Interconnectedness and difference between Action Research and a Lesson Design Study in Shanghai, China

Liping Ding, Department of Teacher Education, Norwegian University of Science and Technology, Trondheim, Norway

Keith Jones, School of Education, University of Southampton, Southampton, UK

Svein Arne Sikko, Department of Teacher Education, Norwegian University of Science and Technology, Trondheim, Norway

Abstract
The professional development of teachers in China takes place, to a large extent, in Teaching Research Groups (TRG) that exist in all schools. Though there are diverse models of TRG activities, these might, on the surface, appear to resemble forms of Action Research (AR) or include elements that might resemble AR. In conducting a Lesson Design Study (LDS) with a TRG in Shanghai, we encountered the specific challenge of what might be the interconnectedness and differences between AR and our LDS. To address this issue, we applied a research-informed depiction of the distinguishing characteristics of AR to our LDS. Based on this analysis, we found that (1) in contrast to the depiction of AR that encompasses a choice of methods, our LDS follows a specific 'design research' methodology, (2) whereas the depiction of AR is simultaneously directed towards teacher self-change and restructuring the organization or institution within which the teacher works, LDS concerns more than the practical questions in one local social context and aims to tackle bigger questions across the social contexts in the subject research field, and (3) whereas in the depiction of AR, teachers engage in a process of authentic collaboration with other teachers seeking to improve their practices, in the LDS community the external researchers and expert teachers play other roles in the TRG. Even though there may be differences between the depiction of AR and our LDS, the interconnectedness is important in that both AR and our LDS contribute directly to school-based teacher professional development.

KEYWORDS Action research; lesson design study; teaching research group; teacher professional development; Shanghai; China

Introduction

The professional development of teachers in China takes place, to a large extent, in Teaching Research Groups (TRG) (Jiao Yan Zu in Chinese) that, since 1952, have been fostered in all schools in the country. According to Yang and Ricks (2013), TRG activity includes three sub-activities in a cyclic process: (1) lesson preparation, (2) public teaching with observation, and (3) post-lesson discussion. This cyclic process has been called 'lesson study' (Huang, Gong, and Han 2016) and 'learning study' (Pang and Marton 2017). During the 1980s, Action Research (AR) was introduced into China alongside the TRG system, and since then, and especially since the start of the 21st century, Chinese education researchers have been working on localising AR in relation to the backdrop of the ongoing national curriculum reform in basic education (Bai 2009). Liu and Wang (2018) and Yuan (2017) both highlight the need for possible ways to create a Chinese version of AR through integration with the indigenous practices in teacher learning in China.

Though there are diverse forms and models of school-based TRG activities in China, the TRG approach might, at the surface, appear to resemble forms of AR or include elements that might resemble AR. The seeming similarities echo the issue raised by Wood (2017) who queried whether there is any difference between 'Learning Study' and 'Lesson Study'. This illustrates the compelling need for greater clarity about the concepts, approaches, and functions of AR and Lesson/Learning study that characterises the school-based TRG system in China.

In conducting a Lesson Design Study (LDS) with a TRG in Shanghai, China (for details, see Ding, Jones, and Sikko 2017), we encountered the specific challenge of clarifying what might be the interconnectedness and difference between Action Research and our LDS. To address this need for greater clarity, the focus of this paper, and our research question, is: what is the interconnectedness and difference between AR and our LDS? Within the specific issue of school-based teacher professional development (TPD) in AR and in our LDS, we applied to our LDS the results of the study by Rowell et al. (2015) in which they identify what they call the distinguishing characteristics of AR; these include that in AR there is a choice of methods, that action is 'simultaneously directed towards self-change and towards restructuring the organization or institution within which the practitioner works' (Rowell et al. 2015, 255), and that there is 'authentic collaboration with participants who seek to improve their practices' (Rowell et al. 2015, 256).

Notwithstanding that other depictions of AR are possible (for a review, see Rowell et al. 2017b), in this article we begin by outlining our approach to our LDS study with a TRG in Shanghai and then summarise what Rowell et al. (2015) depict as the distinguishing characteristics of AR in their study of the views of the members of the *Action Research Special Interest Group of the American Educational Research Association*. We use this depiction of the distinguishing characteristics of AR as an analytical framework to identify the interconnectedness and difference between AR and our LDS.

LDS within a TRG in Shanghai

The overall approach utilised in our LDS project is 'Action Education' (AE) (Xingdong Jiaoyu in Chinese) (Gu and Wang 2003), a form of school-based TPD in China that aims to tackle the significant challenges that teachers have encountered in their implementation of the new national curriculum reforms in China since 2001 (MOE 2001, 2011). In proposing the AE model, Gu and Wang (2003) considered that it is important to emphasise two fundamental ideas underpinning in-service TPD in China: (1) simultaneously to emphasise two dimensions of teacher learning in TPD, namely peer coaching among teachers in TRG (the horizontal dimension, or width, of teacher learning) and an expert's mentoring that provides theoretical and professional guidance (the vertical dimension, or depth, of teacher learning); (2) simultaneously to use Keli (a Chinese term for exemplary lesson development) in the TRG and address the whole process of teachers' reflection on professional learning through the AE model. Thus, as Gu and Wang (2003) explain, the AE model includes three features: (1) using Keli in the school- based TRG activities as a means for developing solutions for the key problems shared by teachers who are teaching a specific topic; (2) establishing the teacher-researcher communication for deliberately guiding teachers' professional learning and development; and (3) teacher follow-up action and reflection.

As such, in our LDS there are three main phases of a teacher's action followed by two key reflections (briefly called 'three actions and two reflections'). During the initial phase, the teacher designs and implements tasks within a lesson according to the teacher's usual teaching practice. For the second phase, the teacher receives guidance and support from the TRG. During this phase, the TRG discussions (addressing both the 'horizontal' and the 'vertical' learning of teachers) are focused on developing new ideas in order to re-design and re-implement the tasks and the lesson. During the third phase, the teacher is expected to adjust the teaching, and the re-redesigned tasks and lesson, according to feedback received on student learning during the earlier phases. Accordingly, the first reflection (taking place between the first two phases) aims at updating ideas; namely, teachers identify the differences between their existing practice and the innovative ideas from the TRG discussions. The second reflection follows and is aimed at improving action; namely, teachers identify the gap between the implementation of the innovative design, including its effects on pupil learning out- comes, between the last two phases.

