Lesson study and open approach development in Thailand: a longitudinal study

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Abstract

Purpose – This research explores the "transformation" ideas of Japanese Lesson Study (LS) and Open Approach (OA) to create and sustain a Thailand LS incorporated OA (TLSOA) model to successfully adapt to the local contexts. Although LS is spreading globally, previous studies have identified several challenges to its implementation.

Design/methodology/approach – The researcher employed a longitudinal research design that involved repeated investigations of a group of participants: from their fourth year as bachelor's degree students until they became eligible coordinators to practice the TLSOA model for teachers' professional development (PD). Data were collected using reflective journals, two types of survey questionnaires, and records of periodical reflective meetings over three cohorts.

Findings – As results reveal, the participating teachers' active engagement in the TLSOA model has made a positive impact on their teaching practices, collegiality, and professional self-identification. Students perceived themselves as having enormous changes in their learning behaviors. Those changes are linked to establishing a positive, student-centered, and active learning-based school culture with teachers' beliefs for innovations.

Research limitations/implications – Further studies should focus on the possible conflicts emerging between the different cultures of teaching.

Practical implications – The idea of the TLSOA model is to ensure teachers are well trained to possess sufficient skills.

Originality/value – The findings could be of value for the leaders, educators, policymakers to advocate the TLSOA model as a systematic approach to whole-school improvement and as a channel for spreading effects at the national, the APEC, and the CLMV regional levels.

Keywords Longitudinal study, Lesson study, Teacher professional development, Open approach, Transformational process

Paper type Research paper

Introduction

Research and experience reveal that innovative teaching approaches promoted by researchers differ significantly from the day-to-day practices of teachers in many countries (Burkhardt,

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2018). Since teaching contexts differ significantly, both within and between regions and countries, it is important to understand how innovative teaching approaches can be adapted to the local conditions while preserving their underlying core principles (Maass *et al.*, 2019). Maass *et al.* emphasize that a teaching innovation is an improvement if there is broadly defined evidence. This evidence can support students' progress towards the identified goals more effectively than the typical forms of instruction. According to Elmore (2000), implementing innovations can be a challenging endeavor, and it is even more demanding across a whole school. It becomes exponentially more challenging when scaling up an innovation aimed to reach many schools, a district, or even a state or nation (Krainer, 2015).

LS is currently an essential method of teachers' PD and empirical studies through actual practice for continuous improvement of classroom teaching (Shimizu and Chino, 2015). The original approach to LS is based on teachers working in small group, collaborating with one another, having met to discuss learning goals; the aim is to plan a lesson, to observe how their ideas work in a live lesson with students, and to report on the results so that other teachers can benefit (Takahashi, 2006). Japanese teachers utilize it as the core process of professional learning to continually improve the quality of the educational experiences. It has attracted international attention as it appears to be a more successful means of PD (Doig and Groves, 2011). This is because the previous PD sessions were designed to deepen content knowledge and support teachers' content needs during execution; they failed to explore the very content they were designed to teach, due teachers' more pressing demands for, for instance, materials management and pedagogy (Banilower *et al.*, 2006). Consequently, LS is a popular PD approach, systematically deepening content knowledge, increasing understanding of pedagogy, and developing teachers' ability to observe and understand student learning (Burroughs and Luebeck, 2010).

The OA was introduced by Nohda (2000): teachers assign their students with open problems where the solution is not precisely given. Therefore, students need to solve an open problem using numerous methods to explore the problem mathematically, thus posing various innovative solutions (Sambová and Tichá, 2016). The emphasis of OA is to encourage student learning in response to their own mathematical power, accompanied with a certain degree of self-determination over their learning; it can elaborate the quality of their process and products toward mathematics (Nohda, 2000). Furthermore, teachers try to understand students' ideas, to sophisticate the ideas in mathematical activities by employing students' discussion with other peers, as well as teachers' advice to encourage autonomy students' in elaborating the activity mathematically (Nohda, 2000). This can be done by combining students' knowledge, skills, or ways of thinking that have previously been learned (Becker and Shimada, 1997).

