TEACHER QUESTIONING PRACTICES ACROSS A SEQUENCE OF CONSECUTIVE MATHEMATICS LESSONS:
A MULTIPLE-CASE STUDY OF JUNIOR SECONDARY TEACHERS IN AUSTRALIA AND MAINLAND CHINA

Lianchun Dong
B.Sc. (Maths), M.Ed. (Curriculum and Instruction)

Submitted in total fulfilment of the requirements of the degree of
Doctor of Philosophy

2017
Melbourne Graduate School of Education
The University of Melbourne
Abstract

Question asking is one of the most common strategies used by teachers in their everyday classroom instructional practice. Over recent decades, many attempts have been made to categorise teacher questions asked during classroom instruction and to report on teachers’ skilful questioning strategies. These categorisations consider the context where the questions are asked, the appropriate use of different types of questions, the learning opportunities created in the sequences of teacher-student interactions and so on. This study was designed to extend our understanding of teachers’ questioning practices in classrooms through a fine-grained analysis of mathematics lessons taught by four competent junior secondary teachers from mainland China and Australia. The study demonstrates the importance of examining teaching strategies over a sequence of lessons, the power of the IRF (Initiation-Response-Follow-up) framework as a basic structure for investigating classroom interactions, and the complexity of teaching practices, made evident through the focused investigation of the ubiquitous practice of teacher questioning.

Based on the IRF framework, a comprehensive coding system was developed to analyse what kinds of verbal questions were initiated by the teachers to elicit mathematical information and in what ways the teachers made use of students’ verbal contributions in order to facilitate student construction and acquisition of mathematical knowledge. In particular, a distinction was made between Q&A question pairs, IRF (single) sequences, and IRF (multiple) sequences. Classification systems were developed for question types within each interactive category. Within IRF (multiple) sequences, the categories: initiating and follow-up represented a fundamental distinction, each category having its own suite of sub-categories. For each participating teacher, a whole unit of consecutive lessons was examined (from 6 to 10 lessons per unit).

Analysis of the data suggested that:

(1) Across the professional practice of the four teachers, two each in mainland China and in Australia, similarities and differences in the ways in which teachers employ questioning strategies were observed. The differences regarding questioning strategies across the consecutive lessons include: (i) number/frequency of questions asked in each lesson; (ii) the proportions of questions in IRF (multiple) sequences and the proportions of the questions in Q&A question pairs and IRF (single) sequences; and, (iii) the use of
subcategories for initiation questions in each lesson. And the similarities are as follows: (i) the proportion of initiation questions in IRF (multiple) sequences out of all questions in each lesson; and, (ii) the use of subcategories for follow-up questions in each lesson. The essential point suggested by the comparison of similarities and differences regarding teacher questioning practices in this study is that the Chinese teachers and Australian teachers employed questioning strategies with similar forms but with distinctly different functions.

(2) Regardless of the geographical location of the classroom, teachers’ questioning strategy choice is made rationally based on such contexts as the nature of instructional tasks and the constraints facing the teachers at the time. Those constraints might involve time limit and overemphasis on procedural fluency caused by the need to prepare students for high-stakes examinations, the demands of catering to students’ individual differences, the need for coherent delivery and explanation of sophisticated mathematics and the need to elicit information about student existing understanding. Unlike the two Chinese teachers who valued the achievement of lesson goals above any other factors, both Australian teachers placed greatest emphasis equally on students’ demands and lesson content.

(3) In the case of the use of the three kinds of IRF (multiple) sequences (leading, facilitating/probing, orchestrating), the nature of teacher lesson planning – collaborative and institutionalised in the case of mainland China, and individually done in the case of Australia – affects how teachers make use of questions in class. These local educational contexts pose culturally-situated challenges, even though the teacher questioning strategies that are chosen and performed may reflect rational professional decisions by all four teachers, predicated on similar pedagogical goals. Teachers’ adjustment of their questioning routines in response to competing tensions in their classroom practices provided some of the most interesting features of the research.

In addition, this study also suggests that teacher professional development program designers should ensure that novice teachers are given an opportunity to observe the teaching of a sequence of lessons and to observe closely how one expert teacher’s questioning strategies are strategically employed according to the demands of the particular lesson and its place in the topic sequence. Such strategic variation of
questioning practice cannot be fully or correctly understood without the examination of the teaching of consecutive lessons.
Declaration

This is to certify that:

i. the thesis comprises only my original work towards the PhD except where indicated in the Preface,

ii. due acknowledgement has been made in the text to all other material used,

iii. the thesis is fewer than 100 000 words in length, exclusive of tables, maps, bibliographies and appendices.

Lianchun Dong
Preface

To date, the following conference papers have been presented based on this study:

Mathematics education in the margins (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia), pp. 197–204. Sunshine Coast: MERGA.


Table of Contents

CHAPTER 1 INTRODUCTION .................................................................................. 12

1.2 Objectives of this study .................................................................................. 13

1.3 Rationale of the study ................................................................................... 13

1.3.1 Why study teacher questioning strategies? .............................................. 13

1.3.2 Why choose mathematics teachers in Australia and mainland China? .... 14

1.4 Overview of the chapters in this thesis ....................................................... 15

CHAPTER 2 LITERATURE REVIEW .................................................................... 16

2.1 The classification of teacher questions ....................................................... 16

2.1.1 Cognitive requirements ........................................................................... 16

2.1.2 Predetermined answer .............................................................................. 17

2.1.3 Teacher intention ...................................................................................... 17

2.1.4 A hybrid perspective ............................................................................... 18

2.1.5 Implication for this study ....................................................................... 19

2.2 Question types and student learning ......................................................... 20

2.2.1 High-level/low-level questions and student achievement ..................... 20

2.2.2 High-level/low-level questions and student responses ....................... 21

2.2.3 Display/referential questions and student thinking ............................... 22

2.2.4 Implication for this study ..................................................................... 22

2.3 Sequences of teacher questions ................................................................. 22

2.3.1 Funnelling and focusing ........................................................................ 23

2.3.2 Probing and leading questions ............................................................... 24

2.3.3 Implication for this study ..................................................................... 24

2.4 Teacher questioning in discourse structure ............................................. 25

2.4.1 Introduction to IRE/IRF ......................................................................... 25

2.4.2 IRF chain ................................................................................................ 25

2.4.3 Investigations of the follow-up move in IRF .......................................... 26

2.4.4 Implication for this study ..................................................................... 27

2.5 Teacher questioning and lesson contexts ................................................. 27

2.5.1 Teacher questioning and instructional goals ......................................... 27

2.5.2 Teacher questioning in consecutive lessons ......................................... 28

2.5.3 Interpreting teacher questioning in the context of consecutive lessons .... 28
2.5.4 Implication for this study ........................................................................30
2.6 Summary ..................................................................................................30

CHAPTER 3 METHODOLOGY .......................................................................32

3.1 Introduction ..............................................................................................32
3.2 A multiple-case study .............................................................................33
3.3 Data Generation .......................................................................................34
  3.3.1 Identifying data required .....................................................................34
  3.3.2 Interrogating the Alignment Project data collection .............................35
3.4 Settings and participants ...........................................................................38
3.5 Data analysis .............................................................................................38
  3.5.1 The identification of teacher questions and preliminary classification .... 38
  3.5.2 The development of coding systems ....................................................40
  3.5.3 The coding schemes for initiation questions ........................................42
  3.5.4 The coding schemes for follow-up questions .......................................59
  3.5.5 Reliability check for the coding systems .............................................76
  3.5.6 Three stages of data analysis ...............................................................76

CHAPTER 4 RESULTS: QUESTION TYPE AND FREQUENCY ACROSS
THE FOUR CLASSROOMS ..........................................................................78

4.1 Basic information about the four teachers’ classes .................................78
  4.1.1 Organisation of the instruction in the four teachers’ classes ...............78
  4.1.2 Organisation of mathematical content in the four teachers’ classes ........ 80
4.2 Questioning practices of the four teachers .............................................85
4.3 The class of teacher CHN1 ......................................................................88
  4.3.1 The number of questions asked across lessons by teacher CHN1 ....... 88
  4.3.2 The proportion of questions asked across lessons by teacher CHN1 ...... 91
  4.3.3 The ratios of questions asked across lessons by teacher CHN1 ........... 93
  4.3.4 Summary for Teacher CHN1 ...............................................................94
4.4 The class of Teacher CHN2 ...................................................................95
  4.4.1 The number of questions asked across lessons by teacher CHN2 .........95
  4.4.2 The proportion of questions asked across lessons by teacher CHN2 ...... 98
  4.4.3 The ratios of questions asked across lessons by teacher CHN2 .......... 100
  4.4.4 Summary for Teacher CHN2 ..............................................................101
4.5 The class of Teacher AUS1 .......................................................................................... 102
  4.5.1 The number of questions asked across lessons by Teacher AUS1 ........ 102
  4.5.2 The proportion of questions asked across lessons by teacher AUS1 .... 104
  4.5.3 The ratios of questions asked across lessons by teacher AUS1 .......... 107
  4.5.4 Summary for teacher AUS1 .............................................................................. 108
4.6 The class of teacher AUS2 ...................................................................................... 109
  4.6.1 The number of questions asked across lessons by teacher AUS2 ....... 109
  4.6.2 The proportion of questions asked across lessons by teacher AUS2 ... 111
  4.6.3 The ratios of questions asked across lessons by teacher AUS2 .......... 114
  4.6.4 Summary for Teacher AUS2 ............................................................................. 115
4.7 Summary of four teachers’ classes ......................................................................... 115

CHAPTER 5 RESULTS: SUBCATEGORIES OF TEACHER QUESTIONS .119

5.1 Introduction ............................................................................................................... 119
  5.1.1 Distribution of sub-categories for initiation questions (1) ................. 119
  5.1.2 Distribution in sub-categories for initiation questions (2) ................. 121
  5.1.3 Distribution in sub-categories for follow-up questions ..................... 123
5.2 The class of teacher CHN1 ....................................................................................... 125
  5.2.1 Initiation questions in QA and IRF (single) sequences ....................... 125
  5.2.2 Initiation questions in IRF (multiple) sequences ................................. 127
  5.2.3 Follow-up questions in IRF (multiple) sequences ............................ 128
5.3 The class of teacher CHN2 ....................................................................................... 129
  5.3.1 Initiation questions in QA & IRF (single) sequences ......................... 129
  5.3.2 Initiation questions in IRF (multiple) sequences ............................... 131
  5.3.3 Follow-up questions in IRF (multiple) sequences ............................ 132
5.4 The class of teacher AUS1 ....................................................................................... 133
  5.4.1 Initiation questions in QA&IRF (single) sequences ......................... 133
  5.4.2 Initiation questions in IRF (multiple) sequences ............................... 135
  5.4.3 Follow-up questions in IRF (multiple) sequences ............................ 136
5.5 The class of teacher AUS2 ....................................................................................... 137
  5.5.1 Initiation questions in QA&IRF (single) sequences ......................... 138
  5.5.2 Initiation questions in IRF (multiple) sequences ............................... 139
  5.5.3 Follow-up questions in IRF (multiple) sequences ............................ 140
5.6 Summary of the four teachers’ classes .................................................................... 141
### CHAPTER 6 RESULTS: THE EMPLOYMENT OF IRF (MULTIPLE SEQUENCES)