From this description, it is already clear that the AE model is, as Bai (2009) explains, an example of the incorporation of aspects of AR by Chinese educators to suit local circumstances during a period of significant school transformation and social transition. Indeed, Gu and Wang (2003) discuss how the AE model shares features of AR. For instance, AE chiefly concerns teachers' PD in their own classroom practices, and the main purpose of the AE study is to enhance teachers' 'Xingdong Zhihui' ('wisdom of action' in English; 'Xingdong' can be translated into 'action' or 'practice' in English). According to Gu and Wang (2003), 'wisdom of action' is most likely

germinated con- currently with the accumulation of an individual teacher's reflection and action. As such, it can only be developed and completed through the teacher's personal teaching practice and reflection.

Nevertheless, Gu and Wang (2003) point out that the AE model is neither solely for researchers to test whether a theory works in practice, nor is it an empirical experiment of a theoretical idea for teachers to follow. The nature of our LDS entails a dual function: on the one hand, our LDS aims to tackle the practical problems that teachers encounter in their PD and accordingly help to improve teachers' teaching practices; on the other hand, our LDS uses scientific research methods to collect data in order to build new scientific hypotheses or theory. It is exactly this dual nature of our LDS that underpins the challenge to make clear what might be the interconnectedness and difference between action research and our LDS.
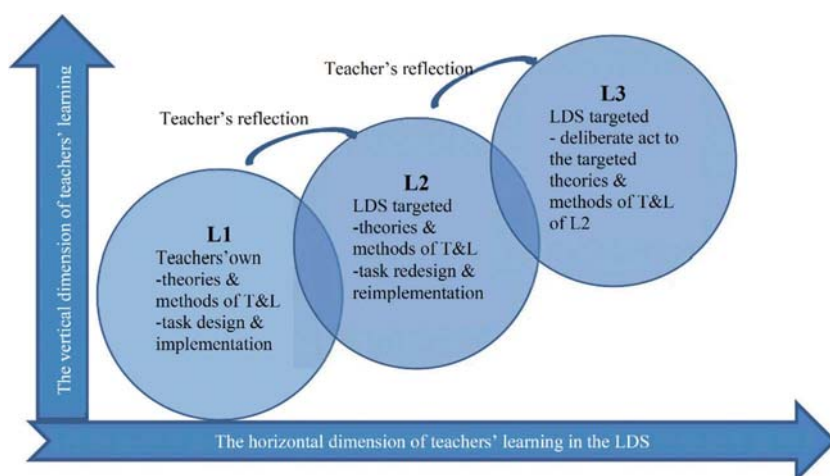

Figure 1. The three layers of teachers' learning to act and reflect in the LDS.

Overall, the LDS model attends to the teachers' targeted professional learning through the multiple layers of action and reflection in the three cycles illustrated in Figure 1: the first layer of action and reflection is the teachers' own belief and assumptions of mathematics and their own teaching and learning in the first teaching cycle (L1 in Figure 1, note that T&L in Figure 1 represents 'Teaching and Learning in class'); the second layer of action and reflection concerns the improvement of the teachers' belief and critical reflection on their learning of the targeted theories in the second teaching cycle (L2 in Figure 1); and the third layer of action and reflection focuses on the progress of the teachers' action on the targeted theories and the relevant methods of teaching and learning in the third teaching cycle (L3 in Figure 1). Through the whole process of the three cycles, the teachers' personal belief and identity together with their learning to act and reflect are concurrently developed (see Figure 1) (Ding and Jones 2018). The overlapping of the cycles in Figure 1 indicates the accumulation of 'wisdom of action' through teacher action and reflection that the LDS aims to study closely in order to foster it within TPD.

Analytical framework: the distinguishing characteristics of action research

Although other depictions of AR are possible, in our analysis we made use of a study of the views of members of the American Educational Research Association's Action Research Special Interest Group (AERA AR SIG) by which Rowell et al. (2015) constructed a depiction of the distinguishing characteristics of AR using three elements; namely, its nature (i.e. the nature of knowledge, its possibility, scope, and general basis), the key processes (i.e. assumptions about inquiry and understandings), and the practices (i.e. the description of methods and rationale for the choice of methods and the particular forms in which the methods are employed).

Table 1. Distinguishing characteristics of action research (Rowell et al. 2015, 255-256).

The nature of action research	• Action research seeks transformative change through the simultaneous process of taking action and doing research, which are linked together by critical reflection. • Action research practitioners reflect upon the consequences of their own questions, beliefs, assumptions, and practices with the goal of understanding, developing, and improving social practices. This action is simultaneously directed towards self- change and towards restructuring the organisation or institution within which the practitioner works. • The nature of action research places the researcher in the middle of the problem and not on the outside as an observer and/or experimenter. Action researchers do not claim 'neutrality' but rather account for their position in the action and inquiry. A strength of action research is that the researcher studies what she or he does in concert with others. Therefore, the knowledge created through action research is inevitably dialogical in nature, and is thus always a negotiated and co-created knowledge. This knowledge is not inert, but serves to improve the quality of life by engaging participants in a quest for deeper understandings that lead to improvement. • Action researchers are often guided by questions of the kind, 'How do I improve my practice?' Action research takes time, energy, commitment, and courage because it is about changing oneself, which means changing one's thinking, and recognising that, once changed, there is no going back. However, action researchers are also engaged in a process of authentic collaboration with participants who seek to improve their practices. The focus is on the actors (participants) within their local social contexts. These participants are often co-researchers.
The key processes of action research	• The four key processes of an action research cycle include planning, implementing the plan, gathering and analysing data as the plan is implemented, and reflecting on these results. • The cycles of action research represent iterative problem solving linked by reflection. Critical reflection on action and reflexive writing are key and central processes of action research.
The practices of action research	• The choice of research methods in action research is dependent upon the question, problem, dilemma, or dissonance to be examined, and the nature of the practice situation.

We use this depiction of the characteristics of AR, as set out in Table 1, as our analytical framework for analysing the interconnectedness and important differences of AR and our LDS approach.

We are aware that these distinguishing characteristics of AR were identified by Rowell et al. (2015) through a study of AERA AR SIG members and that, as such, the characteristics they identified may well comprise 'an overly Westernized view of action research' (Rowell et al. 2015, 90; emphasis in the original). Likewise, as noted above, other depictions of AR are possible. We return to these issues in our discussion and conclusions sections. For the moment, we turn to our analytical method and thence our findings.