Introducing TLSOA model

The researcher prepared the necessary surrounding contexts including teacher education programs, graduate studies, workshops for in-service teachers, and a long-term teacher PD program. In doing so, they aimed to confirm their belief that the application of LS in the Thailand context is possible and can be sustained (Inprasitha, 2004). Past researchers (Baricaua Gutierez, 2016; Chichibu and Kihara, 2013; Lieberman, 2009) revealed that LS is a valuable model to support the development of teacher communities; it provides a context for school-based collaboration and is rooted in both teacher and student learning (Lewanowski-Breen *et al.*, 2021). Therefore, teacher professional communities have been recognized as vital structures for fostering teacher learning and capacity building in schools in recent years (Vescio *et al.*, 2008). Subsequently, Inprasitha (2015a) defines a teacher professional community as a cohesive group of teachers who perform collaboratively to improve teaching practices and students' learning, consistent with Vescio *et al.*'s definition.

Several LS models have been introduced by past researchers: Stigler and Hiebert (1999) set out their eight steps as follows: (1) defining and researching a problem; (2) planning the lesson; (3) teaching and observing the revised lesson; (4) evaluating the lesson and reflecting on its effect; (5) revising the lesson; (6) teaching and observing the revised lesson; (7) evaluating and reflecting a second time and (viii) sharing the results. Fernandez and Yoshida (2004) set out their five steps as follows: (1) collaboratively planning the lesson; (2) seeing the lesson in action; (3) discussing the lesson; (4) revising the lesson (optional), and (5) sharing reflections about the new version of the lesson. Lewis's (2002) four steps feature: (1) goal setting and planning; (2) teaching the lesson; (3) the post-lesson discussion, and (4) the resulting consolidation of learning.

Unlike the Japanese LS model, the researcher incorporates OA that emphasizes a "unique collaboration" in every step of the LS cycle; this is because traditional Thai classroom culture denies students opportunities to explore various forms of mathematical free thinking. Therefore, teachers must change their teaching approach from emphasizing the rote learning of mathematics content, formulas or theories to an innovative method that encourages students to express their mathematical thinking (Inprasitha and Loipha, 2007). The above literature review illustrates the need for a maturing LS effort; thus, the researcher of the present study concluded that the transforming process needed to go through similar stages and to persist in their learning to adapt LS to local Thai contexts. After the researcher studied the above LS models, he proposed an LS process consisting of three steps; collaboratively design lesson (Plan), collaboratively observe lesson (Do), and collaboratively reflect on teaching practice (See) to change the paradigm of teaching practices using the Japanese LS model as a reference (Inprasitha, 2004). Moreover, he incorporated OA in the Do step and the weekly Plan-Do-Check-Act (PDCA) procedure in the See step. The rationale of incorporating OA in the LS process was to generate students' independent learning and transform teachers' traditional teaching approach, while the weekly PDCA procedure used the "Kaizen" concept as a cycle of instructional "improvement" in which teachers work together to formulate goals for student learning in long-term development (Lewis, 2002). The weekly PDCA was found to be more important than the number of steps in the LS model. The unit of analysis in Japan is the "lesson" but the unit of analysis in Thailand is the "classroom".

Before the researcher transformed the ideas of Japanese LS, he reviewed Thai students' culture-based learning styles: most are passive recipients, merely accepting and absorbing everything that teacher say. He found that students were always asked to solve the problems that were presented by their teacher or textbook. Students were rarely given opportunities to pose their mathematics problems. The researcher acknowledged the importance of student-generated problem posing and formulated that, along with problem-solving, these are the two components of instructional activity, as emphasized in the contemporary constructivist theories of teaching and learning (Silver, 1994). Therefore, he defined problem-posing as both the generation of a new problem and the re-formulation of given problems to be included in the first phase of OA. This was followed by adopting the "What-if-not?" process from Brown and Walter (1983) to incorporate the problem-posing-oriented instruction as the systematic variation of problem situations, which was closely aligned with the general inquiry-oriented philosophy (Brown, 1984) in the following phases of OA. The urgent issue of Thai education could be transformed from the product-oriented approach to that of OA, which emphasizes both the product and the process (Inprasitha, 2006). The details are as follows:

Step 1: Collaboratively Plan:

The LS group meets to discuss and design a lesson by considering students' thinking skills in their learning. They determine open-ended mathematics problems, followed by OA to organize the learning activities, ultimately, achieve the aims of revision. The OA must start

with students engaging in open-ended problems which are formulated to have multiple "open-ended" answers. Inprasitha (2006) suggests revising the open-ended problems in terms of OA while the LS group is collaboratively designing the lesson.