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Introduction</td>
<td>143</td>
</tr>
<tr>
<td>6.2 The class of teacher CHN1</td>
<td>145</td>
</tr>
<tr>
<td>6.2.1 The Introduction and Strategies lessons</td>
<td>146</td>
</tr>
<tr>
<td>6.2.2 The Consolidation and Application lessons</td>
<td>151</td>
</tr>
<tr>
<td>6.2.3 The Summarization lesson</td>
<td>158</td>
</tr>
<tr>
<td>6.2.4 Summary of teacher CHN1’s class</td>
<td>160</td>
</tr>
<tr>
<td>6.3 The class of teacher CHN2</td>
<td>161</td>
</tr>
<tr>
<td>6.3.1 The Introduction lesson</td>
<td>162</td>
</tr>
<tr>
<td>6.3.2 The Exploration lessons</td>
<td>163</td>
</tr>
<tr>
<td>6.3.3 The Strategies lessons</td>
<td>175</td>
</tr>
<tr>
<td>6.3.4 The Consolidation and Application lessons</td>
<td>181</td>
</tr>
<tr>
<td>6.3.5 The Summarization lesson</td>
<td>183</td>
</tr>
<tr>
<td>6.3.6 Summary of teacher CHN2’s class</td>
<td>185</td>
</tr>
<tr>
<td>6.4 The class of teacher AUS1</td>
<td>186</td>
</tr>
<tr>
<td>6.4.1 The Foundation lesson</td>
<td>187</td>
</tr>
<tr>
<td>6.4.2 The Introduction lesson</td>
<td>189</td>
</tr>
<tr>
<td>6.4.3 The Strategies lessons</td>
<td>191</td>
</tr>
<tr>
<td>6.4.4 The Consolidation and Application lessons</td>
<td>194</td>
</tr>
<tr>
<td>6.4.5 Summary of teacher AUS1’s class</td>
<td>197</td>
</tr>
<tr>
<td>6.5 The class of teacher AUS2</td>
<td>198</td>
</tr>
<tr>
<td>6.5.1 The Foundation lessons</td>
<td>199</td>
</tr>
<tr>
<td>6.5.2 The Introduction lesson</td>
<td>207</td>
</tr>
<tr>
<td>6.5.3 The Exploration lesson</td>
<td>208</td>
</tr>
<tr>
<td>6.5.4 The Strategies lesson</td>
<td>211</td>
</tr>
<tr>
<td>6.5.5 Summary of teacher AUS2’s class</td>
<td>212</td>
</tr>
<tr>
<td>6.6 Summary</td>
<td>213</td>
</tr>
</tbody>
</table>

### CHAPTER 7 DISCUSSION: VARIATIONS AND CONSISTENCIES

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 The variations in questioning strategies</td>
<td>215</td>
</tr>
<tr>
<td>7.1.1 Factors related to variations in teacher questioning</td>
<td>215</td>
</tr>
<tr>
<td>7.1.2 Teacher CHN1</td>
<td>217</td>
</tr>
<tr>
<td>7.1.3 Teacher CHN2</td>
<td>224</td>
</tr>
</tbody>
</table>
7.1.4 Teacher AUS1 .......................................................... 230
7.1.5 Teacher AUS2 .......................................................... 236
7.1.6 Summary .................................................................. 243

7.2 The consistencies in questioning strategies ......................... 243

7.3 Culturally-informed employment of IRF (multiple) sequences .... 245

7.4 Summary .................................................................. 248

CHAPTER 8 CONCLUSIONS AND IMPLICATIONS ......................... 250

8.1 Revisiting the research questions ...................................... 250

8.2 Origins and influences on the teacher questioning practices ...... 255
  8.2.1 Teacher questioning as a strategy in response to changing instructional goals .......................................................... 256
  8.2.2 Teacher questioning as a resolution of tensions in class .... 257
  8.2.3 Teacher questioning as a habitual and valuing act ............ 258

8.3 Implications .................................................................. 259
  8.3.1 Implications for mathematics education research .......... 259
  8.3.2 Implications for classroom mathematics teaching ........... 262

8.4 Limitations .................................................................. 262

8.5 Directions for future research .......................................... 263
  8.5.1 Competent and novice teachers .................................. 263
  8.5.2 Primary and secondary teachers .................................. 264

8.6 Closure .................................................................... 265

REFERENCES .................................................................. 267

APPENDICES ................................................................ 284

APPENDIX 1 ALIGNMENT PROJECT DATA CHECK LIST ......... 284
APPENDIX 2 TEACHER QUESTIONNAIRE ......................... 285
APPENDIX 3 TEACHER INTERVIEWS ................................. 290
APPENDIX 4 CATEGORIES IN THE FOUR PREVIOUS STUDIES .... 292
CHAPTER 1 INTRODUCTION

This study was designed to investigate how four mathematics teachers made pedagogical use of questions in a sequence of consecutive lessons in Australia and mainland China. It aimed to interpret at a very fine-grained level the variations and consistencies of teacher questioning strategies in the context of different cultural settings, different instructional purposes and different established forms of classroom interaction.

Question asking is one of the most common strategies used by teachers during their classroom instructional practices. By asking questions in classroom instruction, teachers can collect instant information about students’ learning progress and thereby adjust their subsequent teaching accordingly. Teachers’ appropriate use of questioning strategies could be essential to the development of students’ mathematical knowledge and thinking skills, whereas inept ways of asking questions might constrain students’ opportunities of participation in the process of knowledge construction. Therefore, questioning skill in classroom instruction is widely regarded as an essential part of teaching capabilities.

How to help teachers employ questioning strategies more effectively has been one of the most frequently discussed issues in educational studies and teacher professional development programs (Borich, 2007; Brown & Edmondson, 1984; Brown & Wragg, 2003; Harris, 2014; Moore, 2007; Walsh & Sattes, 2016). However, despite the large number of books and journal articles on improving teachers’ use of questioning strategies in classroom instruction, studies of teacher questioning have tended to aggregate teacher questions and report the frequency of occurrence of question types rather than viewing questions as a part of teacher questioning practices, and requiring investigation in relation to the stage in the lesson and in the lesson sequence that a particular questioning pattern is deployed. Only in this way can we do justice to the situated nature of teacher questioning and give appropriate recognition to the strategic adjustment that teachers make in their questioning practices in response to changing classroom conditions. Studies need to be done to unpack and understand teachers’ use of questions in classroom instruction. One of the possible directions is to examine specific teachers’ questioning practices as comprehensively as possible in sequences of lessons in order to develop more knowledge about how teachers use questioning strategically to meet the changing demands of classroom instruction.
1.2 Objectives of this study

This study does not seek to compare the practices of the teachers in the two participating countries in order to identify the more effective teaching strategies. This study employs a different research logic. It aims to examine teachers’ instructional practices in two contrasting cultural settings so as to achieve a more comprehensive understanding of teacher questioning practices and their strategic deployment in response to class instruction. A central premise of this research is that comparison of teacher questioning practices situated in such different teaching communities will be more likely, through that contrast, to reveal features of teacher questioning that would not be evident if the study were conducted in a single cultural setting. The detailed research questions will be listed in the end of Chapter 2.

1.3 Rationale of the study

1.3.1 Why study teacher questioning strategies?

Firstly, the study of teacher questioning strategies contributes to better understanding of the relationship between teaching and learning in classroom instruction. By raising questions, teachers can elicit and support students’ expression of their mathematics thinking in an explicit and accurate way (Frank et al., 2009; Nathan & Kim, 2009; Schleppenbach et al., 2007), which could facilitate students’ construction of new mathematical concepts and ideas (Martino & Maher, 1999; Sahin & Kulm, 2008) and promote students’ development in terms of mathematical proof and generalization (Martino & Maher, 1999). Therefore, the investigation of teacher questioning should achieve better appreciation of teaching practices in mathematics classrooms and reveal more details about how teaching influences learning.

Secondly, the study of teacher questioning strategies helps to understand classroom communication. Teacher questioning and students’ responses serve as the principal media through which teacher and student undertake mathematical communication and interaction with one another in classroom instruction (Sullivan & Clarke, 1991; Boaler & Brodie, 2004). Detailed analysis of teacher questioning in classroom instruction enables the examination of teacher-student communication and the social accumulation of knowledge in natural instructional settings (Cazden, 1988; Nathan et al., 2007; Sfard, 2007).
Thirdly, teacher questioning in classroom instruction is a sophisticated art requiring further investigation. Using questioning strategies effectively requires considerable pedagogical content knowledge and necessitates the accurate monitoring of students’ cognitive development, as well as their prior knowledge (Boaler & Brodie, 2004; Martino & Maher, 1999). Besides, teachers also need to master the techniques in terms of how to deal with students’ reactions after questions are posed (Franke et al, 2009). That is, questioning consists of not only what this thesis has called “initiation questions” but also the “follow-up questions”, from which questioning sequences are constructed. Therefore, this study represents a further step toward the goal of providing teachers with suggestions about how to pose questions and follow up students’ responses in mathematics classrooms: that is, how to develop effective questioning practices.

Fourthly, the study of teacher questioning strategies has implications for worldwide educational research and practice. Questioning techniques are used frequently almost universally in mathematics instruction by teachers in both western and eastern countries including U.S., U.K., Canada, Australia, New Zealand, Germany, the Netherlands, South Africa, Japan, Singapore, China and Malaysia (Bonne & Pritchard, 2007; Brodie, 2007; Hiebert, & Wearne, 1993; Hogan, Rahim, Chan, Kawanaka & Stigler, 1999; Koizumi, 2013; Kwek, & Towndrow, 2012; Nicol, 1998; Ong, Lim, & Ghazali, 2010; Perry, VanderStoep, & Yu, 1993; Schleppenbach, et al., 2007; Sullivan & Leder, 1990; Van der Meij, 1990; Watson, 2007). Therefore, new insights into questioning strategies would have implications and generate suggestions for mathematics instructional practices and curriculum development globally.

1.3.2 Why choose mathematics teachers in Australia and mainland China?

Firstly, the features of teaching practice should be revealed more comprehensively and clearly through the employment of a cross-cultural lens. Teaching mathematics is actually a cultural activity embedded in a set of shared beliefs and assumptions about how one subject should be delivered and what roles teachers and students should play in classrooms (Schmidt et al., 1996; Stigler & Hiebert, 1998). Teaching practice in one single cultural setting is always as culturally common as people’s everyday routines and thus becomes invisible or unnoticeable inside this cultural setting (Hiebert, et al., 2003). Thus, the cross-cultural approach provides participating countries with opportunities to examine their own implicit practices within a much broader context (Kaiser, 1999; Stigler
& Hiebert, 1998), enabling a deeper and more explicit understanding of teaching behaviour in each country (Hiebert, et al., 2003; Stigler & Perry, 1988).

