

Pedagogical Tensions in Teacher's Questioning Practices in the Mathematics Classroom: A Case in Mainland China

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ABSTRACT

During the last decades, curriculum reform has been implemented in mainland China to emphasize classroom interaction in mathematics teaching and learning. The intention to create more chances for classroom interaction in large-size classrooms has led to the introduction of self-learning guide which allows students to go through the learning contents before the classroom learning. This study investigates the pedagogical tensions emerging in a mainland Chinese mathematics teacher's practices of using self-learning guide to reform classroom questioning. The analytical entry point is the examination of the IRF (Initiation/Response/Follow-up) structures evident in the reform-based mathematics classroom interactions. The results show that, by using various reform-based questioning strategies, students were given adequate opportunities to present and share their mathematical thinking and ideas. The nature of the pedagogical tensions has shifted from *imbalance of time allocation for classroom discussion and lecturing* to *imbalance of opportunities for guided classroom discussion and elaborated classroom discussion*.

Keywords: teacher questioning, reform-based, pedagogical tensions, Chinese, mathematics

INTRODUCTION

Recent reforms in mathematics curriculum worldwide call for a shift of the focus from learning results to learning processes, emphasising students' construction of mathematics through communication and discussion (NCTM, 2000; Ministry of Education (China), 2001). This transformation directed the research in classroom teacher questioning to focus on teachers' approaches to facilitate and promote students' engagement and opportunities to talk and communicate their mathematical thinking, and teachers' strategies for orchestrating and building on students' contributions (Aizikovitch-Udi, Clarke, & Star, 2013; Boaler & Brodie, 2004; Frank et al., 2009; Stein, et al., 2008).

In Mainland Chinese, students have been outperforming their peers elsewhere in the world in international tests (OECD, 2010, 2014), but high academic achievements do not mean school mathematics curriculum and classroom mathematics teaching and learning in mainland China is perfect. As a matter of fact, many problematic issues about Chinese students' mathematics learning were also posed and discussed by educational researchers. For example, Chinese students were reported to be more fluent in solving routine mathematics problems than their counterparts in other nations, but when solving non-routine mathematics problems Chinese students tend to have more difficulties (Cai & Lester, 2005; Li & Ni, 2011). Chinese students were less likely to use creative ways and take risks in mathematics problem solving than students in US (Cai & Cifarelli, 2004). School education in China was blamed for emphasizing exam-oriented learning and thereby "either indifferent to or suppressive of" the cultivation of students' creativity (Zhao, 2009). In addition, conventional mathematics classroom in mainland China has been characterized as teacher-dominated and students' low participation (Li & Ni, 2011; Zhao, Mok & Cao, 2016).

Contribution of this paper to the literature

- This study presents mathematics teacher's strategies to reform classroom interaction so as to increase students' participation in classroom communication, which provides a case of how mainland Chinese mathematics classroom teaching and learning is evolving in the changing context of curriculum reform.
- This study shows that the IRF sequences can be very productive in promoting students' mathematics understanding, and thereby presents the sophisticated nature and diverse functions of IRF (Initiation/Response/Follow-up) sequences in classroom interactions. This suggests the limitation of the previous literature's criticism that IRF sequences are often associated with constraints on students' opportunities to talk in classroom interaction.

In the past decades, the Chinese government has been committed to reforming school mathematics curricula and classroom instruction. The new mathematics curriculum standards were released and implemented in 2001 and then updated in 2011 (Ministry of Education, 2001, 2011). The main objectives concern the shift from an overemphasis on knowledge delivery to interactive and constructive learning, aiming to provide students with more opportunities to participate and make contributions in the construction of knowledge (Li & Ni, 2011).

Undoubtedly, it will never come easily to fulfil the goals of any curriculum reform. But the diversity of demographic, societal and educational situations in mainland China makes it even more challenging. The average class size in mainland China, when compared with other nations, is much larger, with 38 students sharing one classroom in primary schools on average and 50 students in lower secondary schools (OECD, 2015). Obviously, the overcrowded class is a huge obstacle that teachers have to overcome while making efforts to encourage and facilitate students' participation in classroom discussions and to promote peer interactions. Meanwhile, the existence of high-stake examinations and their highly competitive nature tend to compel the teachers to deliver and practise mathematics formulae and procedures covered in the tests instead of focusing on the reform initiatives. Besides, most of the teachers have not experienced the new way of teaching and learning mathematics neither as teachers or students. Although educational departments designed a range of teaching materials and teacher training programs to support the implementation of curriculum reform, these are far from satisfying the diverse demands of 11,595,664 teachers (Ministry of Education, 2013) all over mainland China. Thus, insufficient support and teacher training left mathematics teachers a lack of knowledge and confidence or even a feeling of strong resistance to implement reform-based instructions (Law, 2014). As documented by Li and Ni (2011), compared with the conventional classrooms, changes in the nature of classroom discourse were not prominent in the so-called reform mathematics classrooms, although the utilisation of reform-based textbooks is mandatory in these classrooms.

As a resolution to manage the dilemma and tensions faced by mathematics teachers in mainland China, a new learning resource called the "self-learning guide" was designed and introduced by some school mathematics teachers and then has been increasingly adopted in mathematics classrooms (Zhang & Meng, 2013). The purpose of the self-learning guide is to allow students to preview and explore new topics by attempting to solve some investigation tasks prior to the formal classroom instruction. Then during the formal classroom instruction, teacher and students could engage in revisiting, discussing and reflecting on these tasks, which would act as a springboard for the construction and development of new mathematics knowledge. Therefore, by introducing the self-learning guide, more time could be allocated for classroom discussion and communication and students could be provided with more opportunities to share and communicate their mathematical thinking. However, more time and opportunities for students' talk don't necessarily guarantee productive teacher-student interaction which could be substantially influenced by how the teachers orchestrate and build on students' thinking and contributions (Franke, et al, 2009; Wood, 1998). Therefore, further studies are needed to examine the effects of the self-learning guide on reforming mathematics classroom communication and discussion in mainland China.