Method

The LDS in Shanghai

Our LDS was conducted in an international school (Grades 1–9) in the west suburb of Shanghai from 2013 to 2015. We selected seven Keli topics from Shanghai elementary mathematics textbooks (for details see Ding, Jones, and Pepin 2013; Ding et al. 2014a, 2014b, 2015; Ding, Jones, and Sikko 2017). The choices of these Keli activities were based on a need at the time to foster teachers in the school to make a shift from traditional skill-based lecture pedagogies to a more student participation-oriented pedagogy so as to be able to teach well using the reformed textbooks.
In our LDS, when a Keli topic was chosen from, for example, the grade 1 mathematics textbook, then a grade 1 teacher from the school was assigned to join the LDS. In this way, there was an attempt by the school to align teaching load to the Keli teachers so that they could participate in the LDS. In the school there were six classes at each grade, with about 25 pupils in each class. When the Keli topic was chosen in, say, the Grade 1 textbook, three different Grade 1 classes were arranged by the school for the Keli teacher to practice through the three teaching cycles of the LDS model. Of the seven teachers who participated in the LDS, three were experienced (each with about 5 years teaching experience) and four were beginners or junior teachers (with 2–5 years teaching experiences).

The LDS community included the following participant groups: (1) a number of researchers (regional, national, and international); (2) two expert teachers (external teachers who are specialists in their teaching and provides in-service teacher education in their school district); and (3) seven Keli mathematics teachers from the mathematics TRG in the elementary section, together with a number of mathematics teachers from the mathematics TRG of the whole school (from G1 to G8, ranging from newly appointed teachers to teachers with about 10 years teaching experience); and (4) the head of the primary division of the school, who was in charge of the school-based TPD and had responsibility for improving the quality of school learning, and was also a teacher himself with over 10 years teaching experience and expertise in secondary school mathematics teaching.

The data sources from our LDS included: the case teachers' initial lesson plans; the transcripts of the video-recorded lessons; the transcripts of the video-recorded TRG meetings; and the transcripts of the video-recorded re-taught lessons; the teachers' teaching diary, and teachers' interviews after their   lessons.

Approach to analysis

To address our research question, we used the three key elements of the distinguishing characteristics of AR proposed by Rowell et al. (2015) as our analytical framework: (1) the nature, (2) the key processes, and (3) the practices (see Table 1). To enable us to identify the interconnectedness and difference between AR and our LDS, we used the following aspects of our LDS relating to each of the three elements from Rowell et al. (2015): the nature of our LDS comprises: (1a) our LDS model, (1b) the nature of teacher's learning, change and reflection, (1c) the role of the researcher, (1d) the nature of knowledge generated in the LDS, (1e) the role of members in the LDS community, and (1f) the nature of the questions addressed in the LDS; the key processes of the LDS comprise: (2a) the key process of each teaching cycle in the LDS, and (2b) the nature and the pattern of action and reflection in the LDS; the practices of the LDS comprise: (3a) the choice of specific data collection and analysis methods of the LDS, (3b) the LDS researcher's epistemological and ontological belief systems in mathematics education and its TPD, and (3c) the nature of design research methodology.

Findings

In this section, we report on our use of the analytical framework in the foregoing section in relation to the characteristics of the nature, the key processes, and the practices of the LDS. In doing so, we use the characteristics of our LDS, and the distinguishing characteristics of AR proposed by Rowell et al. (2015) in Table 1, to analyse the interconnectedness and difference between the LDS and AR. We begin by paying particular attention to the key categories identified in each of the elements of the LDS: the nature, the key processes, and the practices of the LDS. We begin with the nature of our LDS.

The nature of the LDS

Based on our analysis, the nature of our LDS embraces the following three features (1) multiple dimensions of professional learning through the LDS model, (2) the mentoring role played by the researcher and the expert teachers in the LDS, and (3) knowledge co- generated by the LDS aims to tackle bigger questions across the social contexts of the research field. We expand on each feature in turn.

The multiple dimensions of professional learning through the LDS model

Our LDS aimed at concurrently developing teachers' professional knowledge, beliefs, and identity through three teaching cycles of the LDS model (see Figure 2). Each of the teaching cycles included multiple dimensions of targeted learning through lesson

design, lesson implementation, TRG discussion, and reflection. In Figure 2, T means teacher, LD1 means lesson design 1, action1 is teaching in lesson 1, reflection1 is teacher's reflection after lesson 1, TRG1 is school-based TRG meeting after lesson 1, and so on.

In the first cycle of the LDS (L1), the researcher focused on examining teachers' own beliefs and assumptions of mathematics and of their role in classroom teaching and learning by engaging them in the self-oriented lesson design and practice of the targeted lesson topic. The form of the professional learning activities in this cycle is the same as that of the school-based TRG model (Yang and Ricks 2013): (1) design a lesson plan, (2) delivering the lesson, and (3) post-lesson discussion. Nevertheless, in this first cycle (L1) the researcher's concern was not solely the teachers' self-oriented action. Rather, the researcher (the first author of this article) focused on understanding the possible gap between the LDS teachers' own belief and assumptions of mathematics and its teaching and learning, on the one hand, and the targeted theoretical ideas and its implementation to be introduced to teachers in the re-designed and re-implemented lesson in the second cycle on the other hand.

In the second cycle of the LDS (L2), the researcher and the expert teachers played a significant mentoring role in supporting the teachers' deep learning of, and reflection on, the targeted theoretical ideas and implementation (the vertical dimension, or depth, of learning in Gu and Wang 2003). Though the form of learning was the same as that of the TRG model, the nature of the teachers' learning was different from those in the first cycle. In this second cycle, the teachers were expected to learn, and to use, the targeted theory and teaching methods to re-design the L2 tasks. That is, in the transition from cycle 1 (L1) to cycle 2 (L2) (see Figure 2), teachers' 'wisdom of action' is emphasised through their reflective teaching experiment of the targeted theory. In using the targeted theory and teaching methods, the teachers were asked by the researcher to reflect on the gap between their own beliefs or assumptions of the subject and its teaching and learning and the innovative ideas embedded in the reformed textbooks and from the TRG discussions. Thus, in L2, the teachers' learning through the social interaction processes within the TRG was highly emphasised in the LDS.
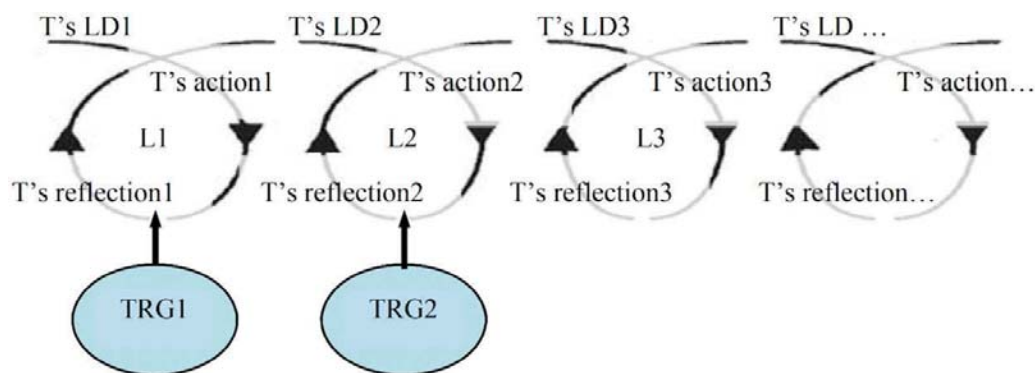

Figure 2. The three main cycles of the LDS (including L1, L2, L3) (Ding et al. 2017, 246).

