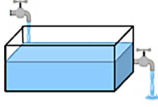
From Host school																																													
Problem	<p>Problem 3 Tap A alone can fill a tank to its brim in 8 minutes. Tap B alone can fill the same tank to its brim in 12 minutes. If both taps are turned on at the same time, how long will it take to fill the tank to its brim?</p> 	<p>Problem 4 An inlet tap can fill a tank in 5 minutes. An outlet tap can drain the tank in 7 minutes. Both taps are fully turned on at the same time. How long will it take to fill the tank completely.</p> 																																											
Solution	<p><u>Solution 1</u> 8 min + 12 min = 20 min (wrong concept)</p> <p><u>Solution 2</u> 24 min (from Tap A and Tap B) 3 + 2 = 5 tanks 5 tanks 24 min 1 tank $\frac{24}{5} \times 1 = \frac{24}{5} = 4\frac{4}{5}$ min</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="2">Tap A</th> <th colspan="2">Tap B</th> </tr> </thead> <tbody> <tr> <td>8 min</td> <td>1 tank</td> <td>12 min</td> <td>1 tank</td> </tr> <tr> <td>16 min</td> <td>2 tanks</td> <td>24 min</td> <td>2 tanks</td> </tr> <tr> <td>24 min</td> <td>3 tanks</td> <td></td> <td></td> </tr> </tbody> </table> <p><u>Solution 4</u> 1 min $\frac{1}{8} + \frac{1}{12} = \frac{3}{24} + \frac{2}{24} = \frac{5}{24}$ 5 units 1 min 24 units $\frac{1}{5} \times 24 = \frac{24}{5} = 4\frac{4}{5}$ min</p>	Tap A		Tap B		8 min	1 tank	12 min	1 tank	16 min	2 tanks	24 min	2 tanks	24 min	3 tanks			<p><u>Solution 3</u> 1 min 3 units + 2 units = 5 units 1 tank = 24 units $24 \div 5 = \frac{24}{5} = 4\frac{4}{5}$ min</p> <table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Tap A</th> <th>Tap B</th> </tr> </thead> <tbody> <tr><td>3u</td><td>2u</td></tr> <tr><td>2u</td><td>2u</td></tr> <tr><td>3u</td><td>2u</td></tr> <tr><td>2u</td><td>2u</td></tr> <tr><td>3u</td><td>2u</td></tr> <tr><td>2u</td><td>2u</td></tr> <tr><td>3u</td><td>2u</td></tr> <tr><td>2u</td><td>2u</td></tr> <tr><td>3u</td><td>2u</td></tr> <tr><td>2u</td><td>2u</td></tr> <tr><td>3u</td><td>2u</td></tr> <tr><td>2u</td><td>2u</td></tr> </tbody> </table>	Tap A	Tap B	3u	2u	2u	2u	3u	2u	2u	2u	3u	2u	2u	2u	3u	2u	2u	2u	3u	2u	2u	2u	3u	2u	2u	2u	
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Tap B	2 tanks/24min	2 units/1min	1/12 of tank/1min																																										
Tap A and Tap B	5 tanks/24min	5 units/1min	5/24 of tank/1min																																										
Time	$1 \div 5 = 1/5$ 1/5 of 24 min	$24 \div 5 = 24/5$	$1 \div 5/24 = 24/5$																																										

Figure 1. Suggestions from the host and guest schools

- (1) Worksheets which we received were about “Consolidation of different strategies” and these were not worksheets which were written in the class we observed. We needed worksheets of “Group Work” too, because we want to know how students’ way of thinking changed or were improved.
- (2) The recorded video focused more on entire classroom and did not record the front of the classroom. Therefore, we could not read and understand what was projected on the screen and how students learned during group activities.