Secondly, Chinese and Australian mathematics classrooms have the potential to provide significant variation in terms of classroom interaction through which teacher questioning strategies functions. It has been shown in the Trends in International Mathematics and Science Study (TIMSS) (Stigler & Hiebert, 1999) that there are cultural differences in mathematics classroom pedagogical practices such as questioning. It was reported that a high percentage (approximately 50 per cent) of lesson time in Australian mathematics classrooms was spent on private teacher-student interaction when students work individually, in pairs or in groups (Hiebert, et al, 2003; Hollingsworth, Lokan, & McCrae, 2003). In contrast, mathematics teachers in China (Hong Kong SAR) spent 75 per cent of lesson time in public interaction but only 25 percent of time on private interaction (Hiebert, et al, 2003). The differences in classroom interaction between the two nations provide an opportunity to reveal more variations in terms of mathematics teachers’ questioning strategies.

It is a great advantage to this study that the researcher is familiar with mathematics teaching and learning in Chinese schools. The researcher is a native Chinese speaker enrolled in PhD program in an Australian university. The researcher received schooling education in mainland China, and then acquired a Bachelor’s Degree in Mathematics and a Master’s Degree in Education in mainland Chinese universities. Having two Australian researchers as supervisors makes it possible for the researcher to investigate Australian mathematics teaching and learning with greater confidence and insight.

1.4 Overview of the chapters in this thesis

In this doctoral thesis, there are 8 chapters in total. Chapter 2 will review the previous research related to teacher questioning and the research questions of this thesis will be listed at the end of Chapter 2. A detailed description of the methodology used in this study will be covered in Chapter 3. The results of this study will be reported in Chapters 4, 5, 6 and 7. The conclusions and implications of this research are reported in Chapter 8.
CHAPTER 2 LITERATURE REVIEW

In the previous chapter, the aims, rationale and significance of conducting this study were discussed. Here, in this chapter, the review of academic literature about teacher questioning in classrooms will be presented. This chapter begins with the documentation of question-classification systems used in previous studies in section 2.1, followed by section 2.2, which presents the exploration of the relationship between teacher question type and student learning. Next, teachers’ use of question strategies in the context of question sequences and discourse structure is discussed separately in section 2.3 and section 2.4. At last, section 2.5 introduces the investigations of teacher questioning strategies that considered the detailed lesson context (including the instructional goals of one lesson and the location of one lesson in one sequence of consecutive lessons).

2.1 The classification of teacher questions

As teachers generally ask questions with a high frequency in classroom instruction (Chin, 2007; Franke et al, 2009; Gall, 1970; Sahin, & Kulm, 2008), the first and foremost issue requiring examination is what kinds of questions the teachers asked in the classrooms. To this end, a number of classification schemes have been developed to quantitatively describe the kinds of questions asked in classroom instruction (e.g., Boaler & Brodie, 2004; Franke et al, 2007; Gall, 1970; Hiebert & Wearne, 1993; Long & Sato, 1983; Winne, 1979). In this section, four criteria employed by previous researchers to classify teacher questions are discussed.

2.1.1 Cognitive requirements

One of the most influential criteria used to classify teacher questions is the level of cognitive process needed to achieve the answers. The application of this criterion is represented by the Bloom’s Taxonomy (Bloom, 1956; Gall, 1970). By this criterion, all the spoken questions were classified according to the questions’ cognitive requirements: knowledge (e.g., What is …?), analysis (e.g., What is the relationship between …?), synthesis (e.g., Can you propose an alternative …?), evaluation (e.g., Do you agree with …?), comprehension (e.g., what is meant by…?) and application (e.g., what approach would you use to …?).

Similarly, Huang and Wang (2011) developed a coding system for teacher questions to compare the quality of two mathematics teachers’ classroom teaching in mainland
China. The coding system includes seven question categories: perception, memorization, understanding, application, analysis, synthesis, and evaluation. Out of the seven question types, perception, memorization and application were grouped as low-cognitive questions, while understanding, analysis, synthesis, and evaluation were grouped as high-cognitive questions. With this coding system, Huang & Wang (2011) found that higher frequency of high-cognitive questions was observed in high-quality mathematics lessons.

For some other researchers, however, a dualistic approach was adopted to consider the cognitive requirement of questions, which simply categorized teachers’ questions into two different types: higher cognitive questions (Winne, 1979) versus fact questions (Gall, 1984) or recall questions (Bloom, 1956; Brown & Edmondson, 1984). Higher cognitive questions “ask the students to mentally manipulate bits of information previously learned to create an answer or to support an answer with logically reasoned evidence” (Winne, 1979, p.14), while fact questions requiring “students to recall previously presented information” (Gall, 1984, p.40).

2.1.2 Predetermined answer

Another classification system examines whether teachers have predetermined answers in mind when posing questions to students, resulting in two question types: display questions and referential questions (Long & Sato, 1983). Display questions, also known as close-ended questions, known-answer questions, test questions, or convergent questions (Rymes, 2009), refer to those questions requiring students to display or provide the knowledge or information that have been known by the teacher (e.g., how to calculate \( \sin A \) where \( A \) is an angle in a right triangle?). In contrast, when the teacher raises a referential question (also called genuine, authentic, information-seeking, open-ended or divergent questions (see Rymes, 2009), the intentions are to elicit information he/she does not know in advance (e.g., who has some idea about how to solve this problem?).

2.1.3 Teacher intention

Some other researchers developed question classification systems focused on the teacher’s intentions when asking questions. Three classification systems, typical of this approach and specifically intended for use in studying mathematics classrooms, are reported in this section.
The first two systems introduced here were developed by Hiebert and Wearne (1993), and Boaler and Brodie (2004), both coding teacher questions in mathematics lessons. Hiebert and Wearne (1993) grouped teacher questions into four broad categories, namely requesting recitation of previously taught facts or procedures, asking students to describe invented solution strategies, requesting students to generate problems, and asking students to explain why things work the way they do. Similarly, in Boaler and Brodie’s (2004) classification system, all the categories were named with verbs to describe teacher intentions when asking questions: (1) gathering information, leading students through a method, (2) inserting terminology, (3) exploring mathematical meanings and/or relationships, (4) probing, getting students to explain their thinking, (5) generating Discussion, (6) linking and applying, (7) extending thinking, (8) orienting and focusing, and (9) establishing context.

In addition, a third classification system focused on the knowledge that mathematics teachers intend to elicit via asking students questions (Hogan, Rahim, Chan, Kwek & Towndrow, 2012). Teachers may ask performative questions to check student knowledge or understanding, as well as students’ efforts to give the correct responses (e.g., “If we multiply an even number by an even number shouldn’t we get an even number as well....” “Have you considered....”). Besides, teachers may pose procedural questions, requiring students to illustrate the process of solving a problem or achieving a solution (e.g., “What’s the standard procedure, algorithm or rule for solving this kind of problem?” “Are there alternative procedures for solving this kind of problem?” “Are there better procedures for solving this problem?”). Also, conceptual questions are used by teachers to scaffold students’ conceptual development. For example, teachers can ask students questions to give reasons and explanations (e.g., “can you give me reasons for why you think that”?), to explore the conceptual relationships (e.g., “what is the relationship between these two ideas?”), and so on. The common focus of all these classification schemes is the teacher’s intentions in asking the question.

2.1.4 A hybrid perspective

Some researchers have adopted more than one criterion during the process of coding teacher questions in classrooms. For example, Oliveira (2010) pointed out that special attention should be paid to those teacher questions which are reactions to students’ verbal responses to teacher questions posed earlier. To describe these questions, Oliveira
adopted the term “reaction/echoic questions”, in contrast with “initiation/epistemic questions”. Two different criteria were employed to separately classify initiation questions and reaction questions. To be specific, based on whether teachers have predetermined answers, initiation questions were subdivided into display questions and referential questions, which were discussed in more detail in section 2.1.2. For reaction/echoic questions, three subcategories were identified through examining teacher intentions when asking questions. Firstly, *comprehension checks* refer to teacher questions aiming to ensure teachers’ utterance were heard or understood (e.g., “Do you understand me?” and “Alright?”). Secondly, *confirmation checks* are teacher questions posed to check whether the teacher has correctly grasped the point of students’ utterances (e.g., “so, you are arguing that…?”). Lastly, *clarification requests* refer to teacher questions requiring students’ repetition or explanation of their previous utterances (e.g., “What do you mean?” or “what?”).

**2.1.5 Implication for this study**

In summary, the development of these classification systems is associated with different perspectives of viewing teacher questions and different research purposes, making it possible to reveal different features of teacher questions. However, it is necessary to take account of problems existing in some classification systems.

The first problem is about the challenge when employing the systems to code teacher questions. For example, for the classification systems based on cognitive requirements, the potential utility is limited due to the fact that the identification of cognitive requirements depended entirely on inferences rather than direct observation, which might result in challenges and inaccuracy in practical analysis (Gall, 1970). Furthermore, there is a chance that what is considered to be an application type question for one student (for example) may be treated as knowledge type question for another student.

The second problem concerns the application of these systems to the classroom practices associated with a specific subject, such as mathematics. For instance, Watson (2007) claimed that it is not necessarily appropriate to apply Bloom’s taxonomy to mathematics classrooms because it “underplays knowledge and comprehension in mathematics, both of which are multi-layered and require successive experiences in different mathematical contexts” (p. 114-115). Similarly, the dichotomy of display question and referential question is relatively simplistic when dealing with the complexity
of teacher questions in general classrooms, which involve complicated social and cognitive demands (Oliveira, 2010). Using this dichotomy to investigate the nature of teacher questions in mathematics classrooms runs an even greater risk of over-simplifying the data and misrepresenting the sophistication of teacher practice.

The third problem is the lack of distinction in previous research between initiation questions and follow-up questions. The latter term refers to those teacher questions which are reactions to students’ verbal responses to teacher questions posed earlier. The investigation of follow-up questions is significant because teachers were reported to experience more challenges when following up students’ responses than posing initiation questions (Franke et al, 2009). For most classification systems mentioned above, they consider all the questions as initiation questions, making it impossible to examine the connections between initiation questions and the follow-up questions. Although Oliveira (2010) took follow-up questions into consideration in his classification system, he failed to adopt a more complex approach requiring the development of subcategories for initiation questions and follow-up questions, and this omission restricts his analysis, removing the possibility of a more in-depth investigation of teacher questions.

For this study, classification systems were developed to code teacher questions in mathematics classrooms. This was achieved by synthesizing the previous coding systems discussed above, while comprehensively considering merits and problems of these systems in order to unfold the nature of teacher questioning in mathematics classrooms.

### 2.2 Question types and student learning

Apart from describing the questions used in classrooms, researchers also investigated which kinds of teacher questions are more effective to improve students’ learning.

#### 2.2.1 High-level/low-level questions and student achievement

Many researchers attempted to identify more effective questions by examining the relationship between teacher questions’ cognitive requirements and student achievement, but the results proved to be mixed, even contradictory with each other. Rosenshine (1976) reviewed a set of three large correlational studies about teacher questioning and concluded that fact questions were more effective for the improvement of students learning. And Winne (1979) argued that teachers’ behaviour of asking higher cognitive questions showed little effect on the promotion of students’ achievements. However,
Redfield and Rousseau (1981) reported a positive correlation between teachers’ predominant use of higher cognitive questions and students’ achievements.