In the third cycle (L3), the researcher focused on examining the teachers' effort in making changes to their teaching practice, and their reflection on their action changes from L2 to L3. Again, although the form of teacher learning in this cycle is the same as that of the TRG model, the emphasis on teachers' learning in the third cycle is different from that in the first two cycles. Here, the expert teachers played a significant role in mentoring the teachers' wisdom of action' – in guiding them to improve their class- room action with a targeted theoretical idea and to reflect on their action changes and develop their teacher identity.

In sum, the teachers in the LDS were not solely engaged in self-oriented teaching practice and research as a form of self-led reflection. The LDS teachers conducted the LDS teaching experiments in their own classes, or their colleagues' class of the same grade. Nevertheless, the whole research process of the LDS was guided by the researcher, particularly in terms of the research design method, data collection and analysis through the LDS model. The researcher's role in the dual function of the LDS is further explained in what follows.

The mentoring role played by researcher and expert teachers in the LDS

The researcher and the expert teachers played an important mentoring role in the teachers' professional learning in the LDS. The guided learning was necessary partly due to the mentoring feature of the LDS and partly due to the challenge and need of the school.

Firstly, the LDS emphasised the vertical dimension (depth) of professional learning (Gu and Wang 2003), with a specific aim to update teachers' 'wisdom of action' of two targeted pedagogical theories and teaching methods in the lesson design and implementation: one is the inquiry-based learning that has been advocated in the reformed curriculum and pedagogy in Shanghai, the other is 'teaching with variation' which is highly advocated in school practice in Shanghai (Gu, Huang, and Marton 2004; Gu, Huang, and Gu 2017). Thus, the teachers in the LDS were specifically asked by the researcher to reflect upon the gaps between the consequences of their own questions, beliefs, assumptions, and practices in L1 and those introduced and targeted in L2 and L3 (see Figure 2). This reflective teaching demanded a mentoring role of the researcher and the expert teachers to support the teachers by scaffolding between the teaching cycles of the LDS. The researcher and the expert teachers' mentoring role is further explained in the section that follows this.

Next, the mentoring support in the LDS was necessary due to the school's challenging circumstances, and need to improve young teachers' classroom teaching quality, at the time of the LDS. The school was newly established (less than 5 years) at the beginning of the LDS. Most of the schoolteachers were young teachers with limited teaching experiences. At the time of the LDS, only three out of seven teachers were experienced (each with about 5 years teaching experience). These three teachers were particularly active in collaborating with the researchers in the field study. For instance, they were active in the TRG meetings, giving their own instructional

reasoning of their own lesson design and implementation (in L1). They demonstrated their experience in their teaching diary of their reflection on 'why' questions – being able to formulate clearly their reasoning of their changes and challenges to make a change in the re- designed lessons (in L2 & L3). The other four teachers were beginners or junior teachers. These teachers often showed their uncertainty in their lesson design and implementation, and asked the type of 'yes or no', 'what' and 'how' questions in the TRG meetings and in their teaching diaries. For instance, 'what are exactly the operational phases of an inquiry-based lesson?', 'Does the teacher need to lead a summary after each classroom activity?', 'What kind of tasks can help me to achieve this learning goal?', 'I was so uncertain and not sure how to deal with students' learning response if it is out of my lesson plan.' Thus, the researcher had to arrange considerably more time in the TRG meetings in the second and the third teaching cycle, so as to engage these beginner and junior teachers in the LDS for them to be able to be open to the LDS community with their questions and learning difficulties, in order to make a shift towards teaching the targeted pedagogical theories and teaching methods.

After the third cycle of the LDS, the researcher developed a set of questions to support the teachers to reflect on their learning of the targeted lesson design in their teaching diary, such as 'what was the main gap of your initial lesson design and the ideas from the expert teacher's comments in the TRG meeting?', 'What did you consider taking from the comments of the TRG into the re-designed lesson?', 'What did you not consider taking from the TRG into the re-designed lesson?', 'Why did you, or did you not?', 'What did you learn through this LDS?', etc. Data from the teachers' teaching diary proved valuable in enabling us to capture the nature of the teachers' professional learning and the factors that helped or hindered their learning.

Knowledge co-generated in the LDS aimed at bigger questions across social contexts

Challenges and opportunities usually go hand-in-hand. On the one hand, the research team was confronted with three main practical challenges in operating the LDS in the busy school context: (1) a group of young teachers with diverse professional back- grounds and teaching experiences; (2) the reality of teachers' main duty of teaching rather than research in the school's daily schedule; (3) the goal of the LDS of developing the teachers' deep learning of the targeted theories and teaching methods through the LDS model. On the other hand, the school context, in turn, offered the team unique opportunities to establish researcher-teacher collaboration and to form the LDS community with different professional groups to tackle the teachers' practical challenges in the school-based TRG activities and to examine the diversity and complexity of the teachers' professional growth in their daily-based school situation.

A strength of the LDS was that the LDS community included four professional communities: a number of academic researchers from both Shanghai and overseas; two expert teachers from outside of the school and the school district; a group of school teachers from different grades (Grades 1–5) and the head of the primary division of the school who was in charge of the school TPD and the quality of school

learning (see Ding, Jones, and Pepin 2013; Ding et al. 2013; Ding et al. 2014a, 2014b, 2015; Ding, Jones, and Sikko 2017). The knowledge created through LDS was thus co-created knowledge by the LDS community (for another report of co-created teacher-researcher knowledge, see Edwards and Jones 2003).