This study intends to investigate one mathematics teacher's questioning practices in a mainland Chinese reform-based classroom where the self-learning guide was used to facilitate the implementation of constructive and interactive learning. In particular, this study analyses the degree to which the teacher's strategies of utilising with the self-learning guide to manage the tensions related to classroom communication and discussion in reform-based mathematics class.

LITERATURE REVIEW

Pedagogical Tensions

In the context of classrooms, tensions, or dilemma, usually mean a strained state or condition resulting from a variety of conflicting or even contradictory pedagogical or societal demands either originating inside the classroom

(e.g., students' individual meaningful learning) or outside the classroom (e.g., external high-stake examinations) (Berry, 2007; Fregola, 2011; Kennedy, 2006). Many researchers pointed out the unsolvable nature of the tensions involved in the teaching of mathematics and thereby advocated for managing the tensions instead of attempting to solve them (Fregola, 2011). The implementation of curriculum reform normally calls for substantial changes regarding the ways of teaching and learning in classrooms. Inevitably, these changes will bring out tremendous tensions to teachers daily instructions. Teachers' conscious or unconscious management of these tensions thereby shapes their decision-making and prioritisation in lesson preparation and implementations. Therefore, the exploration of teachers' strategies in tensions management could help to understand teachers' instructional practices within the context of curriculum reform more clearly and deeply (Manouchehri & Goodman, 1998).

Teacher Questioning

Classroom interactions are usually initiated by teacher questioning. Many researchers claimed that effective employment of questioning strategies can be very challenging because asking productive questions is such a highly sophisticated art that requires considerate teaching experiences and pedagogical content knowledge (Boaler & Brodie, 2004; Frank et al., 2009). Within a limited period of time in a lesson, once classroom discussion is opened up by teacher questions, it is quite easy to become off the track and sometimes drift aimlessly without teachers' tactical guidance and orientation. However, teachers' over-control of classroom communication and leading questions tend to comprise students' opportunities of sharing and communicating mathematical ideas, making the implementation of constructive and interactive learning perfunctory and superficial. Therefore, when using questioning strategies, the teachers need to create as sufficient opportunities as possible for students to express and communicate their mathematics ideas on the one hand, but on the other hand the teachers ought to ensure the productivity of mathematics communication and the accomplishment of the lesson goals (Sherin, 2002; Stein, 2000). The above tensions will be intensified in the situation where the teachers are new to the reform-based teaching approaches. As claimed by some researchers (Stein, et al., 2008; Orrill, 2013), mathematics teachers tend to feel frustrated and exhausted to adapt themselves to the new pedagogy. These tensions need to be taken into consideration so as to better understand and thereby improve teacher questioning strategies in reform-based classrooms.

The Use of Self-Learning Guide in Mathematics Classroom

Self-learning, also called self-directed learning or self-directed learning is not a new concept in the fields of education and psychology. Some researchers analyzed the characteristics of self-regulated mathematics learners, claiming that during self-regulated learning learners experienced a sophisticated cognitive process including analyzing tasks, evaluating problem-solving strategies, and decision making (Butler, 2002; Zimmerman, 2002). Therefore, successful learners with self-regulated learning experiences are more flexible in solving mathematics problems than those learners who get used to teacher-directed learning (Butler, 2002). Some other researchers examined the approaches used by the teacher to promote students self-learning. For example, Travers and Scheckley (2000) identified four instructional practices that could facilitate students' self-learning: (1) guidance on students' self-belief, (2) promotion of classroom reflective dialogues, (3) making connections among abstract concepts, and (4) assisting students to link new experiences to previous learning.

In mainland China, self-learning is connected with mathematics curriculum reform. The self-learning guide was developed by the teachers to facilitate the changes in the ways of students' mathematics learning (Zhang & Meng, 2013). In other words, students study mathematics concepts and knowledge using self-learning guide in the first place and then the teacher organizes a classroom discussion to allow students share and communicate mathematics thinking in classroom. As some researchers (Zhang & Meng, 2013) claimed, there are some similarities between the teaching with self-learning guides and the flipped classrooms where students are asked to go through the new material or instructional content (mostly via watching lecture videos) as homework and then the majority of lesson time will be used to more in-depth problem solving, discussions or collaborations (Bergmann & Sams, 2012; Tucker, 2012). Both initiatives are distinct from traditional way of instruction in local cultural settings, with a purpose of allocating more time to engage more students with higher-level classroom learning. However, it is worthwhile mentioning that no lecture videos tend to be used in teaching with self-learning guide and the tasks included in self-learning guide usually require investigation rather than simply procedure repetition or calculation.

Re-examination of Initiation-Response-Follow-up

According to Cazden (2001), classroom lessons could be interpreted as a process of alternating communicative acts, involving verbal and nonverbal behaviour that are jointly created by teachers and students and these alternations are characterised by interactional sequences of three interconnected parts: teacher *initiation*, student *response* and teacher *follow-up* or IRF. In the past few years, the IRF structure has been criticized as "teacher-

dominated", "procedure-bound", and this structure tends to constrain the potential of teacher-pupil dialogue in promoting pupils' conceptual learning in mathematics classrooms (e.g., Drageset, 2014; Franke,). However, there have been an increasing number of investigations revealing that the IRF pattern includes many more possible variations which could fulfil a diverse range of pedagogical purposes, such as providing students with more opportunities to verbalize their mathematical thinking and encouraging students to engage in more sophisticated mathematical reasoning (Drageset, 2014; Nathan & Kim, 2009; Tsay, Judd, Hauk & Davis, 2011). Furthermore, the investigation of IRF pattern in classroom discourse would help to unpack teachers' intentions regarding questioning strategies. For example, Smith and Higgins (2006) argued that teachers' intentions behind questioning practices will not be fully unconcerned without the examination of IRF sequences where teacher questions are used.