Gall (1984) claimed that the reason lies in different ethnographic backgrounds of the students involved in the two reviews: fact questions are more effective for disadvantaged children’s learning, which focuses primarily on the acquisition of basic knowledge, whereas higher cognitive questions are more important for older students with an average to high level of capability to enhance their independent thinking. Carlsen (1991) emphasized the drawbacks in the selection of studies in these reviews, stating that some articles measured the effects of questions by investigating the cognitive level of questions in standardized tests rather than the actual questioning strategies in classroom instruction. This is an important distinction. The focus of this doctoral research is the questioning employed by teachers during actual classroom instruction.

2.2.2 High-level/low-level questions and student responses

Another attempt to understand the relationship between teacher questions and students’ learning concerns whether teacher questions with different cognitive requirements could elicit a similar cognitive level of student response.

Cole and Williams (1973) found that student response is closely related to teacher question in terms of cognitive level and claimed that high-level questions could elicit high-level responses. This conclusion was supported by Arnold et al.’s (1974) research in which both teacher questions and the corresponding student responses were classified in terms of the cognitive level based on Bloom’s Taxonomy.

However, other researchers disagreed with the postulated cognitive correspondence between teacher question and student reply. Dillon (1982) found that only half of the responses were at the same cognitive level as teacher questions and less than one-third of replies to higher level questions could actually be categorized as higher level. The same conclusion was achieved by Mills et al (1980) who attempted to investigate the degree of the correspondence between the cognitive level of teacher questions and student responses through re-examining the data in previous studies. Kawanaka and Stigler (1999) also found that higher-order teacher questions are not necessarily related to higher-order student responses.
Many researchers had commented on the inconsistent results. Mills et al (1980) pointed out that the degree of correspondence is actually affected by many factors, such as the coding system used to analyze the cognitive levels, grade level of students, and the clarity of questions. Besides, it was also argued by Klinzing, Klinzing-Eurich, and Tisher (1985) that this inconsistency could be attributed to the nature of research, the subject taught in the lesson, as well as the training program used to develop questioning skills.

### 2.2.3 Display/referential questions and student thinking

Display questions have been found to be asked more frequently than referential questions in classroom instruction (Long & Sato, 1983), but it is claimed that referential questions are more effective in producing longer and more syntactically complex responses with greater numbers of connectives whereas display questions tend to prompt shorter replies involved lower-level thinking (Brock, 1986; Nystrand, 1997; Oliveira, 2010). Some researchers objected that the use of display questions in classroom instruction was just the process of aligning students’ thinking with the teacher’s, which actually removed the function and potential of educational enquiry (Francis, 2002).

Nevertheless, it was also pointed out that either type should not be privileged simply based on the differences between students’ responses produced and that the selection of different questioning strategies should take into consideration the teacher’s pedagogical contents and goals (Nunn, 1999; Walsh, 2006).

### 2.2.4 Implication for this study

The aim of this study is not to examine what kinds of questions are more effective in supporting and scaffolding student learning. However, the documentation and discussion of the literature on this topic make it obvious that the nature and function of teacher questions cannot be truly understood without considering the context. This study will particularly consider the context where teacher questions are raised, hoping to capture and describe, as accurately as possible, the nature of teacher questioning in mathematics classrooms.

### 2.3 Sequences of teacher questions

Instead of investigating questioning practices by looking at various question types, some other researchers focused on the sequences in which the teachers pose questions in
classroom instruction. In particular, the previous exploration about the sequences of funnelling, focusing, probing and leading will be reported in this section.

2.3.1 Funnelling and focusing

When students experience some difficulties in answering teacher’s questions accurately and completely in mathematics classrooms, the teacher might provide necessary guidance or support to bring out the desired answers (Schleppenbach, Flevares, Sims & Perry, 2007). Fine-grained analysis of the guiding process resulted in the identification of two different patterns: funnelling and focusing (Herbal-Eisenmann & Breyfogle, 2005; Wood, 1994, 1998) (see Appendix 4 for examples of the two sequences).

In the funnelling pattern, the teacher typically raises a sequence of questions as guidance towards the correct answers and students merely need to give the answers to each question without necessarily understanding the connections among the questions (Herbal-Eisenmann & Breyfogle, 2005). By asking questions, the teacher is engaged in cognitive activity to demonstrate his or her way to solve the problem, while the only necessary activities for the students are actually to fill the blank in the teacher’s questions (Wood, 1998).

In contrast, the focusing pattern allows students to articulate their own mathematical thinking and to reflect on the meaning of teacher-student dialogues (Wood, 1994). Although the focusing pattern is similar to the funnelling pattern in that both involve a series of teacher questions and student answers, the questions asked by the teacher employing the focusing pattern are intended to elicit students’ mathematical ideas, as well as their related explanations for selecting and using mathematical strategies (Wood, 1998) rather than just to elicit short answers to discrete mathematical procedures which is the case in the funnelling pattern. Therefore, in the focusing pattern the teacher actually turns the responsibility to solve the problem back to students, engaging students in constructive mathematical activities (Wood, 1994, 1998). Meanwhile, this pattern also makes it possible for teachers to understand students’ thinking in clearer ways (Herbal-Eisenmann & Breyfogle, 2005).
2.3.2 Probing and leading questions

Generally speaking, probing questions are asked for clarification, justification and explanation (Sahin, & Kulm, 2008). Such questions could promote students’ deeper thinking about the topics under discussion (Krupa, Selman, & Jaquette, 1985), thus assisting in extending students’ learning from simple recall of the previous skills and procedures to exploration and development of new knowledge (MSDE, 1991). Franke et al (2009) showed that probing sequences were always used in mathematics classrooms to elicit students’ further elaboration and provide students with opportunities to revise their initial answers if they were ambiguous, incomplete or incorrect.

Leading questions or guiding questions (also known as helping questions), appeared frequently as a set of “factual or open-ended or mix of factual and open-ended questions” (Sahin, & Kulm, 2008). When teachers use leading questions, they give students’ opportunities to respond, expecting to guide students towards complete or correct answers (Franke et al, 2009). Franke et al (2009) also pointed out the differences between probing and leading questioning: the latter merely involves the strategies that the teacher thinks could help to achieve the right answer without considering students’ mathematics thinking. By their guiding character, through the provision of suggestions, leading questions are similar to the funneling questions illustrated by Wood (1998), in the sense that both question types do not require students to engage in much mathematical reasoning and thinking, if at all.

2.3.3 Implication for this study

The examination of question sequences shows that it is not enough to just focus on the teacher questions themselves. It is also necessary to look at the flow of teacher-student exchange, including both questions and responses, and to explore what kinds of responsibilities the teacher and students separately take during the process of using questioning strategies to support student learning. This doctoral study examines both teacher questions and student responses in order to reveal teachers’ educational principles underlying the teachers’ use of questioning strategies.
2.4 Teacher questioning in discourse structure

2.4.1 Introduction to IRE/IRF

Classroom lessons can be interpreted as a process of alternations in verbal (and nonverbal) behaviour that are jointly created by teachers and students. These alternations are characterized by interactional sequences of three interconnected parts: initiation, reply/response and evaluation (Caden, 1988; Mehan, 1978, 1979; Mishler, 1978a, 1978b). The initiation is typically enacted by the teacher questioning, followed by students’ reply and subsequently the teacher’s evaluation of students’ reply. Because the teacher may, for example, ask students to elaborate on their answers clearer rather than evaluating the answers or may rephrase students’ responses to check if the teacher’s interpretation is what the student intended, the third move can be interpreted as feedback (Johnson, 1995; Wells, 1986) or follow-up (O’Connor & Michaels, 1993, 1996; Sinclair & Coulthard, 1975). This basic structure of interactional sequence is commonly referred as “IRE (Initiation-Response-Evaluation)” or “IRF (Initiation-Response-Feedback/Follow-up)” or triadic dialogue. This thesis employs this basic triadic structure as the entry point in the development of an analytical approach that expands consideration of the IRF structure to include extended interactive sequences, while also developing a classificatory substructure for each IRF component that better reflects the sophistication and complexity of classroom practice.

2.4.2 IRF chain

The IRE/IRF structure could show more variations on some occasions. For example, as one type of initiation move, the teacher always checks students’ learning by raising some questions to which the teacher already knows the answers and for which the teacher therefore has specific expectations about students’ likely replies. However, the replies called for by the teacher might not be provided immediately after the teacher’s initiation (e.g., students might give incomplete or partially correct answers). Under such circumstances, other strategies (e.g., prompting replies, repeating elicitations, and simplifying elicitations) rather than simple evaluation tend to be used by the teacher to elicit the expected reply (Mehan, 1979). These strategies are regarded as re-initiation moves functioning as attempts to re-elicit students’ replies, which lead some researchers (e.g., Mortimer & Scott, 2003; Sinclair & Coulthard, 1975) to call this IRIRF (the second I means re-initiation) or IRFRF structure. Teacher use of this extended pattern effectively
supports teacher-student dialogic interaction, making it possible for the teacher to explore students’ ideas (Mortimer & Scott, 2003).

**2.4.3 Investigations of the follow-up move in IRF**

In recent years, various forms of IRF, especially the inclusion of the third move in IRF have attracted increasing attention from educational researchers in their attempts to investigate the value of IRF for teaching and learning. Radford, Ireson, and Mahon (2006) also pointed out that IRF proved to be productive in fostering collaborative work, during which the follow-up move plays a significant role. It has also been suggested that students would be provided with a larger “space of learning” when the teacher makes follow-up moves on the basis of students’ contribution and needs through strategic use of a second turn of IRF (Tsui, 2004). The point is that students are actually provided with opportunities to develop their own point of view after the teacher gives various feedbacks other than simple evaluation (Mortimer & Scott, 2003).

Nassaji and Wells (2000) identified six functionally different follow-up moves (evaluation, justifications, counter-argument, clarification, meta-talk and action) and claimed that IRF could provide different functions to satisfy different teaching and learning demands. Chin (2006) reported that the third move can take the form of a further question that will promote students’ deeper thinking and encourage students to be engaged in more cognitively active roles. Franke, et al (2009) particularly examined teacher questions when they were used as the third move of IRF and showed that teachers asked various questions to support student thinking after students gave their responses to teacher initiation questions.

Huang and Wang (2015) argued that in mainland China there has been a lack of research about analysing follow-up moves in teacher questioning practices. By analysing mathematics lessons given by an experienced teacher in mainland China, Huang and Wang (2015) proposed four types of follow-up moves in mathematics classrooms: (1) pushing forward which means the teacher asks a few small questions to move students’ thinking forward, (2) enlightening which means the teacher gives some cues to help students to answer questions, (3) requesting explanations which means the teacher requests students to give explanations or justification for his or her ideas, and (4) correcting which means the teacher corrects students’ misconceptions.
2.4.4 Implication for this study

Through the discussion about IRF structure and its connection with teacher questioning, it is clear that the IRF structure provides a platform which can cover teachers’ initiation of questions, students’ responses and teachers’ follow-up moves. Extension of the IRF structure can help to examine teachers’ and students’ participation when teachers use questioning strategies in classrooms. In this study, the IRF structure will be used to investigate teacher questioning in mathematics classrooms. As mentioned in the beginning of this report, “teacher questioning strategies” will concern teachers’ moves in two phases: (1) question initiating phase, and (2) following-up phase. In the second phase, the teacher will usually be following up students’ responses, and this follow-up response by the teacher will be considered as a strategy in the second phase of teacher questioning.