3.2 Overview of 2nd year GLS

At starting-up, a lesson plan of “What is the original number? Going back one by one” and the sample of board writing is shown in Figure 2, where lesson development was laid out, was presented from school B to school A. In Japan, the content of an hour’s lesson is summarized

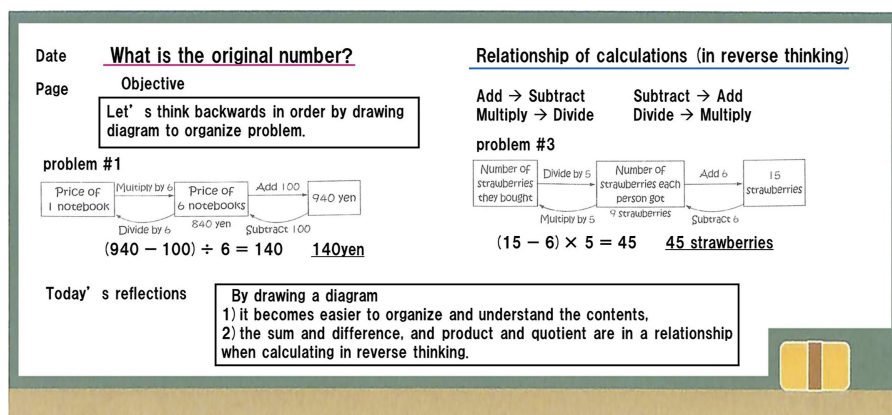


Figure 2.
 Sample of board writing planed before lesson

structurally on a single blackboard without erasing from the beginning to end of a lesson, which is called a “board plan”, so that the students can see the development of an hour-long lesson from left to right.

Discussions at pre-lesson conference focused on the following topics: problem-solving outlook, use of diagrams and solution methods, lesson development and problem structure, previously learned content, reverse thinking and working backward. During the discussion, we found that there were significant differences in the conventional teaching practices in each country, especially with regard to the diagrams utilized in the classroom. In Japan, instruction using relational diagrams – showing numerical relationship between different situation in Figure 2 – is the mainstream, and school B presented a method of instruction using relational diagrams this time. In response, school A made a proposal for the teaching method with the bar model, which is the mainstream teaching method in Singapore. Following this suggestion, the teaching method was changed to one in which children approach problem solving using a variety of diagrams, including the bar model and relational diagrams.

In order to record the demonstration lesson, a fixed camera was used to film the entire lesson from the rear of the classroom, and an iPad was used to film close-up of diagrams students draw to solve the problem. Lesson observation and analysis was conducted by sharing video and photocopies of students’ notes. In post-lesson conference, data of classification of children’s thoughts was provided as a resource to examine the change in children’s thoughts, and discussion focused on the use of diagrams and interactive activities. Finally, as a closing, second year GLS and entire two-year GLS cycle were reviewed and achievements and issues were shared.

4. Analysis and discussion of survey results

4.1 Analysis and discussion of survey results with the Likert scale

Based on the results of pre- and post-survey, answers from five teachers for items (1) to (7) were regarded as the scores of each item as described above and shown in Table 1. From these scores, mean value is calculated for each item. In addition, Wilcoxon’s signed rank test, as shown by z -value and p -value in Table 1, is used as a nonparametric test of correspondence between pre- and post-survey for the scores of each item. Correlation analysis between each item in post-survey is also conducted. Correlation coefficients between items are also calculated.

Before looking at individual items from (1) to (6), we first checked item (7). As shown in Table 1, there is a significant difference at the 10% level for item (7). Therefore, it can be

Item	Timing	Teacher					Mean	z-value	p-value	Correlation coefficients	
		A	B	C	D	E				(1)	(2)
(1)	Pre	5	2	5	3	3	3.60	-1.289	0.197	(1)	
	Post	5	4	6	2	6	4.60			(2)	0.49
(2)	Pre	4	3	4	3	4	3.60	-1.890	0.059	(3)	0.44
	Post	4	5	6	5	7	5.40			(4)	0.44
(3)	Pre	5	6	5	5	6	5.40	-1.732	0.083	(5)	0.28
	Post	5	7	6	5	7	6.00			(6)	0.36
(4)	Pre	5	3	3	5	4	4.00	-1.633	0.102	(1)	
	Post	5	7	6	5	7	6.00			(2)	
(5)	Pre	5	4	5	5	6	5.00	-1.342	0.180	(3)	0.65
	Post	5	7	6	5	6	5.80			(4)	0.65
(6)	Pre	5	5	4	4	6	4.80	-2.000	0.046	(5)	0.36
	Post	5	6	5	5	7	5.60			(6)	0.68
(7)	Pre	5	2	5	3	4	3.80	-1.890	0.059	(1)	
	Post	5	4	6	5	6	5.20			(2)	

Table 1.
Means, z-values,
asymptotic
significance
probabilities, and
correlation coefficients
for pre- and post-
surveys

considered that participants felt their intercultural competence for lesson study, as a whole, had improved more at the time of post-survey.