Generally speaking, the research team in the LDS was not only concerned with the teachers' practical questions in one local social context, but also aimed to narrow the gap between research and practice and to tackle bigger questions across the social contexts in the education research field. For instance, the following research questions and issues were a focus in the LDS: 'how published tasks (sourced from textbooks) are appropriated by teachers for instructional purposes and hence how task design influences mathematics teaching?' (Ding, Jones, and Pepin 2013); 'what are the expert teacher's implicit 'local instruction theories' (Gravemeijer 2004) that underpin the guiding of a junior teacher in lesson design and implementation, with the particular teaching objective of developing individual children's mathematical reasoning in the class?' (Ding et al. 2014a); 'how does a teacher utilise advice from an expert teacher to improve pedagogic thinking and instructional practice in the classroom?' (Ding et al. 2014b), 'in what way does Greeno's (1998) model help to conceptualize the nature of the Chinese expert teacher's expertise in the LDS?' (Ding and Jones 2018), and so on.

Having considered the nature of our LDS, we turn to the key processes of our LDS.

The key processes of the LDS

The key processes of each cycle of the LDS are the same as those of the school-based TRG model (Yang and Ricks 2013); (see Figure 2). These cyclic processes might, at the surface, appear to resemble forms of AR or include elements that might resemble AR. Nevertheless, as explained in the foregoing section, the nature of the teachers' action and reflection in each of the cycles in the LDS model (see Figure 1) is different from that in AR (as depicted by Rowell et al. 2015). Here, too, it is necessary for us to point out that the nature and the pattern of the teachers' actions and reflections in our LDS are considerably different from the AE model. This is due to the fact that the majority of teachers in our study were beginning and junior teachers. During the project (see Ding et al. 2014b; Ding, Jones, and Sikko 2017), we found that it was difficult for these young teachers to go through the two hierarchical phases of reflections addressed in the 'three-actions-two-reflections' of the AE model (also see 'conceptual renewal' in reflection one, and 'behaviour improvement' in reflection two; Bai 2009, 148, explains this as a teacher growth model). That is, the young teachers in the LDS could not immediately identify and reflect on the differences between their existing belief and the innovative theoretical ideas from the TRG discussions between the first two cycles. Consequently, they struggled to follow the AE model as a way of continuing to identify, and reflect on, the gap between the implementation of the innovative designs and the immediate learning effect for their pupils during the last two cycles of the AE model. In our LDS, a teacher's action and reflection on the designed lesson were thus simultaneously fostered by the

researcher and the expert teachers through the three cycles of the LDS (see the overlapping part of the cycles we highlighted in Figure 1).

Notwithstanding the challenges, these young teachers' three actions through the LDS model provided rich sources not only for them to make reflections towards 'wisdom of action' in their professional learning, but also for the research team to learn about, and to reflect on, teacher learning; in particular, the learning of those young teachers with little teaching experience (we expand on this aspect of our learning in the next section). Here, we provide Figure 3 to illustrate the relationship between a teacher's action and reflection as professional learning resources both for the teacher and for the whole LDS community. In Figure 3, we use A1–A3 to represent a teacher's three actions and R1 and R2 as the two reflections. As illustrated in the figure, this professional learning process is underpinned by dynamic social interactive systems (such as the mentoring role of the research team and the expert teachers).

In our LDS, the 'three-actions-two-reflections' concurrently address both action and knowledge in the teachers' professional learning process, which includes their simultaneous learning of lesson design (LD in Figure 3) according to the targeted theory and their learning of the act of lesson implementation (LI in Figure 3). The simultaneous emphasis on action and reflection in a teacher's teaching in fact shows our effort to tackle a widely shared, but oversimplified, view of the relationship between knowledge and practical skills in TPD (e.g. how well teachers know their subjects affects how well they can teach). It is commonly assumed that prior knowledge is necessary to guide practice in TPD (e.g. how much and what kind of mathematics schoolteachers need to know and how to use the knowledge in order to teach mathematics successfully). In our LDS, we considered that it was important to understand the nature and patterns of 'wisdom of action' in teachers' professional learning.
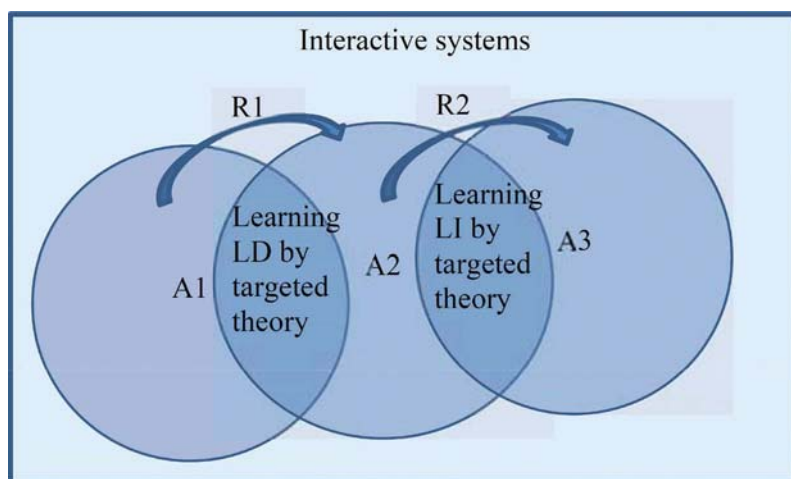

Figure 3. 'Three-actions-two-reflections' in the LDS model (LD = lesson design, LI = lesson implementation).

Having outlined the nature and key process of our LDS, we now turn to the practices.

The practices of the LDS

Though a distinguishing characteristic of AR (as depicted by Rowell et al. 2015) is a choice of data collection and analysis methods, the specific choice in our LDS reflects our epistemological and ontological views of mathematics education and related TPD. These are rooted in Wittmann's (1995) view of mathematics education as a 'design science', viz., Scientific knowledge about the teaching of mathematics . . . presupposes a specific didactic approach that integrates different aspects into a coherent and comprehensive picture of mathematics teaching and learning and then transposing it to practical use in a constructive way. (Wittmann 1995, 356)

The design of the LDS cycles (see Figure 2) chiefly refers to the specific methodology of 'design research' (Gravemeijer 2004). That is, the designed lesson in each of the cycles represents the pedagogical thinking experiment of a targeted theory. The lesson implementation in each of the cycles is thus a teaching experiment to see how the targeted theory works. Our LDS takes van den Akker's (1999) view of the design approach that researchers should not only concentrate on the question of whether a theory yields coherent and accurate predictions, but also ask whether it works – especially whether the theoretical concepts and principles inform practices in productive ways. Moreover, it should be noted that the teaching cycles in the LDS model – the iterative processes – are not solely teaching experiments as tests of preconceived lesson designs (Keli) and the LDS community's effort to provide prescriptions for developing solutions for the key problems that teachers share when teaching a specific topic, but function as learning situations for researchers as well (see Ding and Jones 2018). To this purpose, the LDS entails the dual function of the AE model (Gu and Wang 2003) – to use targeted theories to improve teachers' teaching practices on the one hand; and to build up new scientific hypotheses or theory according to the collected data on the other hand.