It is worthwhile to stress that teacher questioning is not the only strategy to engage students in mathematics communication and discussion, which could otherwise be facilitated, for example, by introducing a variety of group activities or stimulation games involving students' listening, sharing and critiquing of mathematical ideas (Fregola, 2011). However, as uncovered by the previous studies, the majority of classroom interaction were initiated by teacher questioning and appeared in the structures of IRF (Franke, et al., 2009). So the examination of teacher questioning in IRF structures is of significance to the establishment of a desirable environment for rich mathematics communication and discussion.

In summary, the examination of pedagogical tensions in mathematics teachers questioning practices could advance our understanding of the transformation of mathematics communication and discussion in reform-based mathematics classes. And the IRF framework could serve a powerful tool to further our attempts to investigate teacher questioning practices. In this study, the following research questions are investigated and discussed:

- (1) With the introduction of the self-learning guide, how did the participating mathematics teacher in mainland China employ questioning strategies to reform classroom communication and discussion?
- (2) How well did the participating mathematics teacher in mainland China manage the pedagogical tensions between creating sufficient opportunities for students' participation in classroom discussion and maintaining classroom discussion's productivity and lesson goals' completion?

METHODOLOGY

Research Design

A case study design was adopted in the present study so as to undertake a detailed analysis of how well a teacher used the self-learning guide to facilitate the reform-based mathematics classroom instructions. Since this study aims to reveal the detailed and in-depth features of teacher questioning practices in reform-based mathematics classrooms, there is a need to utilize a case study design which could provide tools for researchers to explore complex phenomena within the research setting (Baxter & Jack, 2008) and to understand "the meaning individuals or groups ascribe to a social or human problem" (Creswell, 2009, pp.4). To this end, a representative reform-based class containing rich information about teacher-student communication and the integral use of the self-learning guide is the particularly satisfactory choice of data collection.

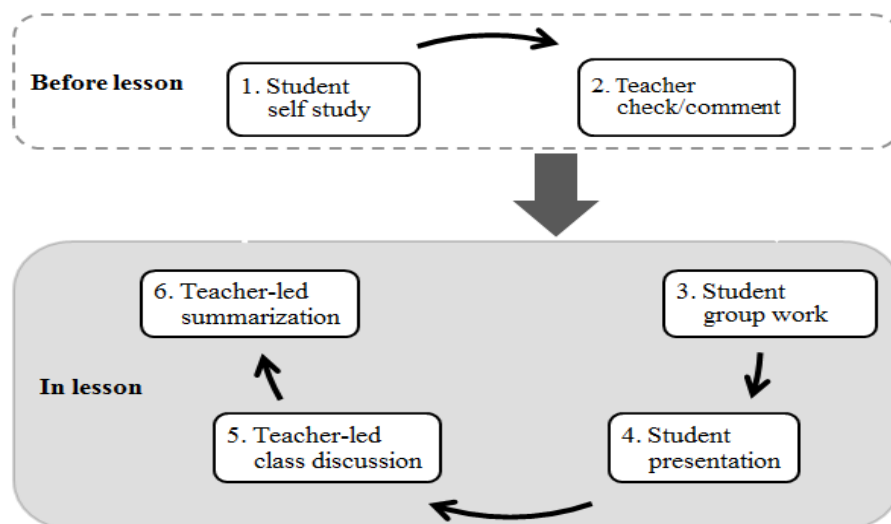
Setting and Participants

In this study, data were collected in a junior high school in the City of Nantong, Jiangsu Province located in the eastern coast of mainland China. The participants were one male teacher and his forty-six students (23 females and 23 males) in a year eight class. Jiangsu province was selected as one of the experimental provinces for the implementation of new mathematics curriculum. Therefore mathematics teachers in Jiangsu Province are the pioneers in carrying out new mathematics curriculum and have more experience in the exploration of teaching with the reform-based textbooks.

The participating teacher has had 16 years of teaching experience, holding a bachelor's degree in mathematics and a teaching certification diploma. He is the school leading teacher in mathematics and quite passionate in reforming the traditional ways of teaching and learning mathematics. The 46 participating students in this class were divided into 8 heterogeneous groups. In every group, the group members varied in mathematics competence or capabilities, but the set of group members in each group was fixed for the mathematics class. A group leader was appointed to mediate group members' cooperation.

Table 1. Lesson Topics

	Lesson content	Time
Lesson1	An introduction to quadratic functions	45mins
Lesson2	Investigating the graph of $y=ax^2$	45mins
Lesson3	Investigating the graph $y=ax^2+k$	45mins

**Figure 1.** The regular structure of a lesson in this study

Data Collection

Video-recorded observations of the participating teacher's lessons were collected with three cameras separately capturing the behaviours of the teacher, the whole class and a group of focus students. At the time of data collection, the self-learning guide had been used in the classroom for around two years.

The topic of quadratic functions was chosen for data collection. The reason is that this topic is important for students' appreciation of mathematics as a discipline and it is a very significant learning content included in school mathematics curriculum for both mainland China and elsewhere. A whole unit of consecutive lessons about the topic of quadratic functions was documented and the analysis of the first three lessons was presented in this study. The contents of the lessons are listed above in [Table 1](#).