Step 2: Collaboratively Do:

The Do step is implementing the lesson that has been planned. The LS group observes the learning activities aiming to focus on students' thinking processes, not the teacher's teaching ability. Hence, the role of teachers is shifted from the transfer of knowledge to their attempts to identify students' learning processes. Teachers must understand students' ideas to identify the ways to support students' progress in their learning processes (Inprasitha, 2006). Consequently, the OA is composed of four phases: (1) posing open-ended problems; (2) students' self-learning; (3) whole-class discussion and comparison, and (4) summarizing by connecting students' mathematical ideas (Inprasitha, 2010). Inprasitha found that OA should be the focus of Step 2, otherwise teachers will fall back on traditional methods, although they are posing the open-ended problem.

Step 3: Collaboratively See

Those observers in Step 2 are required to reflect on the learning activities that they have observed in a weekly cycle, instead of immediately after each lesson as in the Japanese LS model. This is because Thai teachers desire to teach the syllabus and finish teaching the textbook. Therefore, the researcher made adjustments by adding another two cycles to ensure the teachers had sufficient reflection opportunities. The researcher organized open class activity at the school and national level, on a semester and yearly basis. Ultimately, participants could revise and make necessary adjustments to the remaining lesson plans based on the inputs from the weekly reflections and open class activities.

The TLSOA model with three additional layers of reflective activities is elucidated in Figure 1 (Inprasitha, 2010). Inprasitha (2004) also proposed guidelines to innovate teachers to

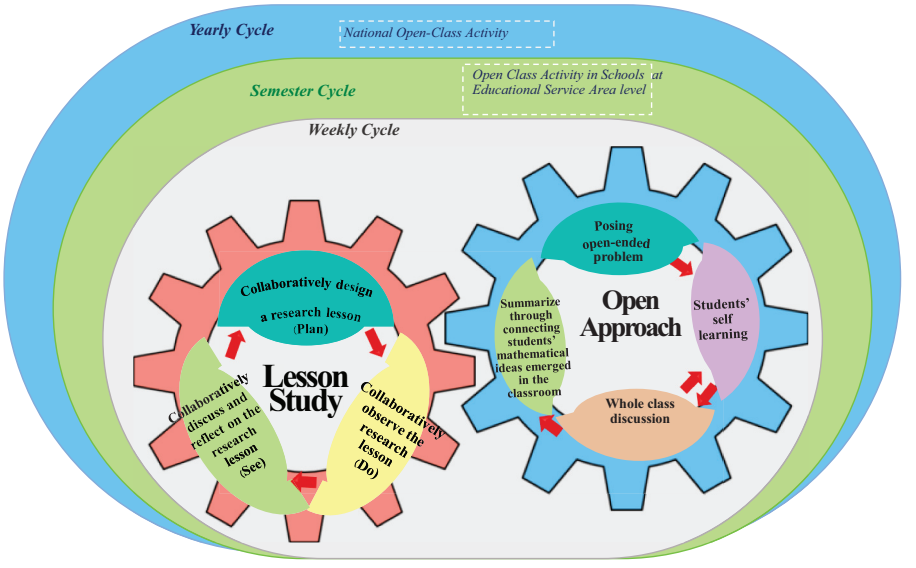

Figure 1.
TLSOA model

Soruce(s): Inprasitha, 2010

teach using mathematical activity based on open-ended problems to be institutionalized into Thailand's school culture.

After the TLSOA model was developed, the researcher intended to utilize it as an innovative mathematics teaching approach to improve teacher education in Thailand (Inprasitha, 2006). Although the researcher attempted to promote the Thai model, he found that teachers could not accept the OA at the initial stage, and they refused to apply it because of differences of culture and values (Inprasitha, 2010). One of the reasons was inappropriate preparation and assimilation to a different culture (Inprasitha, 2015a). Therefore, the transforming process needed to consider different contexts. This is because we lacked clarity about how to best design the LS and OA innovations in Thailand's teaching education program, which involved the examination of practice. At that time, the existing teacher preparation program in mathematics education, and its graduate level, was revised by emphasizing higher order thinking, rather than rote learning of mathematical rules or formulas.