The interconnectedness and difference between a LDS and AR

Through our analysis reported above, we summarise the interconnectedness and differences between AR (as characterised by Rowell et al. 2015) and our LDS in Table 2.

Our analysis, as summarised in Table 2, found that the methodological approach, the knowledge developed, and the role of the participants were features that distinguished our LDS from AR (as characterised by Rowell et al. 2015). The blend of action and reflection, and the collaborative effort to develop a form of communicative space (Kemmis 2001) with the aim to support reflection and improve practice, is something that interconnects AR and LDS.

Notwithstanding these findings, and as already noted, the distinguishing characteristics of AR were identified by Rowell et al. (2015) through a study of AERA AR SIG members. The extent to which the characteristics are overly *Westernised* is

one of the issues that we discuss below.

Table 2. The interconnectedness and differences between AR and LDS.

	AR (as characterised by Rowell et al. 2015)	LDS
The differences between AR and LDS	- Researcher's choice of methods. - Simultaneously directed towards teacher self-change and towards restructuring the organisation or institution within which the teacher works. - A process of authentic collaboration with other teachers seeking to improve their practices.	- Researcher follows a specific 'design research' methodology. - Concerns more than the practical questions in one local social context and aims to tackle bigger questions across the social contexts in the subject research field.
The interconnectedness between AR and LDS	Both AR and LDS support teachers learning through their personal and reflective teaching in the form of lessons and contribute directly to school-based teacher professional development	

Discussion

The iterative processes emphasised through the teaching cycles of our LDS model, illustrated in Figures 2 and 3, entail the dual function of our LDS: one being the operational function of the use of the western 'design science' methodology (such as the use of targeted theories to conduct the teaching experiment to support Chinese teachers to improve understanding of students' alternative learning and their teaching practices) and the other being the research function of building new scientific hypotheses or theory according to the data collected through the LDS context in China. This raises two issues.

The first is that our LDS embraces the dual nature of the learning ecology (Cobb et al. 2003); that is, both pupils' learning and teachers' learning in our LDS. In the field of mathematics education research, Cobb et al. (2003, 9) highlight that an important purpose of design experiments study is to contribute to 'a greater understanding of a learning ecology – a complex, interacting system involving multiple elements of different types and levels – by designing its elements and by anticipating how these elements function together to support learning'. The LDS highlights the cultural and educational values underlying the learning ecology; that is, the cultural and educational values of both the leading role of teachers and the active role of students in learning in the Chinese classroom settings. The findings of our LDS indicate that it is important for researchers to be aware of the limitations of theory and its use in different cultural contexts. As such, researchers should not simply concentrate on

studying the effects of the use of the 'introduced western' (or foreign) theoretical frameworks and methods of design study on the development of pupils and teachers in a local school context. In fact, researchers should proceed the other way around. It is necessary for researchers to develop network with practitioners in the local context to see how people may localise, harness and develop the 'introduced western' theories and methods for their own purposes. In so doing, the theoretical framework and methods can be developed and enriched for a much wider application across cultures. For instance, further study on the Chinese teachers' indigenous practice of the teacher-led-and- student-centred learning approach in the Chinese classroom settings (see Ding et al. 2014a, 2015; Ding, Jones, and Sikko 2017; Ding and Jones 2018) would enable better understanding of the comprehensive operational system of task design for the users, both pupils and teachers (Kieran, Doorman, and Ohtani 2015).

In this way, our LDS highlights a number of research issues bigger than the practical questions in one local social context. For instance, the personal and social nature of teachers' professional learning together with the dynamic development of their belief and identity, the relation between teachers' action and reflection in learning targeted theory, the gap between research and practice in the form of 'wisdom of action' beyond the Chinese mathematics classroom (Gu and Wang 2003; Gu and Gu 2016; Ding et al. 2014a, 2015; Ding and Jones 2018), etc. The local expert teachers' teaching expertise, especially the nature of 'wisdom of action', was one of the main research focuses in our LDS. As Gu and Gu (2016, 443) explain, 'wisdom of action' is a kind of practical knowledge that integrates subject knowledge with pedagogical knowledge in the context of purposefully improving action. As the researchers in the LDS, we considered that it was important to understand the nature of 'wisdom of action' and the distinction between theoretical constructs (such as constructivist theory, scaffolding, and so on) and the micro (classroom practice) and macro (the curriculum reforms and the culturally valued philosophy) perspectives of learning viewed by the Chinese expert teachers in the form of their 'wisdom of action' with local classroom practice (i.e. teaching/learning methods called 'Xun Xu Jian Jin', 'gradually deepening learning through an orderly layered teaching procedure' in English, and 'Pu Dian', i.e. procedural variation, in Gu, Huang, and Marton 2004, 340; see also Ding et al. 2015; Ding, Jones, and Sikko 2017). In our LDS, we also aimed to make a contribution towards developing a deeper understanding of the 'black box' of teacher's professional learning (Ding, Jones, and Sikko 2017) and the complexity of teaching expertise in the form of 'wisdom of action' valued in the Chinese mathematics classroom (Ding et al. 2014a, 2015; Ding and Jones 2018).

The second issue raised from the LDS is of the significance of the development of school-based teacher-researcher community for supporting teachers' reflective teaching ('wisdom of action') and narrowing the gap between research and practice in the TPD. Our LDS echoes Bai's (2009) concern that the 'three-actions-two-reflections' of the AE model is difficult for young teachers with limited teaching experiences to practice, even given the mentoring support from the researcher and other experts.

We have highlighted the leading role of the researcher in the LDS in guiding teachers to focus on the 'targeted theory-based teaching' through the LDS model, and the mentoring role of the knowledgeable others (expert teacher) in particular in guiding the teachers to learn the action of the targeted theories. Bai (2009) points out that, in China, university faculty never consider themselves as 'experts', but rather as learners and explorers of the localisation of AR in China.