Structure of the Lessons

For each lesson, the teacher had established a regular structure which had been used for around two years at the time of data collection. The regular structure of each lesson can be summarized as six steps as follows and these six steps are illustrated in [Figure 1](#).

- (1) One day before every mathematics lesson, the teacher passed out the self-learning guides to every student, asking them to learn the new topic on their own and then to accomplish the tasks in self-learning guide independently.
- (2) The next day, students handed in the self-learning guides to be corrected by the teacher, who would give detailed written comments and then passed out the corrected self-learning guides to students before the lesson. Thus, prior to every new lesson, all students had walked through the tasks about the new lesson in the self-learning guides and also had their answers commented or corrected by the teacher.
- (3) At the beginning of the lesson, the teacher asked students to exchange ideas in their groups on the tasks in the self-learning guide, as well as on the solutions to the tasks.
- (4) After discussion and exchange in groups, one group was selected by the teacher to present in public the unanimously agreed ideas they had achieved on how to solve the tasks and each member of this selected group was responsible for one part of the whole group's presentation.
- (5) After each member accomplished his/her part of the presentation, other students were encouraged to give comments and ask questions. The teacher would generally get involved in this part and direct the public discussion.

Self-learning design	My thoughts
<p>Review and thinking</p> <p>The graph of a linear function is ____; the graph of an inversely proportional function is _____. Generally speaking, how to sketch the graph of a function?</p> <p>Do you remember how to sketch the graph of a linear function using the method of plotting points?</p>	

Figure 2. Questions/tasks for review in the self-learning guide

Self-learning design	My thoughts																				
<p>Hands-on practice</p> <p>Sketch the graph of the simplest quadratic function $y=x^2$.</p> <p>(1) By examining the expression $y=x^2$, it can be seen that x could be any real number. Set up a table to represent pairs of corresponding values:</p> <table border="1" style="margin-left: 40px;"> <tr> <td style="text-align: center;">x</td> <td style="text-align: center;">...</td> <td style="text-align: center;">-3</td> <td style="text-align: center;">-2</td> <td style="text-align: center;">-1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">...</td> </tr> <tr> <td style="text-align: center;">$y=x^2$</td> <td style="text-align: center;">...</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td style="text-align: center;">...</td> </tr> </table> <p>(2) Plot the points in a Cartesian coordinate system.</p> <p>(3) The graph of $y=x^2$ is obtained by joining all the points with a smoothly curved line.</p> <p>Observing the graph and thinking</p> <p>For the graph of the quadratic function $y=x^2$,</p> <ol style="list-style-type: none"> For $x<0$, as the x value gets larger, how is the y values changing? What is the graph's trend of change when $x>0$? For what x values, the corresponding y value is the minimum? Explain your answer. Is the graph symmetric with respect to a line? If so, what is the axis of symmetry? Please find out several pairs of two points that are symmetric with respect to the axis of symmetry. 	x	...	-3	-2	-1	0	1	2	3	...	$y=x^2$	
x	...	-3	-2	-1	0	1	2	3	...												
$y=x^2$												

Figure 3. Questions/tasks for new topics in the self-learning guide

- When the whole group completed the presentation, the teacher always gave a short concluding lecture, to sum up the presentation and discussion, as well as the main mathematical points in the lesson.

The Use of the Self-Learning Guide

The self-learning guides tend to vary a lot in the contents depending on different teachers and instructional purposes. The self-learning guides collected in this study consisted mainly of two sections, namely "review tasks" and "tasks for new topics". The section of "review tasks" included review questions or tasks requiring students to recall and apply mathematical knowledge taught previously. By designing these questions and tasks, the teacher expected the students to re-familiarise themselves with the prior mathematics knowledge and thereby to apply this knowledge in the new lesson, as well as make connections between the old and new mathematics knowledge. A sample of "review tasks" in the self-learning guide is presented in Figure 2. In the section of "tasks for new topics", the students were required to solve some new tasks so as to investigate and make sense of the new topic. A sample of "tasks for new topics" in the self-learning guide is presented in Figure 3.

Within each section, there was a separate space called "my thoughts" in the self-learning guide (see the right column "My thoughts" in Figure 2 and Figure 3) and the students were encouraged to write down any comments, thoughts, or questions that occurred to them when working on the tasks. These comments could be used later in the classroom for group or whole-class discussion. Sometimes the teacher would select and present some students' comments in public and at other times the students would also be encouraged to stand in front of the whole class and present their ideas or comments by themselves.

Data Analysis

In this study, the term "question" refers to what the teacher said to elicit students' verbal responses related to mathematical content. Questions that were not mathematical were excluded unless they were associated with other mathematical "talk". Questions that were immediately repeated using the same wording were counted only once.

Table 2. Sub-categories for Initiation Questions

Category	Description
Understanding check (UND)	Questions used to check whether students can understand the teacher's actions and statements.
Evaluation (EVA)	Questioning requiring students' comments.
Review (REV)	Questions used to elicit the previously learnt or mentioned mathematics knowledge.
Information extraction (INF)	Questions requiring students to identify and select information from text descriptions, graphs, tables, or diagrams.
Link/application (LIN)	Questions requiring students to provide examples or to apply mathematical knowledge.
Result/product (RESL)	Questions requiring results of mathematical operations or the final answer of the problem solving.
Strategy/procedure (STR)	Questions used to elicit the procedures or strategies of problem-solving.
Explanation (EXP)	Questions requiring students to provide explanations.
Comparison (COM)	Questions requiring students to make comparisons.
Reflection (REC)	Questions requiring students' reflection after mathematical activities.
Variation (VAR)	Questions requiring students to consider a problem for which certain aspects vary while the other aspects are kept the same as a previous problem.