2.5 Teacher questioning and lesson contexts

2.5.1 Teacher questioning and instructional goals

Hiebert and Wearne (1993) pointed out the connections between instructional goals and teacher questions in mathematics classrooms, claiming that teachers raised questions with the intention to direct students’ attention to interpret and solve mathematics problems in the expected ways according to the instructional goals. Meanwhile, Nathan and Knuth (2003) also highlighted the effects of teachers’ curricular goals on classroom interactions. They examined information flow and scaffolding in mathematics classrooms and demonstrated that classroom questioning practices could be shaped by teachers’ interpretation of curricular goals.

Based on the TIMSS 1995 data, Kawanaka and Stigler (1999) investigated mathematics teachers’ questioning in Germany, Japan and United States, intending to account for the influence of lesson context on classroom questioning. Kawanaka and Stigler (1999) also examined, in more depth, mathematics teachers’ use of high-order questions in three nations (Japan, Germany and the United States) and found mathematics teachers used higher-order questions strategically to effect their pedagogical goals which varies among three different nations.

Shi (2011) argued that in mainland China the analysis of teacher questioning practices could be used as a framework to interpret the teachers’ pedagogical goals in classroom
instruction. By examining five aspects of classrooms, namely, teachers’ questions, student responses, teachers’ responses to student answers, student activities, and teachers’ balancing on student answering and student discussion, Shi (2011) found that teachers adjusted the cognitive requirements of classroom questions so as to make sure the completions of lesson goals.

2.5.2 Teacher questioning in consecutive lessons

The necessity of examining mathematics teachers’ practices over a sequence of lessons rather than a single lesson has been highlighted by many researchers (see, for example, Boaler and Brodie, 2004; Clarke, Mesiti, Jablonka & Shimizu, 2006; Lopez-Real, Mok, Leung & Marton, 2004). In particular, Koizumi (2013) pointed out teachers might prepare each lesson as one part of a sequence of lessons which could be regarded as a unit and thus different lesson within one unit usually had different instructional goals and structures which would influence classroom questioning practices. However, much previous research has focused on single lessons, leading to an inability to comprehensively consider the lesson context as a factor in understanding teacher questioning.

In order to investigate teacher questioning in consecutive lessons, Koizumi (2013) chose a sequence of consecutive lessons as the unit of analysis with a narrower focus on the introductory stages in mathematics classrooms in Japan and Germany. The results showed that questioning sequences occurred frequently in both countries’ mathematics classrooms but demonstrated different characteristics. As a consequence, Koizumi emphasized that the analysis of sequences of questions could show more aspects of teaching practices in clearer ways than the analysis of single lessons disconnected from their instructional and curricular context.

2.5.3 Interpreting teacher questioning in the context of consecutive lessons

Education researchers aim to interpret teachers’ actions in classrooms so as to obtain a better understanding of classroom dynamics. As is presented in section 2.5.2, a sequence of consecutive lessons provides a useful lens to identify some features of one teacher’s actions in classroom instruction. To better interpret and understand these features of teacher actions, two theories, habitus and values in teaching, are discussed here in this section.
Habitus refers to “a system of endurable and transposable dispositions, attitudes and habits” (Bourdieu, 1979, p. vii) developed as a result of the past and active present and this system could drive people to perform particular actions (Engstrom & Carlhed, 2014; Zevenbergen, 2006). Shaped by past and present experience, the habitus is thought to generate schema through which people were driven to think or behave in particular ways (Belland, 2009). The way of gaining or developing the habitus by an agent is usually non-conscious and the habitus stays relatively stable across various contexts (Webb et al., 2002). In the field of educational research, the theory of habitus could be utilised to interpret teachers’ classroom practices. One teacher’s habitus could contribute to the generation of teaching-related schema, which represent what this teacher “unconsciously knows about teaching from years of experience as students and teachers” (Belland, 2009, p.355).

The observed teacher actions recurring in consecutive lessons also reflected the implicit values held by the participating teachers. Although teaching and learning of mathematics had traditionally been viewed as a “value-free” subject (Bishop, 2008), values have more recently been regarded as being involved in teachers’ efforts of “making school mathematics more relevant to the demands of everyday living” (Seah, 2008, p. 239). In other words, what teachers valued with regards to the subject is implicit in their practice. On the basis of previous studies on values, Bishop highlighted some important aspects of valuing: (1) the existence of alternatives, (2) choices and choosing, (3) preferences, and (4) consistencies. Once a particular system of values has been developed, certain types of actions would be repeatedly observed (Raths, Harmin, & Simon, 1987). For the participating teachers, they had asked different number of questions in different lessons in the teaching sequence. When the teachers posed questions in class, they had various choices about what proportion of the total number of questions would be used as initiation questions in IRF (multiple) sequences. But the proportion of all the questions in each lesson used to initiate the IRF (multiple) sequences stayed consistent across the consecutive lessons. Likewise, for each participating teacher, while many subcategories of follow-up questions were identified in the instructional practices, the majority of the follow-up questions consisted only of a consistent group of subcategories across the teaching sequence. Although in the unit of consecutive lessons, each participating teacher had distinct instructional objectives to accomplish and unique tensions or challenges to cope with, the above consistencies were shared by all teachers.
2.5.4 Implication for this study

One conclusion from the above discussion, is that it is necessary to consider instructional tasks and the location of the lesson in one unit (connected lesson sequence) when examining how teachers use questioning strategies in mathematics classrooms. In this study, teacher questioning strategies were examined by analysing how teacher used questions across a sequence of consecutive lessons. Meanwhile, the interpretation of teacher questioning practices over a sequence of consecutive lessons were made by considering instructional goals and the theory of habitus ad values in teaching.

2.6 Summary

Despite the fruitful findings mentioned above, there is still a lack of comprehensive understanding of teacher questioning in mathematics classrooms. First of all, the previous studies failed to consider mathematics lessons in a variety of cultural backgrounds. The research on mathematics teacher questioning was predominantly conducted in the western world, and fewer investigations have been made to explore mathematics teacher questioning in other cultural settings like China. This gap is significant especially when considering ethnic Chinese students’ outstanding performance in international mathematics tests. In addition, fewer studies have been conducted to investigate follow-up questions. Follow-up questions refer to those teacher questions which are reactions to students’ verbal responses to teacher questions posed earlier (see Section 2.1.5). The investigation of follow-up questions is significant because teachers were reported to experience more challenges when properly following up students’ responses than posing proper initiation questions (Franke et al, 2009). Thirdly, these studies mostly consider teacher questioning in discrete lessons rather than in consecutive lessons. Yet, a sequence of consecutive lessons could show more variation in teachers’ teaching practices and also offer greater insight into the teachers’ purposeful deployment of particular question types, reflective of their changing instructional purposes over the course of a lesson sequence. Thus, there is an evident need to check mathematics teachers’ use of questioning sequences as these are purposefully employed across a sequence of consecutive lessons.

In addressing these concerns above, this current research study has been designed to address the following research questions:
(1) What kinds of initiation questions were asked by the participating teachers in two Australian and two mainland Chinese secondary mathematics classrooms?

(2) What kinds of follow-up questions did the participating teachers employ to build on students’ initial responses in two Australian and two mainland Chinese secondary mathematics classrooms?

(3) What variations or consistencies in teacher questioning practices were evident across the consecutive lessons in two Australian and two mainland Chinese secondary mathematics classrooms?

(4) What similarities and differences were evident between the questioning practices identified in the four secondary mathematics classrooms?

By addressing these questions, it is hoped that this study will demonstrate the value of analyzing lesson sequences in order to understand fundamental components of teacher practice, such as questioning. Also demonstrated will be the viability of the classification schemes for question types developed for this research. Further, the concluding chapter will address the question of the value of international comparison and review the insights provided by the comparison of teacher questioning practices in Australia and China. This research functions, therefore, on two levels: (i) analyses specific to the classrooms examined in the study; and (ii) consideration of what is meant by teacher questioning practices and how these teacher questioning practices are best investigated if our purpose is to capture the complex, dynamic and situated nature of teacher practice.
CHAPTER 3 METHODOLOGY

3.1 Introduction

The researcher carried out master’s level research in Beijing as part of the Alignment Project (http://www.alignment.iccr.edu.au/). The Alignment Project aimed to analyse the valued and performed learning outcomes documented in three educational settings, namely Australia, China and Finland, with respect to curriculum, instruction, standards and assessment, and to critically review the alignment of these four essential elements within each of the three sites and for both mathematics and science. The researcher participated in this project as a research assistant in the mainland Chinese team and was involved in all aspects of data collection related to the subject of mathematics, including classroom videotapes, teacher interviews, teacher questionnaires, and the selection of relevant documents for analysis. The researcher was not involved in the data collection for Australian data which was done by the team of Professor David Clarke at The University of Melbourne. But since Professor Clarke is one of the researcher’s PhD supervisors, he was able to access the Australian data with the assistance of Professor Clarke.

This provided informed access to the Chinese data set of the Alignment Project and, once the researcher had relocated to Australia, the corresponding Australian data set. A key consideration was whether or not the broad project design would generate data that would usefully support the investigation of teacher questioning strategies in mathematics classrooms. In order that each teacher’s questioning practices might be understood in context, overview accounts were generated of the practices and routines in the four classrooms that provided the data for this project. These accounts are provided later in this chapter and are an essential backdrop to the discussion of questioning that is the main focus of the chapter. It was then necessary to develop a suitable analytical approach, involving selection of relevant data and the application of suitable analytical tools. The above considerations resulted in a research design specific to this doctoral study.

This chapter will explain how I formulated my research design and how I selected the relevant and appropriate Alignment Project data (see Appendix 1 for the whole list of data collected in the Alignment Project) to assist me to answer the research questions proposed in the previous chapter.
3.2 A multiple-case study

A qualitative study is an approach used to explore and understand “the meaning individuals or groups ascribe to a social or human problem” (Creswell, 2009, p.4). It provides the researchers with a way to engage in the research that “honours an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation” (Creswell, 2009, p.4). Qualitative research studies most frequently follow the ontological perspective of the interpretative paradigm and are fundamentally concerned with the context of the study, making the meanings acquired from the participants uniquely specific (Strauss & Corbin, 1990). This doctoral research was designed to explore and describe teachers’ strategies of asking questions, aiming to identify the variety of questioning strategies used by the participating teachers in mathematics classrooms in China and Australia and to understand something of the purpose behind the teachers’ questioning practices. The employment of teacher questioning strategies tends to be significantly affected by the instructional contexts (including instructional goals) within which the teacher uses questioning strategies (Carlsen, 1991; Graesser & Person, 1994; Hiebert & Wearne, 1993; Koizumi, 2013). Accepting the obligation to examine the context of teacher questioning strategies in-depth and in detail, the research design was essentially qualitative.