Since there is a significant change in the overall evaluation, we then analyzed in more detail what elements of intercultural competence for lesson study were perceived to have improved. Table 1 shows that there is a significant difference at the 10% significance level for items (2) and (3), and a significant difference at the 5% significance level for item (6). Therefore, it can be considered that participants feel improvement of their competence in three areas of attitude (item (2)), internal outcomes (item (3)) and outward impact (item (6)) through two-year GLS.

Next, we will look at correlations between different items. For external outcomes, item (1), it can be understood that there are moderate correlations between item (3: internal outcomes) and item (4: instruction contents of knowledge and skills). Therefore, the more they feel that

they can communicate with teachers from other countries, the more they feel that they can work on tasks with teachers from other countries while respecting each other's ideas, and the more they feel that they can understand the learning content in education in other countries.

About attitude, item (2), there are moderate to strong correlations between items (1: external outcomes), (3: internal outcomes), (4: instruction contents of knowledge and skills) and (6: outward impact). Higher value in item (2) means less anxious teachers were about communicating and working together with teachers from other countries using English. In addition, lower anxiety level means that they are more confident to work with teachers from other countries while respecting each other's ideas, understand the content of learning in other countries' education, and create lessons that make use of the good points of education in other countries and their own.

Furthermore, internal outcomes, item (3), has very strong correlation with knowledge and skills of items (4: instruction contents) and (5: instruction methods) and outward impact of item (6). Table 1 also shows that both instruction contents and methods of knowledge and skill, items (4) and (5), also have very strong correlation. therefore, in terms of knowledge and skills, there is a tendency for teachers to feel the same way about their ability to understand the content of learning and teaching methods in other countries, and it is thought that the more they feel they can work with teachers from other countries while respecting each other's ideas, the more they feel they can understand the content of learning and teaching methods in other countries.

Finally, for outward impact, item (6), while it has a moderate correlation with item (5: instruction methods of knowledge and skills), it has very strong correlations with item (3: internal outcomes) and item (4: instruction contents of knowledge and skills). Therefore, the more they feel that they can work on tasks with teachers from other countries while respecting each other's ideas, and the more they feel that they can understand the learning contents and teaching methods of education in other countries, the more they feel that they can create lessons that make use of the good points of education in other countries and education in their own country.

4.2 Discussion based on written responses

For items (2), (3) and (6), which showed significant differences in pre- and post-survey, we examined the descriptive responses.

With regard to *Attitudes* in item (2), Japanese teachers were anxious about communicating in English, but the fact that lesson plans were revised based on the content of pre-lesson conference gave them confidence that they were able to work together with teachers from other countries. In addition, GLS system itself was improved by changing method of recording demonstration lessons and information shared for class analysis, and this also gave participants confidence that they had been able to tackle tasks together. Thus, it is thought that the increase in self-efficacy that one's own comments can have an impact on the situation gave them confidence and reduced their anxiety. The descriptive answers to item (2) included:

I have learned how to communicate with teachers through repeated visits. (Teacher B)

I don't feel uneasy because I have received various opinions about my classes. (Teacher C)

Even though our languages, cultures, and values are different, I realized that our educational goals are connected. (Teacher E)

From these descriptions, it can be concluded that through two years of GLS, teachers have been able to build a desirable relationship of teaching and being taught through their experiences as the host and guest. It is also evident that although language, culture, and values may be different, there is a sense of empathy that educational goals are the same. This fostering of relationships and empathy is thought to be essential in relieving anxiety about being different.