The LDS model opens the horizontal and vertical nature and various patterns of teachers' professional learning through the dynamic process of their action and reflection (Figures 1–3). In the LDS, the teachers with different teaching experiences and capabilities were engaged into the 'vertical' (depth) dimension of learning (Gu and Wang 2003) on the targeted theories and its classroom practice through the researcher's simultaneous emphasis on both action and reflection and the expert teachers' mentor- ing in particular in learning the act of the targeted theories (Figure 3). The teachers' personal belief and identity were concurrently developed together so that their learning in both width and in depth occurred throughout the social interaction processes of the LDS community. Moreover, our LDS supports Gu's (2014) observation that there is a complexity and dynamic social pattern of teachers' professional learning of knowledge and action. Gu (2014) identified three stages of teacher's professional learning through various kinds of TPD programs: (1) listening [to 'knowledgeable others'] but not under- standing; (2) listening and understanding, but not knowing immediately how to act; (3) listening, understanding, and acting. There is a need to explain the elusive nature and patterns of teachers' professional knowledge and its learning from a more comprehensive theoretical perspective. It is important not only because it would enable understanding of the nature of the individual teachers' change sequences of their beliefs as intentional, systematic and effortful practice through professional learning (Ding et al. 2014b; Ding, Jones, and Sikko 2017), but also because it would enable the development of various operational schemas of the LDS model in ways that meet the teachers' need for personal learning and identity development in their workplace.

Finally, we are aware of the limitations of our paper in identifying the interconnectedness and differences of AR and our LDS using the distinguishing characteristics of AR identified by Rowell et al. (2015). As we note above, the distinguishing characteristics of AR were identified by Rowell et al. (2015) through a study of AERA AR SIG members, and, as such, the characteristics may be overly *Westernised*. Indeed, as Rowell et al. (2017b, 85) explain 'efforts to find a simple common definition [of Action Research] have been difficult, if not impossible', such that 'This difficulty has resulted in a kind of standing invitation for all manner of considerations regarding what constitutes the actual practice of action research'. Our LDS was also not only informed by the 'Action Education' (AE) (Gu and Wang 2003) form of school-based TPD in China, itself informed by 'Western' notions of AR, but also by the Western notions of 'design science' (Cobb et al. 2003; Wittmann 1995; Kieran, Doorman, and Ohtani 2015). In a globalised world, and a globalised research community, the Chinese notion of the TRG as a vehicle for TPD is going to evolve

beyond simplistic notions of 'Western' and 'Eastern'. On top of this, apart from the difference that our LDS follows a specific 'design research' methodology (compared with the depiction of AR where there is a choice of methods), the other differences (viz. the knowledge developed and the role of the participants) have been characteristics within other writings on AR, such as Pine (2008), Rowell and Hong (2017a) and so on. In line with how Rowell et al. (2017b, 99) conclude, the analysis that we report in this paper is offered as a contribution to exploring 'new ways and possibilities informed by our emergent practices'.

Conclusion

One of the contributions of the LDS is its focus on the teachers' implementation of the reformed textbooks and theoretical ideas through designing and acting on the targeted- theory-based teaching. At the research level, we consider that it is necessary for researchers to commit to narrowing the gap between research and practice and to work side-by-side with practitioners in the real school world to develop innovations in research design, so as to uncover the dynamic action process of teachers both in depth and in width and eventually help to solve teachers' problems and develop their fundamental understanding and commitment in their profession. In our future study we aim to examine in depth the functions of the significant elements embedded in the cycles of the LDS – namely encompassing the use of 'design research method', 'the dual function of the LDS model' and 'the LDS community in practice' – that enable teachers to develop deep dimension learning in the form of 'wisdom of action'. What is more, given that action researchers in China are currently calling for the adaptation of AR to the characteristics of schools in China, and for building up a Chinese version of AR that is suited to the Chinese context, friendly to Chinese teachers, and congruent with the traditional approach to teacher learning (Bai 2009; Liu and Wang 2018; Yuan 2017), then our contribution to identifying the interconnectedness and difference of AR and our LDS may help to inform such endeavours.

Acknowledgement

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Liping Ding   http://orcid.org/0000-0002-8986-271X
Keith Jones   http://orcid.org/0000-0003-3677-8802
Svein Arne Sikko   http://orcid.org/0000-0001-9423-5764

References

Bai, Y. 2009. "Action Research Localization in China: Three Cases." *Educational Action Research* 17 (1): 143–154. doi: 10.1080/09650790802667543.

Cobb, P., J. Confrey, A. diSessa, R. Lehrer, and L. Schauble. 2003. "Design Experiments in Educational Research." *Educational Researcher* 32 (1): 9–13. doi: 10.3102/0013189X032001009.

Ding, L., and K. Jones (2018). "Conceptualizing an Expert Teacher's Expertise in a Lesson Design Study in Shanghai." In *Proceedings of the 42nd Conference of the International Group for the Psychology of Mathematics Education*. Umeå, Sweden: PME.

Ding, L., K. Jones, L. Mei, and S.A. Sikko. 2015. "'Not to Lose the Chain in Learning Mathematics': Expert Teaching with Variation in Shanghai." In *Proceedings of the 39th Conference of the International Group for the Psychology of Mathematics Education*, edited by Kim Beswick et al., 209–216. Vol. 2. Hobart, Australia: PME.

Ding, L., K. Jones, and B. Pepin. 2013. "Task Design through a School-Based Professional Development Programme." In *Proceedings of the ICMI study 22: Task Design in Mathematics Education*, edited by C. Margolinas, 443–451. Oxford, UK: University of Oxford. doi: 10.1037/ a0030967.

Ding, L., K. Jones, B. Pepin, and S.A. Sikko. 2014a. "An Expert Teacher's Local Instruction Theory Underlying a Lesson Design Study through School-Based Professional Development." In *Proceedings of the 38th Conference of the International Group for the Psychology of Mathematics Education*, edited by Peter Liljedahl et al., 401–408. Vol. 2. Vancouver, Canada: PME.

Ding, L., K. Jones, B. Pepin, and S.A. Sikko. 2014b. "How a Primary Mathematics Teacher in Shanghai Improved Her Lessons on 'Angle Measurement'." In *Proceedings of the 8th British Congress of Mathematics Education*, edited by S. Pope, 113–120. Nottingham, UK: BCME.

Ding, L., K. Jones, and S.A. Sikko. 2017. "An Expert Teacher's Use of Teaching with Variation to Support a Junior Mathematics Teacher's Professional Learning." In *Teaching and Learning Mathematics through Variation: Confucian Heritage Meets Western Theories*, edited by R. Huang and L. Yeping, 241–266. Rotterdam: Sense Publishers.