A case study is the study of a specific instance, providing a detailed description of real people within real contexts (Cohen, Manion, & Morrison, 2007). Through analytical rather than statistical generalisation, cases studies can facilitate the understanding of other similar cases, phenomena and situations (Robson, 2002). Compared with other research methods, case study has a definite advantage for investigating and describing the targeted phenomenon in context (Baxter & Jack, 2008; Yin, 2003) and should be employed when it is important to examine the contextual condition of the phenomenon under study (Yin, 2003). This study aims to reveal detailed and in-depth features of teacher questioning strategies in mathematics classrooms. To this end, I need to investigate the whole process of teacher-student interaction where the teacher asks questions and responds to students’ responses to the questions. Such a detailed investigation required the employment of a case study approach. Through the examination of individual cases, as well as cross-case analysis, the study was intended to illuminate the features of teacher questioning strategies when used in different forms of classroom interaction and for different instructional purposes. Each case concerns a single mathematics teacher and his/her class.
By selecting the cases from different cultural settings (China and Australia), it was felt that this research study would be more likely to have access to a greater diversity of aspects regarding teachers’ use of questioning strategies than might have been accessed from a single cultural setting, and thus identify a wider variety of teacher questioning practices based on different cultural values (Stake, 1995).

3.3 Data Generation

The data used in this doctoral study were generated as part of the Alignment Project (see Appendix 1 for the whole list of data collected in the Alignment Project, and Appendix 2 and 3 for more details about teacher questionnaire and teacher interview).

The word “data generation” rather than “data collection” is used in this study to emphasise the agency of the researcher in constructing a data set suitable for the intended analysis. Thus “data generation” is particularly appropriate in this study, where the overall research design of the Alignment Project anticipated multiple analyses, and the dataset used in the doctoral research was a strategically selected subset of the full Alignment Project dataset. This act of strategic selection is no different from the analogous acts of data selection undertaken in any research project, where decisions are made to focus analysis on particular sub-groups within the sampled population (e.g., survey style design) or particular behaviour types within the recorded social situations (e.g., ethnographic and case study designs). In this section, I will first discuss the data required for my study, and then establish the adequacy of the Alignment Project data in fulfilling these requirements.

3.3.1 Identifying data required

To answer the research questions proposed at the end of the last chapter, data associated with teacher-student interaction are required. Specifically, the complete recording of the teacher’s utterances in each classroom is required so as to examine the questions asked by the teacher and his or her follow-up moves when responding to the students’ initial answers to the question. Since the teacher’s follow-up moves build on students’ initial answers, data about how the students responded to the teacher’s questions are also required.

In order to adequately examine teacher questioning strategies presented in a consecutive sequence of lessons, it is necessary to consider information about the
instructional background and how each teacher interacts with the students in each classroom. Moreover, detailed background information is required regarding both the participating teachers and the students to assist in the understanding of the verbal behaviour of all participants in the classrooms.

### 3.3.2 Interrogating the Alignment Project data collection

In the Alignment Project, the data about mathematics and science in the primary and secondary level were collected in Australia, Finland and mainland China. In Finland, these data were restricted to curricular documents. However, in Australia and China, data were also generated about the classroom realisation of the mathematics and science curricula. In Australia and mainland China, a total of 16 mathematics and science teachers from 14 schools, both primary and secondary, participated in the classroom-based component of the Alignment Project. All participating teachers were considered competent by local standards, and were all experienced in teaching the respective grade levels being studied. For each teacher, one unit of consecutive lessons was videotaped through three cameras, separately focusing on the teacher, the whole class and a group of focus students. In addition, pre-unit and post-unit teacher interviews were conducted before and after the teaching of the whole unit. Teacher questionnaires, the key resources employed in instructional planning, student written work and student achievement results were also gathered (see Appendix 1 for the whole list of data).

This doctoral study focuses on secondary mathematics classroom instruction in Australia and mainland China, so the data concerning secondary mathematics classroom instruction in Australia and mainland China were selected, out of the whole Alignment Project dataset, as the focus of this investigation. Of the teachers participating in the Alignment Project in Australia and mainland China, four were teaching secondary mathematics. All of the participating teachers in Australia and mainland China were competent according to the local criteria so as to provide exemplary classroom teaching in each nation. As a result, the core data set available for this study consisted of classroom videos, teacher interviews, teacher questionnaires and instructional materials collected for the four secondary mathematics teachers as part of the Alignment Project. As a member of the Chinese team for the Alignment Project, I was involved in the process of collecting the data of the two secondary mathematics teachers in China. The work I did included
filming videos of classroom teaching, interviewing the teachers, and collecting teacher questionnaires, and teaching and learning materials.

The use of classroom videos has particular advantages in that it can provide a detailed record of the process of instructional practices and therefore enable the investigation of complex teaching practices (Hiebert, et al., 2003). The classroom teaching was recorded with three cameras, respectively capturing the teacher, a focus group and the whole class. Figure 3.1 and Figure 3.2 show the examples of the layout of a typical classroom of Australia and mainland China and how the cameras were positioned in the classrooms.

The three-camera video recordings enabled the continuous documentation of all teacher-student interaction in classrooms, making it possible to examine the questions asked by the teacher, the responses given by the students, and the teacher’s follow-up moves based on students’ responses. The video recording also provides information about the forms of classroom interaction when the teacher uses questioning strategies. Also, the other data sources: teacher interviews, teacher questionnaires and instructional materials reveal both the intended instructional topics and the teachers’ instructional design, which provide additional background information about the lessons in which the teacher questioning was analysed.

Figure 3.1 Camera positions in the typical Australian classrooms
Figure 3.2 Camera positions in the typical classrooms of mainland China

Pre-topic and post-topic teacher interviews were conducted separately before and after the filming of the instruction of the whole unit in attempt to understand the complexity of mathematics classroom teaching and learning. The pre-topic interview questions were mainly about the teacher’s pedagogical goals for the whole unit, the way in which the whole unit was going to be taught, the critical decisions that the teacher had made during unit planning, the resources that were used and the planning in terms of the assessment. The post-topic interview questions focused on the extent to which the teacher’s pedagogical goals were accomplished, the changes and adaptations that the teacher made during the instruction of the whole unit, and the further decisions that that the teacher made throughout the unit regarding such aspects as curriculum and pedagogy. Please refer to Appendix 3 for a detailed protocol for teacher interview.

After each lesson in the unit, the teacher was asked to fill in a questionnaire (see Appendix 2) to mainly collect such information as the teacher’s objectives for each lesson, the instructional strategies used in each lesson, and the extent to which the teacher thinks he or she had fulfilled his or her objectives. Compared with teacher interviews which were used to obtain information about the whole unit, teacher questionnaires were used to collect information specific to each lesson within the unit.

As will be seen in the following sections, the data discussed above provide sufficient information to support a fine-grained analysis of teacher questioning strategies in secondary mathematics classrooms.
3.4 Settings and participants

In this study, the four teachers will be identified by the self-explanatory labels CHN1, CHN2, AUS1 and AUS2. This section outlines the basic information about the four participating teachers. Additional information about the organisation of their classroom instruction will be presented at the beginning of Chapter 4.

Teacher CHN1’s class was in an urban public school in Beijing, China. Beijing is the capital city of this most populous country in the world. There were 36 students in the class and teacher CHN1 was a qualified female junior secondary mathematics teacher with teaching experiences of more than five years.

Teacher CHN2’s class was in an urban public school in Nantong, Jiangsu province, China. Nantong is a middle-size city alongside the Yangtze River with a strong and prosperous economy and education system. Home to some 7 million citizens, Nantong saw the first teacher training college in the modern history of mainland China and has the tradition of embracing education reform in the past decades. There were 46 students in the class and teacher CHN2 was a qualified male junior secondary mathematics teacher with teaching experience of more than ten years.

Teacher AUS1’s class was in an urban public school in Melbourne, Australia. Melbourne is the second largest city by population in Australia. There were 26 students in the class and teacher AUS1 was a qualified male junior secondary mathematics teacher with teaching experience of more than five years.

Teacher AUS2’s class was in an urban public school in Melbourne. Australia. There were 21 students in the class and teacher AUS2 was a qualified female junior secondary mathematics teacher with teaching experience of more than five years.

3.5 Data analysis

Data analysis began with the playing back of the respective lesson video files. As the video files were played back, attention was focused firstly on identification of the teacher questions.

3.5.1 The identification of teacher questions and preliminary classification

The term “question” refers to any teacher’s utterance in classrooms intended to elicit responses from students. This definition requires that to be designated a question the
function of a teacher utterance must be to ask for students’ responses, regardless of whether the utterance took the grammatical form of a question (i.e. requiring a question mark in written form). In other words, the utterances such as “the result of sin 30 degrees is...”, with a pause for students to complete the sentence with a spoken utterance – either individually or through choral response – were regarded as a question. Any utterances that were not mathematical were excluded from the analysis unless they were associated with other mathematical utterances. But any questions repeated immediately using the same wording were considered as a single question and counted only once.

The IRF structure in the classroom was used to serve as a window to analyse teacher-student interaction. In particular, 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:

Q&A: Where the student/s replied to teacher questions but 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.

Two types of IRF sequences were identified:

1. IRF (single) sequences 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) sequences 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. In this study, video-taped episodes corresponding to Q&A pairs, the sequences of IRF (single) and IRF (multiple) were transcribed for analysis.

When analysing 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 in response to a student utterance, such as a student’s answer or response to a question from the teacher. In this study, the Q&A pair contains teacher initiation questions and student responses and the IRF sequence includes the teacher initiation question, student response, and teacher follow-up question. The framework to categorise the questions is shown in Figure 3.3.

![Diagram of Classroom Interaction](image)

**Figure 3.3** The framework to categorise the questions.

Note: FQ-IRF-m= Follow-up questions in IRF (multiple) sequences; FQ= Follow-up questions; IQ-IRF-m= Initiation questions in IRF (multiple) sequences; IQ-QA&IRF-s= Initiation questions in Q&A question pairs and IRF (single) sequences; IQ=Initiation questions.

### 3.5.2 The development of coding systems

This section presents the coding systems for subcategories of both initiation questions and follow-up questions occurring in the unit of consecutive lessons. For the two categories (initiation and follow-up questions), this study did not simply impose a “prefabricated” classification scheme on the classroom data. Instead, names for various subcategories of teacher questions were found (from existing research where possible) or invented by the researcher only following the identification of all questions documented in the videos of classroom instruction that constituted the data source for this research.

Instead of finding or inventing the name of each possible category *in advance*, those questions documented in the data source were analysed 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 informed by the research of Boaler and Brodie (2004), Benedict, Kaur and Clarke (2007), Hiebert and Wearne (1993), and Oliveira (2010),
whose classification schemes included question categories closely aligned with some of the question types identified in this study.

Table 3.1 sets out the coding schemes used for teacher questions in four previous studies (Benedict, Kaur & Clarke, 2007; Boaler & Bordie, 2004; Hiebert & Wearne, 1993; and Oliveira, 2010). More detailed explanations and examples of these categories in these four studies can be found in the Appendix 4.