The IRF structure in the classroom was used to serve as a window to analyse teacher-student interaction. Teacher questioning practices were examined within the IRF structure. Three types of occasions when the teacher interacted with students by using questions were identified first. Where the student/s replied to teacher questions and the teacher did not respond, these interactions were categorised as Question-Answer (Q&A) pairs. IRF (Teacher Initiation-student Response-teacher Follow-up) sequences (Cazden, 2001) were those where the teacher responded to students' answers that were triggered by the previous teacher question. There are two types of IRF sequences: (1) IRF (single) in which the teacher asks a question and then gives closed follow-up moves (such as evaluation) to students so as to accomplish the current discussion, and (2) IRF (multiple) in which the teacher asks a question and then gives open follow-up moves such as clarification or elaborations that require a further student response. The second type has the effect of extending the discussion and the associated IRF sequence. The episodes of Q&A pairs, the sequences of IRF (single) and IRF (multiple) were transcribed prior to the analysis.

When analyzing teacher questions, a distinction was made between initiation questions and follow-up questions. Initiation questions are those questions asked by teachers for the purpose of starting a conversation or discussion. In contrast, follow-up questions are those questions asked for the purposes of responding to a student utterance, such as a student's answer or response to the teacher's previous question. In this study, the Q&A pair contains teacher initiation questions and student responses, the IRF (single) contains teacher initiation questions, student responses and teacher feedback, and the IRF (multiple) includes the teacher initiation questions, student responses, and teacher follow-up questions.

A coding system was developed to categorise the initiation questions and follow-up questions. Instead of inventing the name of each possible category in advance, those questions documented in our data were analyzed first and then attempts were made to provide names to describe these different kinds of questions. The development of the coding system in this study was also informed by the research of Boaler and Brodie (2004) and Hiebert and Wearne (1993), whose classification schemes included question categories closely aligned with some of the question types identified in this study. It is noteworthy mentioning that there are some previous studies focusing on the categorization of teacher verbal actions and on the analysis of teacher-student interaction in mathematics classrooms (Mesa, Celis & Lande, 2014; Mesa & Lande, 2014; Scherrer, & Stein, 2012). But since this study aims mainly to analyze teacher questioning strategies in reform-based classrooms, the coding systems in the above-mentioned studies were not adopted and applied in this study. The coding systems are presented in **Table 2** and **Table 3** in which each question category is associated with a three-letter code.

One lesson was selected for reliability check and two researchers independently coded the questions in the transcripts of the selected lessons. An agreement of 93.2% was achieved between the two researchers' coding results and the inconsistent coding results were discussed and resolved by either combining categories or refining the categories' descriptions. Afterwards, the first author coded all the remaining lessons with the revised coding systems. The identified questions were not coded in isolation. They were instead all coded within the context where the questions were asked.

Table 3. Sub-categories for Follow-up Questions

Category	Description
Clarification (CLA)	Questions requiring a student to show more details about his/her answers or solutions.
Justification (JUS)	Questions requiring students to justify their answers
Elaboration (ELA)	Questions requiring additional information, especially when the students fail to fully achieve the teacher's goals.
Extension (EXT)	Questions used to extend the topics under discussion to other situations or to connect the knowledge under discussion with the students' previous knowledge.
Supplement (SUP)	Questions used to request supplementary knowledge, examples or approaches.
Cueing (CUE)	Questions used to direct students to focus on key elements or aspects of the problem situation in order to enable problem-solving.
Refocusing (REC)	Questions used to guide students to refocus on the key points, especially when students are off the right track.
Repeat/re-phrase (REP)	The teacher repeats or rephrases the question asked in the last turn.
Agreement request (AGG)	Questions used to check whether the rest of the class agrees with the student who gives the answer.

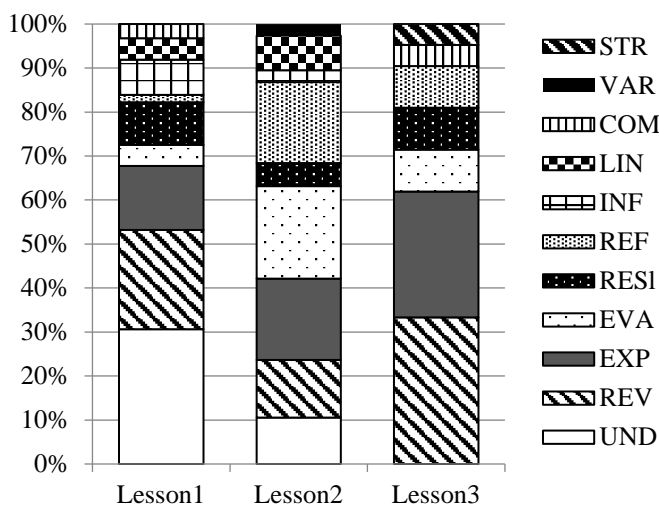


Figure 4. The breakdown of the teacher's initiation questions

RESULTS

The coding systems presented above were applied to analyse the selected lessons taught by the participating teacher. In total, 121 initiation questions and 116 follow-up questions were asked by the Chinese teacher in three lessons which covered 135 minutes altogether. On average, the Chinese teacher initiated approximately 1.8 (237/135) questions in every minute to elicit student responses. And for every initiation question, the Chinese teacher used approximately one (116/121) follow-up question. The detailed information in terms of the breakdown of initiation questions and follow-up questions is shown separately in **Figure 4**, **Figure 5** and **Figure 6**. For the abbreviations employed in these figures, please refer to **Table 2** and **Table 3**.