The spirit of LS is teachers learning together to adapt ideas to meet school culture and sharing what they have learned when they implement those ideas; these are the key issues of the transforming process (Inprasitha, 2010). The major problems are that the LS process takes a considerable amount of time and great effort is needed to identify appropriate teaching strategies to cope with the foreseeable problems (Inprasitha, 2015a). The following contexts were considered to solve the problems, thus ensuring a smooth transforming process:

The context for the teacher preparation program

LS was introduced to a teacher preparation program as a pilot research project involving final year students in undergraduate programs of Mathematics Education who were assigned to schools for their teaching practicum (Inprasitha, 2004). The participants met during the summer session, before starting their initial teaching assignments when the teaching semester began. They had meetings with their advisors every Friday to reflect on their teaching experiences for the whole week. They summarized their problems and the ways of problem-solving before they proceeded to revise the remaining lesson plans that they had developed previously, to make the remaining lesson plans more appropriate to their classroom contexts.

The context for graduate studies

A new master's degree program in Mathematics Education was formed as a great platform for research and innovative development. Those students who enrolled in the post-graduate Mathematics Education program were trained to utilize the TLSOA model to improve their teaching. They had either graduated with a bachelor's degree in Mathematics Education or were in-service teachers who wanted to further their studies. Therefore, they could act as coordinators after attending the intensive training. They were required to participate in the faculty's long-term teacher PD project, whereby they were working closely with the schoolteachers using the TLSOA model. Their roles included collaborating with teachers to conduct the LS process (Inprasitha, 2015a).

The context of a PD workshop for long-term teacher PD

In 2006, the TLSOA model was introduced to two pilot schools located in Khon Kaen province to support the long-term development of the teaching profession. A series of 11 workshops were conducted on the preparation of lesson plans that emphasized the integration of subject contents, process skills, and desirable attributes for a period of three years, from 2003 to 2006. This three-year project aimed at developing the Thai mathematics teaching profession on LS and was called an "incubation of idea" (Inprasitha, 2015b).

Methodology and research questions

Although the literature review showed that LS supports the development of teachers' professional communities (Doig and Groves, 2011; Lewanowski-Breen *et al.*, 2021), it has not yet addressed the sustainability of the emerged communities. Therefore, this research aimed to investigate participants' views of the long-term impact after they had participated in PD using the TLSOA model. This complements the existing literature of LS (Baricaua Gutierez, 2016; Burroughs and Lubeck, 2010; Chichibu and Kihara, 2013) and OA (Becker and Shimada, 1997; Brown and Walter, 1983; Nohda, 2000; Sambová and Tichá, 2016). This is because previous research has been limited to short-term studies (Lewis, 2002).

The researcher employed a longitudinal design whereby a group of participants from his research schools was studied at intervals to examine the effects of the TLSOA model (N. Pam, 2013). It was a cohort type of longitudinal design involving a group of participants who typically experienced the whole transforming process over 10 years of data collection from 2002 until 2011. The transforming process included introducing the LS and OA ideas in 2002 and 2006, respectively, and developing teaching professional training using the TLSOA model to achieve changes in teachers' beliefs toward their teaching practices, which made up a total of 15 years. The research procedure involved three cohorts:

The first cohort in 2002

In the first cohort, the researcher investigated the 15 fourth-year bachelor's degree students who were doing their teaching practicum in seven research schools located in Khon Kaen province. Firstly, they attended a one-month workshop for constructing lesson plans. They were grouped according to the grades they intended to teach in 2002. There were six, five, and four participants in Grade 7, Grade 8 and Grade 9, respectively. Secondly, over the course of a semester, they attended a special seminar every Friday to share their teaching experiences of utilizing the TLSOA model. During the seminar, they expressed their common concerns, interesting points, and changes in students' behavior. Moreover, they developed ideas to conduct classroom research. The instrument used to investigate the changes was their written reflective journals. Data were collected after 15-weeks of implementing the TLSOA model and analyzed using content analysis.

Concurrently, the researcher examined 1,200 students' learning experiences after they were taught by these 15 participants. A questionnaire was administered in the Thai language to ensure that the participants could understand the items. There were 35 items in this questionnaire, which was specifically designed to gauge the agreement of the students' learning experiences while they were taught using OA. There were three aspects to the learning experiences: (1) Give the reasons why you like learning activities (11 items); (2) Give the reasons why you do not like the learning activities (12 items), and (3) Identify how you changed in a positive way (12 items) (Appendix: Questionnaire from Section B to D). To measure the students' responses toward their learning experiences, a Yes/No scale was used. The data were analyzed using descriptive statistics.