It is worth mentioning that there are some previous studies focusing on the categorization of verbal teacher actions and the analysis of teacher-student interaction in mathematics classrooms (Mesa, Celis & Lande, 2014; Mesa & Lande, 2014; Scherrer, & Stein, 2012). But since this study is specifically focused on the analysis of teacher questioning strategies rather than teacher verbal behaviour or teacher-student interaction in general, the coding systems in the above-mentioned studies were not adopted and applied in this study. Nonetheless, the coding schemes served as useful exemplars in the development of the two classification systems employed in this research.

**Table 3.1 Categories of Teacher Questions in the Four Previous Studies**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreement Questions</td>
<td>Gathering information, leading students through a method</td>
<td>Recall factual information</td>
<td>Referential questions</td>
</tr>
<tr>
<td>Factual (short) Questions</td>
<td>Inserting terminology</td>
<td>Recall procedures</td>
<td>Display questions</td>
</tr>
<tr>
<td>Factual (long) Questions</td>
<td>Exploring mathematical meanings and/or relationships</td>
<td>Recall prior work</td>
<td>Clarification requests</td>
</tr>
<tr>
<td>Explanation/Justification Questions</td>
<td>Probing, getting students to explain their thinking</td>
<td>Describe strategy</td>
<td>Confirmation checks</td>
</tr>
<tr>
<td>Opinion/Evaluation/Judgment Questions</td>
<td>Generating Discussion</td>
<td>Describe alternative strategy</td>
<td>Comprehension checks</td>
</tr>
<tr>
<td>Conjecture Questions</td>
<td>Linking and applying</td>
<td>Generate story</td>
<td></td>
</tr>
<tr>
<td>Repeated Questions</td>
<td>Extending thinking</td>
<td>Generate problem</td>
<td></td>
</tr>
<tr>
<td>Repeated Student Questions</td>
<td>Orienting and focusing</td>
<td>Explain</td>
<td></td>
</tr>
<tr>
<td>Repeated Student Answers</td>
<td>Establishing context</td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>Not Teacher</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.5.3 The coding schemes for initiation questions

Figure 3.4 presents the fourteen subcategories of initiation questions emerged from the four participating teachers’ classes. This sub-section of Chapter 3 shows detailed descriptions and examples for each of these fourteen categories. In the examples, all the students’ names are pseudonyms. In the transcripts, the letter “T” is short for the teacher, “S” for the individual student, and “Ss” for choral responses or different but simultaneous student responses. Where a category or code has been published in the report of a previous research study the relevant reference is given. The medium of instruction in mainland China is Mandarin and all episodes cited from the Chinese classrooms in the following examples were translated into English.

![Initiation questions diagram]

**Figure 3.4** The subcategories of initiation questions.

### 3.5.3.1. Comparison

*Comparison* questions are those initiation questions requiring students to make comparisons between mathematical descriptions, graphs, etc. It doesn’t include those
questions requiring students to check whether their final results of problem-solving are the same as those of their peers or the teacher. Instead, these questions were coded as “Result/product” questions (see Section 3.5.3.10).

The question type is similar to the type of “Linking and applying” questions in the research of Boaler and Brodie (2004) but Comparison questions in this study are not used to ask for the relationships between mathematics topics or between mathematics topics and real-life applications as is the definition for “Linking and applying” in Boaler and Brodie (2004). Rather, Comparison questions are used to ask student to make comparisons between two descriptions or two students’ solutions without necessarily identifying the relationships between them (i.e., descriptions or students’ solutions). That is, the linking function refers specifically to comparisons between other students’ responses, but not more widely to other contexts. In this study, these wider forms of connection are taken to be conceptually distinct from between student comparisons and are therefore included within other question categories.

Some examples of Comparison questions are shown below, and the Comparison questions are highlighted in bold and italic text.

Example 1: CHN2-Lesson 07

T: **The standard form [of quadratic functions], and the vertex form, are these two forms different or not?**
S: No.

Example 2: AUS2-Lesson 04

T: They don’t have different angles. **What do they have that are different?**
S: Different sides.
T: Yeah. Different side lengths.

### 3.5.3.2. Conjecture

**Conjecture** questions are those initiation questions requiring students to, mostly by incomplete information, come up with suppositions or presumptions about patterns, changes, or conclusions in mathematics.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) but in this study the Conjecture question category only covers questions asked in the initiation stage of teacher-student interaction. In other words, while Conjecture questions by the definition of Benedict, Kaur and Clarke (2007) might be identified in either
initiation stage or follow-up stage of teacher-student interaction, in my study those “Conjecture” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions, such as Clarification (see Section 3.5.4.2) or Extension (see Section 3.5.4.5).

Some examples of Conjecture questions are shown below, and the Conjecture questions are highlighted in bold and italic text.

Example 3: AUS2-Lesson 06

T: What would happen to the graph [sine graph] after that [one eighty degrees]?  
Ss: [some students] Going negative.

Example 4: AUS2-Lesson 06

T: You don’t have to draw it. But if we were to draw it [cosine graph], what would the graph look like in comparison to the sine graph?  
Ss: [some students] Going down  
T: It will be going down. The opposite. Okay.

3.5.3.3. Evaluation

Evaluation questions are those initiation questions used to elicit students’ opinions or comments on the results, strategies, or statements given by the teacher or other students.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) but in this study Evaluation questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while Evaluation questions by the definition of Benedict, Kaur and Clarke (2007) might be identified in either the initiation stage or follow-up stage of teacher-student interactions, in my study those “Evaluation” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions. For example, the question “Is it advisable to expand it”, which was coded as an “Evaluation” question by Benedict, Kaur and Clarke (2007), might be coded as an Agreement request question (see Section 3.5.4.1) in this study.

Some examples of Evaluation questions are shown below, and the Evaluation questions are highlighted in bold and italic text.

Example 5: CHN2-Lesson 02
T: Now let us have a look at how Wang and Liu described the graph of \( y = x^2 \). Wang’s description is here, and Liu’s is here. Which one are you more inclined to agree with?
S: I agree with Liu.

Example 6: CHN1-Lesson 05

T: Okay, what is the result of calculation for AC?
S: 150 kilometres.
T: 150 kilometres. Compare this with the safety limit of the ship’s sailing. In what range will the ship’s travelling would be affected?
Ss: 250
T: So would the ship’s sailing be affected?
Ss: Yes.

Example 7: AUS2-Lesson 07

T: So can I say \( p \) over seventeen point four? [Writing down “\( p/17.4 \)” after “tan 25°=”]
Ss: [some students] Yes.

Example 8: AUS2-Lesson 07

T: Is that [pointing to the student’s work] the whole distance?
S: Yeah.
T: [waiting for a while] it’s not. It’s just this distance.

3.5.3.4. Explanation

Explanation questions are those initiation questions used to elicit students’ understanding, thinking or interpretation of mathematical concepts, properties, relationships, or the reasoning behind problem-solving strategies and methods.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) and also that of Hiebert and Wearne (1993). However, in this study Explanation questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Explanation” questions by the definition of Benedict, Kaur and Clarke (2007) and Hiebert and Wearne (1993) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in my study those “Explanation” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions. For example, the question “Why did you work the problem like that?”, which was coded as an “Explain” question by Hiebert and Wearne (1993), might be coded as a Clarification question (see Section 3.5.4.2) in this study, depending on where in the questioning chain it occurred.
Some examples of *Explanation* questions are shown below, and the *Explanation* questions are highlighted in bold and italic text.

Example 9: CHN2-Lesson 01

T: Now, [for the expression y=4x^2-96x+572] *from the perspective of functions, how could we interpret in an alternative way the two unknowns as pointed by the last student?* [Then the teacher invites one student to answer the question]

S: [Liu] one is the independent variable, and the other is the function of the independent variable.

T: Please be seated.

Example 10: CHN1-Lesson 04

T: I have one more question, *why did you come up with the idea of constructing the perpendicular line through the points B and C?*

S: Because in this way, I can use the right triangle ABM, and then I could use the Pythagoras Theorem to find the length of AB.

T: Please be seated.

Example 11: AUS1-Lesson 04

S: Like with these, with these questions, how do we know which solution, like, which method to do it?

T: *What do you mean by "which method"?*

S: [inaudible]

T: Tell me what the difference is, what the difference is.

S: I don’t know.

Example 12: AUS2-Lesson 04

T: Yeah. *And why did you think that should have worked?*

S1: Cause they have like the same, maybe because they have the same length

S2: The same shape.

T: Ah, [pointing to S1]

### 3.5.3.5. Information extraction

*Information extraction* questions are those initiation questions requiring students to identify and select information from text descriptions, graphs, tables, diagrams. These questions are intended to elicit students’ interpretation on these texts, graphs, tables, diagrams. For example, the teacher may require students to identify geometric figures’ information, e.g., angles and sides, or to identify some properties from the graphs of functions, or to identify the mathematical information from the descriptions of word problems.
This question type was mentioned in the research of Boaler and Brodie (2004) and of Hiebert and Wearne (1993), though in this study Information extraction questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, Information extraction questions by the definition of Boaler and Brodie (2004) and Hiebert and Wearne (1993) might be identified in either initiation stage or follow-up stage of teacher-student interaction whereas in my study those “Information extraction” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions. For example, the question “what is the value of x in this equation”, which was coded as a “Gathering information” question by Boaler and Brodie (2004), might be coded as a Refocusing question (see Section 3.5.4.7) in this study.

Some examples of Information extraction questions are shown below, with the Information extraction questions are highlighted in bold and italic text.

Example 13: CHN1-Lesson 06

T: Now what conditions do we know? Is this right triangle solvable? We are required to find the tangent of α. So have a look. What conditions are given? Zhang, what are given?
S: The hypotenuse, and...
T: Okay. The hypotenuse is known. So the hypotenuse is in...?
S: In the big square.

Example 14: CHN2-Lesson 08

T: Can we use the graph [pointing to the graph of the quadratic function] to find the solutions of the equations1/2x^2-6x+21=0?
Ss: No real solutions.
T: When it is zero, does it have any points of intersections with the x-axis?
Ss: No.

Example 15: AUS1-Lesson 03

T: So all this is asking is which ratio you use.
S: So you don’t have actually to solve it
T: No. So which two sides are we interested in here?
S: Point five and x, I mean hypotenuse and adjacent.
T: Okay.

Example 16: AUS2-Lesson 07

T: What two sides do I have?
S: Opposite and...
T: Something written “next to”.
S: Adjacent.
Example 17: AUS2-Lesson 02

T: **What are the words that actually give us some information about what we need to do?**
S: One meter squared.
T: So I know that the area is one meter squared. [writing on the board.]

Example 18: AUS2-Lesson 02

T: **What is question C asking me to do?**
S: to find how many centimetres of wood are needed.

Example 19: AUS2-Lesson 02

T: **Do I know anything about this triangle?**
Ss: [some students] yes, [some students] no.

3.5.3.6. Generation

*Generation* questions are those initiation questions asking students to generate a problem/scenario, or components of a problem/scenario, to satisfy given requirements.

This question type was mentioned in the research of Hiebert and Wearne (1993) but in this study *Generation* questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Generation” questions by the definition of Hiebert and Wearne (1993) might be identified in either the initiation stage or follow-up stage of teacher-student interactions in my study those “Generation” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions. For example, the question “Who can tell a story about this number sentence?”, which was coded as a “Generate problem” question by Hiebert and Wearne (1993), might be coded as a *Supplement* question (see Section 3.5.4.10) in this study.