For What Initiating Purposes did the Teacher Ask a question?

Figure 4 shows the proportion of each type of initiation question that was asked in the three lessons and this outlines the teacher's initial purposes when asking initiation questions. As is shown in **Figure 4**, although 11 types of initiation questions were identified in the three lessons, several types of initiation questions were predominant in each lesson. For lesson 1, the teacher's initiation questions were mainly asked for the purpose of understanding check (UND), review (REV), and explanation request (EXP). There are more variations in Lesson 2, where the teacher asked initiation questions mainly for understanding check (UND), review (REV), explanation request (EXP), evaluative comments request (EVA), and reflection request (REF). Two types of initiation questions, namely review (REV) and explanation request (EXP), take up more than 60 percent of all the initiation questions asked in Lesson 3.

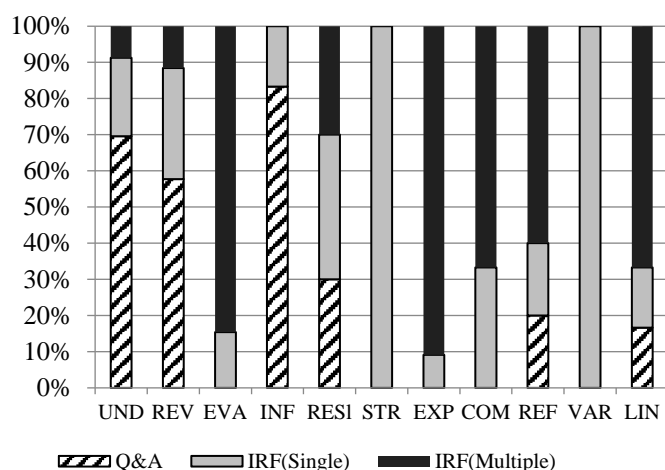


Figure 5. The teacher's initiation questions on three occasions

Among the three lessons, questions for review (REV) and explanation request (EXP) were the two most common types of initiation questions. Apart from these two common types, questions were also asked rather frequently for the purpose of understanding check (UND), evaluative comments request (EVA), and reflection request (REF), even though these types did not occur to the same extent in every lesson.

Theoretically, all these types have the potential of allowing students to express mathematics except the questions for understanding check (UND), which usually required only a "yes" or "no" answer. In particular, explanation requests (EXP), evaluative comment requests (EVA), and reflection requests (REF) are more likely to elicit students' mathematics ideas, on the basis of which the teacher could thereby provide facilitation and request for elaboration. In this way, mathematics communication could occur between the teacher and students. However, it would depend on the teacher's strategies whether students' responses could be used to build up mathematics communication. The analysis of how the teacher dealt with students' responses is reported in next part, including the extent to which the teacher built on students' responses after asking the initiation questions.

To What Extent did the Teacher Build on Students' Responses?

Figure 5 shows the proportion of initiation questions asked in three types of occasions and also shows to what extent the teacher's initiation questions led to sequences of teacher-student mathematics communication. Compared with other types of initiation questions, five types of initiation questions (EVA, EXP, COM, REF, and LIN) were asked with higher chances of leading to IRF (multiple), in which the teacher tended to build on students' responses and therefore create more opportunities for students to communicate mathematics. In Figure 5, it is shown that questions for review (REV) and explanation request (EXP) were the two most common types of initiation questions, occurring in consistently high proportions. Figure 5 shows that almost 90 percent of the questions for review were asked by the teacher without giving follow-up moves that could lead to sequences of mathematics communication. In other words, when the teacher asked initiation questions for review, instead of having opportunities to communicate mathematics in discourse sequences, the students normally just needed to respond with answers to the questions. In contrast, the initiation questions requesting explanations were mostly asked by the teacher with follow-up support through which the students could have further chances to communicate mathematics. As is shown in Figure 5, around 85 percent of questions requesting explanations were asked within the IRF (multiple) structures in which the teacher tended to give open follow-up moves after initiation questions to students, in order to continue the current discussion. A more detailed breakdown in terms of the follow-up moves used by the teacher to assist students to communicate mathematics is presented in Figure 6.

In What Ways did the Teacher Build on Students' Responses?

Figure 6 shows the proportion of follow-up question types employed by the teacher in the three lessons. Nine types of follow-up questions were identified in the three lessons and once again the follow-up questions consisted of a variety of different types. In Lesson 1, the follow-up questions were mainly asked for clarification (CLA), elaboration (ELA) and agreement requests (AGG). For Lesson 2, the teacher posed follow-up questions mainly for elaboration (ELA), giving cues (CUE), and supplement requests (SUP). And questions for clarification (CLA), elaboration (ELA), agreement requests (AGG) and refocusing (REC) constituted the main body of follow-up