The first cohort measured the changes that occurred from both teachers' and students' perspectives after using the TLSOA model over the course of a semester to conclude the practicality of the model in the classroom setting. Specifically, the researcher intended to answer:

RQ1. What changes are there in the teaching practices of the 15 fourth-year bachelor's degree students?

RQ2. What are the perceptions of the 1,200 students' learning experiences after attending the lessons utilizing OA?

The second cohort in 2007

In the second cohort, eight out of the 15 participants in the first cohort together with 12 in-service mathematics teachers continued their postgraduate studies in 2003. The researcher proceeded to train and develop the skills of implementing the TLSOA model with these 20 participants, from four research schools, who had been involved in the first cohort through a series of 11 workshops from 2003 to 2005. In 2006, these 20 participants were fully trained to be coordinators to implement the model.

The researcher employed a qualitative method by collecting data, using video recording, during the periodical reflective meetings with the 20 participants after their initial participation in implementing the model. The participants were required to describe their experiences and situations to convey the effects of the TLSOA model (Burns and Grove, 2003). The rationale for using this method was to discover the views and experiences of participants who were the practitioners in their interpretative phase (Morse and Field, 1996). The researcher aimed to answer the following research question:

RQ3. What are the effects of undertaking a series of intensive training session in developing participants' capabilities to practice the TLSOA model?

The final cohort in 2011

Over the four years from 2007 to 2011, the 20 trained participants from the second cohort acted as coordinators to train 800 teachers using the TLSOA model. The researcher randomly selected 132 teachers from a total of 21 research schools located in the northeast and northern regions of Thailand in 2011. These schools engaged in the TLSOA model for more than two years. All teachers underwent the LS process, as they collaboratively designed the lesson plans with 20 coordinators once a week. This was followed by their observations on the lesson for about 3–4 h per week and, finally, they collaboratively participated in the post-discussion or reflection once a week. When this group of teachers participated in the LS process, they were assigned to operate according to the four phases of OA. A questionnaire related to teachers' beliefs that consisted of three aspects, namely, teaching mathematics, learning mathematics and social context, was conducted. To measure the teachers' beliefs, a five-point Likert scale was used. By the end of the final cohort, the researcher examined the following research questions (see Table 1):

RQ4. What are the perceived beliefs in teaching mathematics?

RQ5. What are the perceived beliefs in learning mathematics?

RQ6. What are the perceived beliefs about the social context after using the TLSOA model?

Cohort	Participants status/ Sample size	Data collection	Data analysis
Cohort 1/Introducing LS and OA innovations	15 fourth-year bachelor's degree students 1,200 Grade 7 to 9 students from seven schools	15 reflective journals 1,200 questionnaires	Content analysis Descriptive statistics
Cohort 2/Generating human resource development Cohort 3/Impacts of practicing the TLSOA model by 20 trained coordinators from Cohort 2	20 participants from four schools 132 in-service teachers from 21 schools	Reflecting meetings by the end of 11 workshops Questionnaire	Content analysis Descriptive statistics

Table 1.
An overview of the research procedure and methodology

Results

The results of the first cohort

The results are derived from two groups of participants and presented in two aspects:

The changes in the teaching practices of 15 fourth-year bachelor's degree students. The results revealed that all participants experienced difficulty in adjusting their roles to organize their classroom at the beginning of the semester. However, every Friday seminar seemed to work well in assisting most of them to understand, adapt and change, gradually, in their teaching roles. The most critical change was identified as they found they had the greatest opportunity to learn from their peers' different experiences when they met together to share their teaching experiences collaboratively. These regular seminars not only resolved their common concerns, but also developed their teaching abilities. The other key result derived from their reflective journals, which indicated that they found that being aware of teaching mathematics does not mean only focusing on the coverage of the content: it should emphasize students' learning processes, original ideas and attitudes toward learning mathematics.

Nevertheless, results also showed that the majority developed positive attitudes in researching their teaching practices. They started to realize that they should conduct classroom research that could assist them to improve their teaching quality from a wider perspective. Consequently, they acknowledged that classroom research enables them to sustain good teaching practices.

Another important result indicated that they changed their perceptions of learning from academic learning to life-long learning. Their mindset paradigm on teaching and learning shifted to integration between the way of life and the learning process. This, ultimately, influenced their educational values in terms of their contributions based on the core values required for living in Thai society.