Edwards, J.-A., and K. Jones. 2003. "Co-Learning in the Collaborative Mathematics Classroom." In *Collaboration in Teacher Education: Examples from the Context of Mathematics Education*, edited by A. Peter-Koop, V. Santos-Wagner, C. Breen, and A. Begg, 135–151. Dordrecht, NL: Kluwer.

Gravemeijer, K. 2004. "Local Instruction Theories as Means of Support for Teachers in Reform Mathematics Education." *Mathematical Thinking and Learning* 6 (2): 105–128. doi: 10.1207/ s15327833mtl0602_3.

Greeno, J.G. 1998. "The Situativity of Knowing, Learning and Research." *American Psychologist* 53 (1): 5–26. doi: 10.1037/0003-066X.53.1.5.

Gu, F., R. Huang, and L. Gu. 2017. "Theory and Development of Teaching through Variation in Mathematics in China." In *Teaching and Learning Mathematics through Variation: Confucian Heritage Meets Western Theories*, edited by R. Huang and L. Yeping, 13–41. Rotterdam: Sense Publishers.

Gu, F., and L. Gu. 2016. "Characterizing Mathematics Teaching Research Specialists' Mentoring in the Context of Chinese Lesson Study." *ZDM Mathematics Education* 48: 441–454. doi: 10.1007/ s11858-016-0756-1.

Gu, L., and J. Wang. 2003. "Teachers' Development through Education Action: The Use of 'Keli' as a Means in the Research of Teacher Education Model." *Curriculum, Textbook & Pedagogy*, 9–15 & 2, 14–19. Vol. I. [教师在教育行动中成长—以课例为载体的教师教育模式研究. 课程一教材一教法, 2003, 第一期, 9–15; 第二期, 14–19.].

Gu, L. 2014. *A Statement of Pedagogy Reform: Regional Experiment and Research Record*. Shanghai: Shanghai Education Press. [顾泠沅著.口述教改一 地区实验或研究纪事. 上海教育出版社].

Gu, L., R. Huang, and F. 2004. "Teaching with Variation: A Chinese Way of Promoting Effective Mathematics Learning" In *How Chinese Learn Mathematics: Perspectives from Insiders*., edited by Lianghuo Fan, Ngai-Ying Wong, Jinfa Cai, and Shiqi Li, 309–347. Singapore: World Scientific.

Huang, R., Z. Gong, and X. Han. 2016. "Implementing Mathematics Teaching that Promotes Students' Understanding through Theory-Driven Lesson Study." *ZDM Mathematics Education* 48 (4): 425–439. doi:10.1007/s11858-015-0743-y.

Kemmis, S. 2001. "Exploring the Relevance of Critical Theory for Action Research: Emancipatory Action Research in the Footsteps of Jurgen Habermas." In *Handbook of Action Research: Participative Inquiry and Practice*, edited by P. Reason and H. Bradbury, 91–102. London: SAGE.

Kieran, C., M. Doorman, and M. Ohtani. 2015. "Frameworks and Principles for Task Design." In *ICMI Study 22: Task Design in Mathematics Education*, edited by A. Watson and M. Ohtani, 19–81. Cham, CH: Springer.

Liu, W., and Q. Wang. 2018. "The Processes of Teachers' Engagement in Action Research: An Ethnographic Study in Beijing." *Educational Action Research* 26 (2): 258–272. doi: 10.1080/ 09650792.2017.1307128.

MOE (Ministry of Education China). 2001. *Mathematics Curriculum Standards (Experimental Version)*. Beijing: Beijing Normal University Press.

MOE (Ministry of Education China). 2011. *Mathematics Curriculum Standards*. Beijing: Beijing Normal University Press.

Pang, M.F., and F. Marton. 2017. "Chinese Lesson Study, Learning Study and Keys to Learning." *International Journal for Lesson and Learning Studies* 6 (4): 336–347. doi: 10.1108/IJLLS-01-2017- 0005.

Pine, G.J. 2008. *Teacher Action Research: Building Knowledge Democracies*. Thousand Oaks, CA: Sage.

Rowell, L.L., and E. Hong. 2017a. "Knowledge Democracy and Action Research: Pathways for the Twenty-First Century." In *The Palgrave International Handbook of Action Research*, edited by L.L. Rowell, C.D. Bruce, J.M. Shosh, and M.M. Riel, 63–83. New York: Palgrave Macmillan.

Rowell, L.L., E.Y. Polush, M. Riel, and A. Bruewer. 2015. "Action Researchers' Perspectives about the Distinguishing Characteristics of Action Research: A Delphi and Learning Circles Mixed-Methods Study." *Educational Action Research* 23 (2): 243–270. doi: 10.1080/09650792.2014.990987.

Rowell, L.L., M.M. Riel, and E.Y. Polush. 2017b. "Defining Action Research: On Dialogic Spaces for Constructing Shared Meanings." In *The Palgrave International Handbook of Action Research*, edited by L.L. Rowell, C.D. Bruce, J.M. Shosh, and M.M. Riel, 85–101. New York: Palgrave Macmillan.

van den Akker J. 1999. "Principles and Methods of Development Research". In *Design Approaches and Tools in Education and Training*, edited by J. van den Akker, R. M. Branch, K.t Gustafson, N. Nieveen, and T. Plomp, 1–14. Dordrecht: Springer.

Wittmann, E.C. 1995. "Mathematics Education as a 'Design Science'." *Educational Studies in Mathematics* 29 (4): 355–374. doi: 10.1007/BF01273911.

Wood, K. 2017. "Is There Really Any Difference between Lesson and Learning Study?: Both Focus on Neriage." *International Journal for Lesson and Learning Studies* 6 (2): 118–123. doi: 10.1108/ IJLLS-02-2017-0008.

Yang, Y., and T.E. Ricks. 2013. "Chinese Lesson Study: Developing Classroom Instruction through Collaborations in School-Based Teaching Research Group Activities." In *How Chinese Teach Mathematics and Improve Teaching*, edited by L. Yeping and R. Huang, 51–65. New York: Routledge.

Yuan, L. 2017. "The Status of Action Research in the People's Republic of China: A Review of Recent Literature." In *The Palgrave International Handbook of Action Research*, edited by L.L. Rowell, C. D. Bruce, J.M. Shosh, and M.M. Riel, 299–309. New York: Palgrave Macmillan.