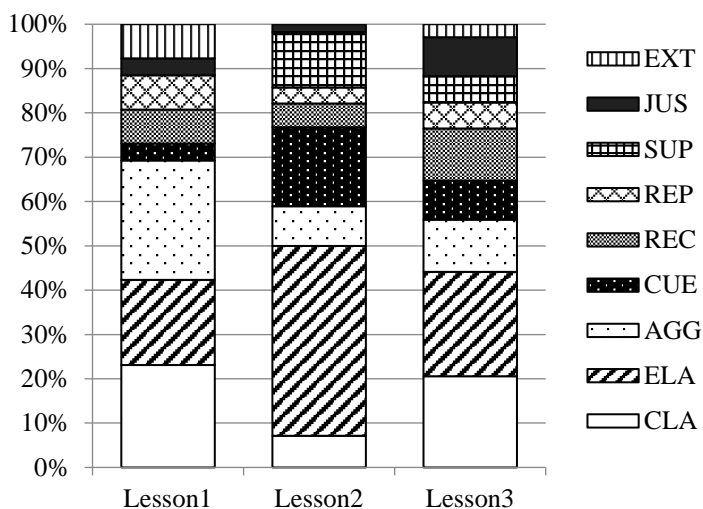


Figure 6. The breakdown of the teacher's follow-up questions

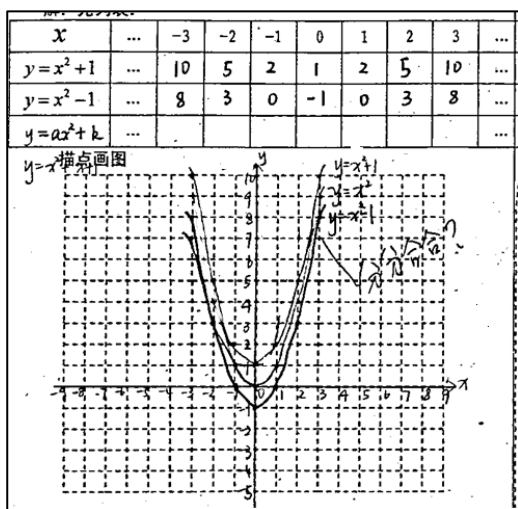


Figure 7. Clare's work in the self-learning guide

questions in Lesson 3. Among the three lessons, the teacher tended to choose elaboration questions as a tool to facilitate students' expression and communication of mathematics ideas.

The Role of Self-Learning Guide

In this part, one episode is presented to demonstrate the role of the self-learning guide in supporting teacher-student interaction. All students' names appeared in the transcripts are pseudonyms. The student work discussed in this episode is shown in Figure 7.

Task: Draw the graph quadratic functions $y=x^2+1$ and $y=x^2-1$: (1) complete the table of values; (2) plot the points on the given number plane and join them with a smooth curve. On the same number plane, draw the graph of $y=x^2$ and then observe the three graphs you have.

Teacher: [presenting Clare's self-learning guide] Now have a look at Clare's work. The two graphs are occasionally joined but occasionally separate. What does that mean? You see, for this part, the two graphs are separate but for this part, the two graphs stick together. How do you think of this? [Wait for a second] Dana. **IQ - Evaluation**

Dana: If they have any points of intersection, it means the two parabolas are identical.

Teacher: The points of intersection means the two parabolas are identical? **FQ - Clarification**

- Dana:** Yes. But apparently, apparently, they are not identical.
- Teacher:** What do you mean? **FQ - Clarification**
- Dana:** [silent]
- Teacher:** Please sit down. Who can explain this? Eric. **FQ - Supplement**
- Eric:** These parabolas were obtained by the translation of one parabola. If there are any points of intersection, it will contradict with the property of graph translation.
- Teacher:** What property is it? **FQ - Clarification**
- Eric:** The graph obtained by translation, for example, two straight lines obtained by translation, it is impossible for them to have points of intersection.
- Teacher:** Don't get away from my question. Who can help with this? Ford, can you help him to explain the property of graph translation? **FQ - Supplement**
- Ford:** The property of graph translation, is, [hesitation]
- Teacher:** What is the relationship between the graph before the translation and the one after? **FQ - Cueing**
- Ford:** The graphs are congruent.
- Teacher:** The graphs are congruent, which means their shape and size are? **FQ - Elaboration**
- Ford:** The same.
- Teacher:** Then is it possible for the two graphs to intersect with each other? **FQ - Elaboration**
- Ford:** No.
- Teacher:** OK. Please sit down.

In this episode, the teacher showed Clare's error when graphing three parabolas in the same axes. Instead of saying that these are mistakes straightforward, the teacher described Clare's graphs and then posed it to the whole class for consideration. Since no student volunteered to give comments, the teacher picked Dana to share her thinking. Dana provided the class with an interesting argument, but she failed to present any evidence to support or elaborate her argument. Building on her argument, the teacher asked a follow-up question for further clarification of her argument. After her failure of giving more information, the teacher redirected his attention to the rest of the class and asked for help and supplementary comments. Eric succeeded in contributing to Dana's argument with the idea of proof by contradiction. However, the teacher continued to pushing Eric to clarify some details in his response. The following lengthy clarification from Eric was considered as off-track and thereby the teacher asked Ford for contribution. By asking a series of follow-up question, Ford made Clare's errors and the relevant reasons explicit and adequate. In this episode, four students were involved in the discussion and made contributions to the construction of mathematical argument and explanation.

The above episode shows how the teacher used self-learning guide to enrich classroom communication and to establish a discourse community. By presenting students' comments and work during the instruction, the teacher raised questions to elicit students' ideas. Based on students' responses, the teacher asked a series of follow-up questions to help students' articulation and construction of mathematical thinking and knowledge.