With regard to *Internal Outcomes* in item (3), not only the revision of lesson plans in pre-lesson conferences and the improvement of GLS system in closing session, but also the discussion based on a common point of view in post-lesson conferences based on data analysis in addition to information from lesson observations, are thought to have led to creation of an environment that facilitated working on tasks together with teachers from other countries. The descriptive answers to item (3) included:

Because we were able to share the same goals despite our differences in language, culture, and values. (Teacher E)

Because we were able to listen to Singapore teacher's comments about our own teaching with interest by answering their questions. (Teacher D)

I was able to understand Singaporean teachers' emphasis on the Bar Model. (Teacher C)

From these descriptions, it can be inferred that teachers were able, to some extent, to work with teachers from other countries with different languages, cultures, and values while respecting each other's ideas. This may be due to the fact that they were able to learn ideas from Singaporean teachers that were not available in Japan, and they were able to accept Singaporean teachers as beings with whom they could engage in friendly competition, which influenced their willingness to respect ideas of teachers from other countries. This attitude of the participants led to changes in teaching methods that could not be found through discussions by Japanese teachers alone, to teaching methods using the bar model that accepted suggestions from Singapore through the pre-lesson conference, and improved the quality of classroom practice. This openness to different teaching ideas from other countries will give teachers new perspectives on how to improve their teaching.

With regard to *Outward Impact* in item (6), it is thought that in the process of GLS, based on the content of pre-lesson conference, lesson plans were revised to incorporate the educational methods and ideas of other countries. This led to realization that teachers were able to create a lesson that made use of the good points of education of other countries with different languages, cultures, and values and education of their own country. The descriptive answers to item (6) included:

Because I learned more about Japanese educational methods by broadening my perspective. (Teacher B)

Because I was able to immediately apply the "method (procedure) for generating active discussion" taught in GLS to my practice. (Teacher E)

Because I have already started to work on group activities by referring to them. (Teacher D)

From these descriptions, it can be seen that teachers are using learning through GLS in their regular math classes to create better lessons.

Next, for items (1), (4) and (5), there were no significant differences between pre- and post-survey, but the mean values became higher, suggesting that there was some improvement.

The descriptive answers to item (1) about *External Outcomes* included:

I have learned that I can communicate in English even if I speak only a few words. (Teacher B)

I am able to understand math terms now. (Teacher C)

I have gained a sense of being able to communicate with teachers from other countries. I would like to continue to actively exchange and improve my skills. (Teacher E)

From these descriptions, we can see that teachers are gradually becoming more and more active in communicating in English through experience.

The descriptive answers to item (4) about *Knowledge and Skills (IC)* included:

Because I was able to learn the Bar Model, which is a mainstream teaching method in Singapore. (Teacher B)

Because I could broaden my view through this exchange that there are various ways of thinking. (Teacher D)

Even though there were some uncommon words in Japan such as the Bar Model, I was able to understand clearly by learning about its concepts and meanings. (Teacher E)

These statements indicate that teachers have some understanding of what they learn in education of other countries.

The descriptive answers to item (5) about *Knowledge and Skills (IM)* included

I understand the part about thinking using the Bar Model, and I am now able to predict how I would solve the problem in Singapore. (Teacher D)

I have learned to accept that there are various ways of teaching. I also learned that I can increase the number of options and make use of them in my own teaching. (Teacher E)

I learned the importance of respecting diverse ideas. (Teacher E)

The descriptions of teacher D in items 3 and 4 and of teachers D and E in item 5 show a positive view of change and learning. However, teachers D and E responded with high values in the pre-survey stage. Items 4 and 5 are items related to contents and methods, and are clearly items that teacher B, whose research field is mathematics, would be expected to rate higher, as evidenced by the fact that teachers D and E rated themselves higher than teacher B in the pre-survey. Therefore, it is considered that no change was observed as a numerical value.

These descriptions indicate that teachers were able to understand the teaching methods in education in other countries to some extent. This is thought to be related to the fact that pre- and post-conference of demonstration lessons were conducted in the form of an online conference, which made it possible to present explanations using whiteboard and images using iPad in real time, and to understand underlying ideas and teaching methods emphasized by teachers from other countries based on specific explanations.

Teacher A showed no pre- or post-numerical changes in all items. In this regard, teacher A stated in the questionnaire, "I have seen school education in the US, UK, Singapore and other countries, and I have obtained information from the Internet and books." This indicates that teacher A has been exposed to education in other countries. Also, as mentioned earlier, teacher A has much experience communicating with foreign teachers. Therefore, the GLS with Singapore was considered as one of those experiences, and it might be judged that collaborating in GLS is similar to these experiences. As a result, it is assumed that no change was observed.