Students' learning experiences after utilizing OA. All 1,200 distributed questionnaires were successfully collected with the assistance of the senior assistant of the seven research schools, giving a response rate of 100%. The researcher then organized the questionnaires according to the gender of the participant and analyzed these separately. The results showed little difference in their agreement on the reasons why they like the learning activities between genders. Table 2 shows that most students liked to do activities in the classroom. The results indicated that about 60% of the students felt that they had more opportunities for mathematical thinking. However, more than 50% of students, regardless of their gender, agreed with the following four reasons why they liked the learning activities: more thinking, more playing, doing something original, and more active learning activities.

In addition, results showed that there was little disagreement between the students about the learning activities. The results suggest that there were two reasons why students disliked doing the learning activities: the classrooms were too noisy and more female students could not understand the questions or instructions compared to male students which accounted for 40% of female participants. The results imply that Thai students tend to be dependent learners relying on their teachers to provide content materials in contrast to the OA philosophy, which encourages more independent learning. This is because good students, in the Thai cultural context, listen to their teachers' instructions instead of discussing with their friends in an active learning environment. This was the reason why students perceived the learning environment as too noisy, rather than as active learning.

The researcher continued to examine the positive impacts on students' learning behavior after they attended lessons using OA derived from the 1,200 students' perceptions. The results indicated that the highest percentage of positive impact was on the students' cooperative working (53.3% for males and 59.7% for females). The result implies that nearly 60% of the students learned to work cooperatively. So, the researcher found that the positive impact of OA contrasts sharply with the traditional approach, which is mainly focused on individual work. This was followed by students who became more reasonable and willing to ask questions while

Reasons why students like	Boys (%)	Girls (%)
When thinking aloud, feel like a "genius"	34.4	33.1
Do real practice with given materials	36.7	44.4
More playful activities	58.6	58.5
Opinion feels more valued	44.3	28.8
Feel independent	43.0	42.1
Do something original	54.6	53.4
Good atmosphere, friendship	46.6	39.6
Use arts knowledge	48.7	40.3
Summarize some ideas by themselves (or their group)	44.7	40.2
More thinking	58.6	63.0
More active	55.2	51.4
Reasons why students dislike		
Time restrictions	14.1	9.9
The teacher cannot observe all students	16.2	14.7
Don't know how to answer, "the why and how questions"	15.5	17.4
Feel that I am not learning the same things as friends in other classes	14.5	9.8
Cannot conclude or connect ideas in the activities	16.1	16.1
Do not know what to do	8.8	11.9
Activity is difficult	13.3	15.4
Do not like someone in my group	13.7	13.8
Do not like working in a group	9.7	7.3
The classroom is too noisy	56.5	48.4
Cannot understand questions or instructions	23.1	45.7
Boring	16.6	25.7
Positive impacts on school students' learning behavior		
Better achievement	28.6	26.8
More enthusiasm	33.6	35.2
Better in connecting the knowledge	23.3	23.9
Know how to solve problems in various methods	40.1	39.3
Possess better communication skills with classmates	27.3	23.9
Dare to disagree	20.2	15.2
Dare to support or defend their own thinking	29.4	29.7
Dare to ask questions	40.5	43.2
Know how to work cooperatively	53.3	59.7
More cool-headed	28.8	22.1
More skillful in observation	34.4	30.0
More reasonable	42.8	40.3

Table 2.
Reasons why students like or dislike the learning activities and positive impacts

learning. This suggests that students changed their learning behavior, as they became more engaging with open-ended problems and actively solved the problems themselves. Both changes of positive behaviors successfully affected more than 40% of the total students.

The results of the second cohort

Changes in the 20 participants after the intensive training. The second phase results were obtained from 20 participants (T1 to T20) over the 11 workshops from 2003 to 2006. The researcher found that five major changes occurred: a better understanding, a higher level of self-confidence, excellent observation skills, ability to adjust and organize their teaching and learning activities, and skills to develop students' thinking after they were intensively trained to practice the TLSOA model for about a year. These changes were reflected in their periodical reflective meetings.