DISCUSSION AND IMPLICATIONS

The construction of a desirable discourse community in the mathematics classroom has been a central goal of school mathematics instructional reform in China and elsewhere. However, it has been widely reported to be challenging and requiring substantial efforts and expertise (Sherin, 2002; Walshaw & Anthony, 2008). The investigation of questioning strategies and the associated pedagogical and other professional tensions within this context should advance our understanding of both the dynamics of classroom interactions and the teacher's role in mediating classroom interactions and constructing classroom discourse community (Nathan & Kim, 2009; Scott, Mortimer & Aguiar, 2006; Sherin, 2002). This study analysed a mathematics teacher's regulation of his questioning strategies, consciously or sometimes unconsciously, when managing a mathematics classroom with rich discourse and discussion in the context of curriculum reform. To deal with the tensions between the facilitation of classroom discussions and the fulfilment of lesson goals, the participating teacher adopted the new material, the self-learning guides, and this made it possible to allocate more time for mathematics communication and discussions while avoiding the failure of achieving lesson goals. As was found this study, the participating teacher posed approximately 1.8 (237/135) questions in every minute and the broad range questions types can be seen in **Figures 1 and 3**. In particular, the teacher initiated a significant proportion of questions to request students' mathematics

explanations (EXP) and in all three lessons, when students gave their responses, the teacher tended to ask elaboration questions (ELA) as follow-up moves, which could further facilitate students' mathematics expression. On these occasions, students' verbal contributions were taken into consideration in order to develop and build up new mathematics knowledge through discussion. In accordance with some other studies into IRF patterns in mathematics classrooms (e.g., Drageset, 2014), the teacher managed to facilitate mathematics communication and discussion in the classroom through the IRF sequences. Meanwhile, the purposes of questioning were demonstrated more clearly and explicitly through the lens of IRF sequences and the unpacking of the teacher's questioning strategies. A key focus of this analysis was the distinguishing and separate examination of initiation questions and follow-up questions. On the other hand, it is also obvious that the teacher asked a large proportion of questions with purposes other than requesting explanations, as is shown in [Figure 2](#). Some of these questions, to some extent, inhibited the creation of discourse opportunities for students as recommended in the new Chinese mathematics curriculum. The reasons why these seemingly "ineffective" questions were used can at least be partly attributed to the demands of fulfilling the lesson goals (Koizumi, 2013). For example, in order to properly and accurately express and communicate mathematics ideas, sometimes it is necessary for students to use their existing mathematics knowledge. Under this circumstance, the teacher might ask questions for review (REV) in order to facilitate students' mathematics communication. Likewise, the questions intended to check understanding (UND) were necessary when the teacher's intention was to make sure whether his teaching or explanations made sense to the students, which is also one significant part of monitoring the progress of the lesson goals' fulfilment.

In many under-developed countries, large class size has been an obstacle to promoting students' participation in classroom discussion and communication, because the teacher usually has no time to allow a large number of students to share mathematical thinking. Thus, the teacher usually sticks to conventional way of lecturing in large-size classrooms rather than adopting interactive ways of teaching (Agyei & Voogt, 2014). This study provides a case of strategically developing and using self-learning guide to promote classroom mathematics communication in a large class. The self-learning guide plays at least two important roles to engage students in large classes. Firstly, the self-learning guide provides students with chances to explore important mathematics contents before class and thereby allows the students to have a basic understanding of the topics to be taught. At the same time, through the self-learning guide, students might also have some misconceptions and questions about the topics. Compared with the students in conventional classrooms who have little understanding about the learning topics before the lesson, students who have explored the learning topic before the lesson and come up with questions and misconceptions have stronger motivations to participate in classroom communication. Secondly, compared with conventional teaching, the use of self-learning guide allows the teacher to check students' learning progress prior to classroom instruction and thus enables the teacher to flexibly spend more time allowing students to talk in classroom. In other words, the use of self-learning guide promotes the effective use of class time and leads to more efficient classroom communication.

Meanwhile, there is some evidence of tensions in the selected episodes. For example, by asking a sequence of questions, the teacher succeeded in engaging more students in the mathematics discussion. Compared with the traditional mathematics classrooms, this teacher had created more opportunities for his students to share their mathematical ideas. However, the teacher seemed to be not interested in substantially probing students' improper responses. Particularly when Dana and Eric could not provide a proper explanation to support their arguments, the teacher did not provide any enabling moves so that Dana and Eric could develop the explanations by themselves. Instead, the teacher tried to get other mathematically capable students in and move forward so that to achieve the instructional objectives.

In summary, the pedagogical tension was sustained in the participating teacher's practices, even though this tension had been relieved substantially through his tactical efforts to reform classroom instructions. However, there has been a huge improvement, since the nature of the pedagogical tensions has shifted from *imbalance of time allocation for classroom discussion and lecturing* to *imbalance of opportunities for guided classroom discussion and elaborated classroom discussion*. This might be articulated by some researchers as the tension between authoritative discourse in which students' free expression and explanation are constrained and dialogic discourse in which students are allowed to give different perspectives and explanations (Scott, Mortimer & Aguiar, 2006). This also reflects the nature of classroom instruction as a balancing act in which teachers have to comprehensively consider and respond to various demands emerging in the classroom environments (Sherin, 2002).

The analytical framework used in this study comprehensively integrates the IRF sequences with the distinction between initiation questions and follow-up questions, providing mathematics teachers with an effective lens to reflect on their own questioning practices. This could also be used to analyse other teachers' practices, for which the features associated with questioning strategies could be revealed more explicitly. By unpacking a variety of aspects of teacher questioning strategies, this detailed analysis could also help to raise practitioners' and researchers' awareness of what possible conflicts and tensions could emerge in the effort to reform classroom instruction. This could lead the practitioners and teacher educators to be better prepared to cope with these conflicts

and tensions by balancing various demands in the mathematics classroom. Given that the time for each lesson is limited worldwide and that there are always some unexpected events occurring in classroom interactions, the tension exists universally between the facilitation of classroom discussion and the completion of the lesson goals, regardless of class size. Thus, the implications of this study could be transferable to other contexts, although the case in this study is in a Chinese classroom. Furthermore, as this case was situated in a distinctly different cultural setting with an educational philosophy different from Western values (Watkins & Biggs, 1996), it might provide some alternative strategies to western practitioners when attempting to handle this sort of tension in their mathematics classrooms.

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