4.3 General discussion

Although path analysis could not be conducted due to the small number of participants in this study, results of correlation analysis suggest that improvement of each competence in intercultural competence for lesson study is related to each other. From comparison of pre- and post-mean values, regardless of the time of survey, mean value of competence on communication with teachers from other countries tends to be lower than mean value of other competences, suggesting that the hurdle of the GLS with English as a common language is high for Japanese teachers whose native language is not English. However, as can be seen from responses to the descriptive questionnaire, understanding intentions of teachers from other countries and being able to convey one's own thoughts to them reduced anxiety about working with teachers from other countries. As a result, Japanese teachers became able to work with teachers from other countries while respecting each other's ideas and understanding the content of learning in education in other countries. Moreover, with

improvements in automated captioning commonly used in applications such as Zoom and Microsoft Teams, the language barrier can be lowered further, possibly leading to improvements in intercultural competence for lesson study through GLS.

Instead of focusing on language differences, we speculate that the opportunities for teachers to understand content and teaching methods in relation to the respective countries' curricula are key to improving intercultural competence for lesson study. As can be seen from the outline of GLS, lesson plans for demonstration classes and classroom practices based on them have been improved in its process for the better, and GLS system itself has also been improved.

These are limited to the results obtained during the period of activities of GLS. However, as can be seen from the responses to the questionnaire, teachers used their learning through GLS in their regular mathematics lessons to create better classes, and it was a new discovery that outward impact continued to develop not only as a cooperative research project but also at the individual level of teachers as they created new lessons using their learning from GLS. In this way, GLS has led to the empowerment of teachers. In addition, GLS in mathematics education is thought to lead to improvement of the qualifications and abilities of subject teaching related to mathematics education, because GLS in mathematics education deepens the understanding of contents and teaching methods of mathematics by learning about the learning contents and teaching methods in mathematics education in other countries, and contributes to the improvement of mathematics lessons based on this knowledge.

In the course of two-year GLS, improvement of each competence in intercultural competence for lesson study is considered to be related to the improvement of outward impact at least for Japanese teachers. In addition, use of learning through GLS in regular mathematics lessons is thought to have an impact on the perceived improvement in outward impact. Therefore, in the GLS program of conducting joint demonstration lesson once a year, two-year period for assimilating and coordinating independent experience of rotating between the host and guest schools and learning through GLS is meaningful.

5. Conclusion

In this study, we analyzed the effects of a full two-year cycle of GLS in mathematics education conducted between teachers in Singapore and Japan, rotating their host and guest roles in the second year, on Japanese teachers. From our analysis and discussion of pre- and post-surveys on intercultural competence for lesson study, we found following four points as the effects of GLS. Items (1) and (2) are answers to RQ1, and items (3) and (4) are answers to RQ2 about Japanese teacher perceptions of not having enough cross-cultural interaction with teachers from other countries.

- (1) Japanese participants felt improvement of their competence in three areas of attitude, internal outcomes and outward impact through the two-year GLS
- (2) GLS in mathematics education contributed to a deeper understanding of the subject content and subject teaching methods of mathematics and, based on this understanding, to improvement of mathematics classes, which led to improvement of Japanese teachers' qualities and abilities of subject teaching related to mathematics education.
- (3) At least for Japanese teachers, improvement of each competence of intercultural competence for lesson study was related to each other, and GLS led to improvement of intercultural competence for lesson study.
- (4) It was meaningful for Japanese teachers to have a two-year period to assimilate and adjust to independent experience of rotating between the host and guest schools and learning through GLS.

These changes were observed in many participants, but not enough changes in perception were observed in teachers who had relatively more experience with education in other countries. In other words, the degree of participants' engagement with education in different cultures may influence the degree of transformation brought about by such experiences.

In the future, it is necessary to accumulate survey data through implementation of GLS and to clarify connections among competences of intercultural competence for lesson study.

This study also demonstrated the improvement of teacher perception among Japanese teachers. However, it was suggested that differences in the experience of cross-cultural interactions may influence the differences in transformation brought about by the GLS. In light of this, it is important to identify changes in the perception of Singaporean teachers, who are considered to have more experience in cross-cultural interactions than Japanese teachers, as a future issue in order to clarify the various values of the GLS in its various target audiences.

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Corresponding author

Takeshi Sakai can be contacted at: sakaita@kyoto-wu.ac.jp