The results revealed that they had a better understanding of how to implement the TLSOA model. Therefore, they developed a higher level of self-confidence in organizing learning activities in their classrooms. They possessed the ability to adjust their way of organizing their

teaching activities according to the procedure of LS and learning activities based on the OA ideas. This result was particularly true with Grade 1, 4, and 7 mathematics teachers while teachers in other subjects at different grade levels somehow adopted the OA ideas and LS procedure in some of their classes. These were indicated in the following verbatim data:

> I understand that learning activities should be entirely different from the conventional method of lecturing, explaining, and demonstrating examples, (T2: Grade 4 mathematics teacher).

> When I participated in the LS project, I knew that I must integrate the four phases of OA in my lesson plans to develop the mathematical ideas through the problem-solving method, (T10: Grade 7 mathematics teacher).

> My LS group has played various roles in preparing lesson plans, as an instructor to implement the lesson plan, an observer during the lesson, and a participant in the reflection session after the lesson, (T4: Grade 1 mathematics teacher).

Furthermore, the participants acknowledged that they had changed both their way of organizing learning activities and their teaching approach because they had learned how to organize learning activities and understand how students learn. This has, eventually, helped them to change their mindset of using OA to teach students' better thinking skills, understanding the origins of a problem, and justifying their actions and thoughts. The following points of view were raised by the participants.

> We have ample opportunity to exchange ideas with our teachers, internship students, post-graduate students, and experts from the Faculty of Education, which helped us to understand how to organize appropriate learning activities, (T15: Grade 6 mathematics teacher)

> Now I know how to create mathematical problems to let my students think about how to solve the problems, (T12: Grade 2 mathematics teacher)

Additionally, results revealed that a network was successfully created in the four schools allowing the participants not only to engage regularly in their classroom activities, but also to frequently meet to observe their peers' teaching and be involved in reflective activities. This significant change never happened previously in the conventional classroom culture. The following verbatim data presents the resulting school culture.

> We have meetings every week to discuss the problems that we face. We always help each other to improve our teaching. We are not working alone, we are working as a team, (T20: Grade 5 mathematics teacher).

> Now the school culture is very positive; we plan the lesson together, sometimes I teach, sometimes my colleagues teach, but we do reflection together, (T16: Grade 2 mathematics teacher).

Moreover, the participants agreed that they had opportunities to work collaboratively to prepare lesson plans, observe classroom activities, and reflect on the lessons by the end of each teaching period, and once more at the end of each week, even though they sometimes could not do as much as they wished due to their tight work schedules. The LS procedure became a routine task as well as a part of their working culture.

> We have used the LS procedure. But sometimes we cannot do it frequently, as we are busy with other tasks in schools, (T13: Grade 8 mathematics teacher)

Consequently, the researcher found that participants were more involved in discussions with their peers regarding the matters of preparing lesson plans for learning activities, their roles in the teaching activities, students' learning behavior, and students' way of thinking.

> T1 said that "Small group discussion encouraged students to generate more ideas and can help students learning."

T5 stated that "My LS group always prepare an activity-oriented classroom that includes more open discussion so that students can work together more and learn from one another."

The results of the final cohort

Participants' beliefs about the TLSOA model. The results of the final cohort are derived from 132 in-service teachers, after they collaborated with the 20 coordinators who were trained from the second cohorts in 21 research schools in 2011. A total of 140 questionnaires were distributed to the participants after they had been practicing the TLSOA model for more than two years. However, only 132 of them responded to the questionnaires, giving a response rate of 94.3%. Table 3 shows that participants generally possessed high opinions about the TLSOA model (Inprasitha and Changsri, 2014). Moreover, results showed that participants' beliefs were high in all three aspects: their method of teaching mathematics ($4.72 < \text{mean} < 4.76$), their ways of learning mathematics ($4.42 < \text{mean} < 4.66$), and their beliefs in a social context ($4.41 < \text{mean} < 4.73$).

Discussion and conclusion

The researcher explored the "transforming" process of using LS and OA in the Thai teaching profession using a longitudinal study encompassing three cohorts for 10 years. The research period of 10 years was the coverage for the first phase of the 30-years Khon Kaen University project. This project is a long-term strategic plan to promote LS and OA, with each phase taking 10 years to complete. Therefore, the results contribute, obviously, to our recognition of the importance of teaching professional training to ensure teachers are well equipped with sufficient and innovative teaching skills to successfully adapt the TLSOA model.

The research results reveal how the TLSOA model supported teachers' teaching and students' learning experiences in a culturally different setting from their prior experiences. Teachers formed beliefs on teaching and learning mathematics in their social context. This implies that the TLSOA model is a method for improving students' learning behavior, as reflected in the result of the first cohort and students' learning attitudes, as perceived in their teachers' beliefs. Moreover, teachers' PD has been improved tremendously includes their observations and reflections. It can be concluded that teaching practices in the context of LS and OA allow teachers a space to allow their students to encounter problem-solving situations, forming new kinds of teachers' beliefs about teaching practices.

Beliefs about teaching mathematics	Mean	*SD*
Teachers allow students to decide how to solve the problems	4.76	0.47
Teachers observe students' behavior while they are solving the problems	4.72	0.47
Teachers give challenging problems for the students to discuss and formulate problems by themselves	4.75	0.47
Beliefs about learning mathematics		
Students can solve mathematical problems by themselves	4.42	0.70
Students can express their ways of thinking and the reasons underpinning their solutions	4.66	0.65
Group discussion can lead to a conclusion to the lesson	4.66	0.60
The student recognizes various ideas from their peers	4.65	0.54
Students enjoy learning mathematics	4.63	0.52
Beliefs about the social context		
Teachers are proud of being observed by other teachers or specialists	4.41	0.82
Teachers gain insight on teaching abilities that need to improve or develop through reflection	4.73	0.44

Table 3.
Participants' beliefs

The pedagogical implications of this research successfully expand the current literature by proposing a descriptive framework to observe students' learning by using their prior knowledge to adapt to their problem-solving methods. Moreover, students can develop their abilities to solve the mathematical problems, find various strategies, connect different related issues to solve these problems, and interpret the learning outcomes by themselves. In addition, the practical implication of using the TLSOA model is to propose a transformational process of LS in a local context through a PDCA weekly cycle, rather than focusing intensively on the details of the quality of the research lesson itself, as has been done in many other countries. In conclusion, the ultimate results of this research corresponding with those of Doig and Groves (2011), who found that Japanese LS and OA innovations can be adapted into be more successful PD practices internationally.

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Appendix
Questionnaire

SURVEY ON STUDENTS' RESPONSES ON OPEN APPROACH LERNING ACTIVITIES IN CLASSROOM

A. General Information

Name of my school: _____

I am studying in Grade: ☐

I am ☐ **a boy** ☐ **a girl**

Instruction: Please tick ✓ in the column to indicate your responses to either "YES" or "NO"

No.	Item	Scale	
		Yes	No
B.	**Give the reasons why I like the learning activities in the classroom**		
1.	When thinking aloud, feel like a 'genius'.		
2.	Do real practice with given materials.		
3.	More playful activities.		
4.	Opinion feels more valued.		
5.	Feel independent		
6.	Do something original.		
7.	Good atmosphere, friendship.		
8.	Use art knowledge.		
9.	Summarize some ideas by themselves (or their group)		
10.	More thinking		
11.	More active		
C.	**Give the reasons why I do not like the learning activities in the classroom**		
12.	Time restrictions.		
13.	The teacher cannot observe all students.		
14.	Don't know how to answer, "the why and how questions".		
15.	Feel that I am not learning the same things as friends in other classes.		
16.	Cannot conclude or connect ideas in the activities.		
17.	Do not know what to do.		
18.	Activity is difficult.		
19.	Do not like someone in my group.		
20.	Do not like working in a group.		
21.	The classroom is too noisy.		
22.	Cannot understand questions or instructions.		
23.	Boring.		
D.	**Identify how I changed in a positive way**		
24.	Better achievement.		
25.	More enthusiasm.		
26.	Better in connecting the knowledge.		
27.	Know how to solve problems in various methods.		
28.	Possess better communication skills with classmates.		
29.	Dare to disagree.		
30.	Dare to support or defend their own thinking.		
31.	Dare to ask questions.		
32.	Know how to work cooperatively.		
33.	More cooled-headed.		
34.	More skillful in observation.		
35.	More reasonable		
E.	**Explain the negative impact of the open approach**		
36.	Feel not belong to the group.		
37.	Quite show off.		
38.	Worse achievement.		
39.	Feel tension and anxiety.		
40.	More bored with mathematics than before.		
41.	Inert.		
42.	Friends or teacher dominate ideas.		
43.	Lose confidence because of rejection of group.		
44.	Do not use one's fullest ability or capacity.		

About the author

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