Some examples of *Generation* questions are shown below, and the *Generation* questions are highlighted in bold and italic text.

Example 20: AUS1-Lesson 04

T: Today we’re going to look at how we go the other way. When we know the length, how do we use them to find the angles of the triangle? So if I have, [writing down the heading of today’s topic “Finding angles in right triangles”] a triangle, a right angled triangle. [Drawing a right angled triangle]So Ellen, **how long is the bottom of my triangle?**
Example 21: AUS2-Lesson 04

T: Alright. Pens down. Can someone give me one that does not have a surd in it?
S: [inaudible]
T: No. That has a surd in it.

3.5.3.7. Link/application

Link/application questions are those initiation questions requiring students to provide examples of mathematics knowledge, or to apply mathematical knowledge, for the purpose of solving problems, or to establish relationships among mathematical ideas, or between mathematics and other areas of study/life. In some contexts, students are required to match the given numbers in a problem with the pro-numerals in a mathematical formula, or match given numbers in a problem with the mathematical meaning or definitions. These questions were also coded as Link/application questions (see Example 25 and 26). And these are different from the Information extraction questions since they require students to establish a connection between the given numbers and their mathematical meanings and definitions.

This question type was mentioned in the research of Boaler and Brodie (2004) but in this study Link/application questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Link/application” questions by the definition of Boaler and Brodie (2004) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in my study those “Link/application” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions. For example, the question “what else have we used this”, which was coded as a “Linking and applying” question, might be coded as a Supplement question (see Section 3.5.4.10) in this study.

Some examples of Link/application questions are shown below, and the Link/application questions are highlighted in bold and italic text.

Example 22: CHN1-Lesson 04

T: Okay. Think back to when we learnt trigonometric ratios’ properties of increasing and decreasing.
For $\alpha$ and $\tan \alpha$, what are the trends of their increasing and decreasing? *Now as the slope of ramp gets larger, what will happen to the size of the angle of the ramp?*

Ss: Getting larger.

T: Then as the angle of the ramp gets larger, the slope will get larger too, because $\tan \alpha$ gets larger with the increase of $\alpha$ when $\alpha$ varies between 0 degree and 90 degrees. In general, as the slope of the ramp gets steeper, the angle $\alpha$ gets larger. These are the basics.

Example 23: CHN2-Lesson 08

T: **Now, the corresponding equation doesn’t have real solutions, so what can be said about the value of the discriminant?**

S: Less than zero.

T: Less than zero. *Then for the corresponding parabolas, what is the relationship between it and the x-axis?*

Ss: There are no points of intersection with the x-axis.

T: There are no points of intersection with the x-axis, or they share no common points.

Example 24: AUS1-Lesson 05

T: Near the whale, that’s right down here, thirty-two degrees. [label “32” on the angle]. And so Okay, well, we want to know how, where the whale was. So we want to work out how far it is horizontal because we know where we are. We knew GPS for that. What we want to work out is that bearing this far away. We’ll call this $x$, [label “$x$” on the horizontal distance], some unknown. So which ratio are you using? So Hellen, *which two sides have you got? Which ratio do we need to use?*

S: The adjacent.

T: Yeah, we do have the adjacent.

S: Opposite.

T: Opposite.

Example 25: AUS2-Lesson 07

Note: In this example, the first question is an *Information extraction* question.

T: What does the question say?

S: Identify which ratio you could use in each of these triangles, given the angle and sides marked.

T: So if that’s the angle.

S: Yeah

T: And I got those two sides, *what are these two sides?*

S: Opposite and Hypotenuse.

Example 26: AUS2-Lesson 02
T: *How do I tell which of these two will be the x one?*
S: The lowest one
T: The lowest one. So whatever have the lowest value, is x one.

### 3.5.3.8. Progress monitoring

*Progress monitoring* questions are those initiation questions requiring students to monitor and regulate the process of reasoning and problem solving. For example, the teacher may ask students to check the progress in the process of problem-solving. This category is different from the *Reflection* questions (see Section 3.5.3.9) because the *Reflection* questions usually require students to look back when they have accomplished the tasks.

This question type was mentioned in the research of Boaler and Brodie (2004), but in this study *Progress monitoring* questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Progress monitoring” questions by the definition of Boaler and Brodie (2004) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in my study those “Progress monitoring” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions, such as *Refocusing* (see Section 3.5.4.7).

Some examples are shown below, and the *Progress monitoring* questions are highlighted in bold and italic text.

**Example 27: CHN1-Lesson 02**

T: **Now let us have a look. After the construction of this perpendicular line, can we fulfil Zhang’s proposal? What we would like to do is, construct a perpendicular through B to AC at D [drawing the perpendicular]. Well, my hand drawing is not very accurate. Let us have a look. Zhang proposed to place AB in a right triangle and BC in another. Now are both of his ideas fulfilled? They are both already in right triangles. Now can we make use of the tangent of the angle A? Can we?**

Ss: Yes.

**Example 28: AUS2-Lesson 07**

T: **Okay, what is the aim of the game again? What do I want to find?**

Ss: x.
3.5.3.9. Reflection

*Reflection* questions are those initiation questions requiring students’ reflection after mathematical activities, e.g., problem-solving or geometric drawing.

This question type was mentioned in the research of Hibiert and Wearne (1993) but in this study *Reflection* questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, according to Boaler and Brodie (2004) and Hibiert and Wearne (1993), “Reflection” questions might be identified in either initiation stage or follow-up stage of teacher-student interaction whereas in my study those “Reflection” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions, such as *Extension* questions (see Section 3.5.4.5).

Some examples are shown below, and the *Reflection* questions are highlighted in bold and italic text.

**Example 29: CHN1-Lesson01**

T: Okay, have a think about the given conditions in example one and two. In example one, side lengths were given, right? There were two side lengths. Based on our investigation, we found that it works as long as two side lengths are given. By contrast, in example two, one side length and one angle size were given, right? There were one side length, one acute angle, and another acute angle. Based on the example one and two, we can learn something about what kinds of conditions could help to solve a right triangle. **The conditions could be divided into...**

Ss: [some students] two cases.

**Example 30: CHN2-Lesson02**

T: We just studied some new elements [about the parabola]: the parabola’s vertex, lowest point, the axis of symmetry. **Now can you describe the properties of y=ax^2 by taking into account its vertex and the axis of symmetry? [Writing the outlines for the summarization] Lin?**

S: The graph of y=ax^2 goes through The Origin, and it is symmetric across the y-axis. When a is greater than zero and x is greater than zero, the y-values increase as the x values get larger. When a is greater than zero and x is less than zero, the y-values decrease as the x values get larger. When a is less than zero and x is greater
than zero, the y-values decrease as the x values get larger. When a is less than zero and x is less than zero, the y-values increase as the x values get larger.

Example 31: AUS1-Lesson02

Note: the first question is an *Understanding check* question

T: So Sam, let’s have a think about it. If that is meant to be the same, what, why, what little things might have got them..., they are a little bit different, aren’t they?
S: Yeah
T: So what would, *what might’ve caused it to be a little bit off?*
S: Bad measurements.

Example 32: AUS2-Lesson07

T: So have we noticed something yet? [pointing to the board]*If we know the hypotenuse, what operation do I end up using?*
Ss: Times.
T: Good. *If I know the opposite, what operations are happening?*
Ss: Divide.

3.5.3.10. **Result/product**

*Result/product* questions are those initiation questions requiring results of mathematical operation, measurements, or the final answer to the problem solving. It includes the requests for the results of substituting numbers into mathematics formulae. And it also includes those questions requiring students to check whether their final results of problem-solving are the same as those of their peers or the teachers.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) but in this study *Result/product* questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Result/product” questions by the definition of Benedict, Kaur and Clarke (2007) might be identified in either the initiation stage or follow-up stage of teacher-student interactions, in my study those “Result/product” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions, such as *Cueing* (see Section 3.5.4.3).

Some examples of *Result/product* questions are shown below, and the *Result/product* questions are highlighted in bold and italic text.
Example 33: CHN1-Lesson05

T: Okay. Then PC is obtained by taking CB from BP. Now there is a requirement about the rounding, and we need to correct the result to one decimal place, right? So we get the original result and then its approximate value is…?

Ss: 1.9.
T: Good. 1.9.

Example 34: CHN2-Lesson05

T: Now I will ask some students to tell us their answers. Huang, questions one?
S: y is equal to x squared plus three. It opens up, and the axis of symmetry is the y-axis. The coordinates of the vertex are (0, 3).
T: Please be seated. Fan, question two?
S: y is equal to 5times x then deducted by 2, the whole squared. It opens up, and the axis of symmetry is x, oh, is the straight line x equals two. The coordinates of the vertex are (2, 0).

Example 35: AUS1-Lesson03

T: So it’s, what angle do we add to this angle to make it ninety degrees?
S: Just seventy-one.
T: Yeah, what do we add to seventy-one to make ninety degrees?
S: Nineteen
T: Nineteen

Example 36: AUS2-Lesson06

T: So how many degrees behind cos is sine?
Ss: [some students] ninety
T: Ninety. So they are the same shape, and they are just ninety degrees behind each other.

3.5.3.11. Review

Review questions are those initiation questions used to elicit the previously learnt or mentioned mathematical knowledge (such as concepts, propositions or formulas), skills, or procedures. It also includes those questions asking students to refer to their own or other students’ ideas, comments, problem-solving strategies which have been already presented or discussed.

This question type was mentioned in the research of Boaler and Brodie (2004) Benedict, Kaur and Clarke (2007), Hiebert and Wearne (1993), and Oliveira (2010). But in this study Review questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Review” questions by the definition of
Boaler and Brodie (2004) Benedict, Kaur and Clarke (2007), Hiebert and Wearne (1993), and Oliveira (2010) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in my study those “Review” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions, such as Clarification (see Section 3.5.4.2) or Extension (see Section 3.5.4.5).

Some examples of Review questions are shown below, and the Review questions are highlighted in bold and italic text.

Example 37: CHN1-Lesson02

T: Now let us think back. **What does it mean to solve right triangles?** **What is it?** Zhang?
S: It means that you’re given two known variables, and you need to find the others. You need to find the other unknown variables in the right triangle. This is called solving right triangles.

Example 38: CHN2-Lesson08

T: The corresponding equation does not have real number solutions. **Then what could be said about its discriminant?**
Ss: Less than zero.
T: Less than zero.

Example 39: AUS1-Lesson02

T: **Which ratio, Frank, uses the O and... the adjacent and the opposite?**
S: tan

Example 40: AUS2-Lesson01

T: Good. So we know that works. **So what do we call that, Ben?**
S: [Beck] numbers of triad
T: A Pythagorean triad, Yeah? So this one [points to the 3, 4, 5 which was written on the board] is a Pythagorean triad. [Then the teacher writes “A Pythagorean triad”] Yeah?

Example 41: AUS2-Lesson02

T: So if I’ve got a square. And I call the side length x [the teacher draws a square on the board and label the side length as x]. **What is the area?**
S: x squared.
T: x squared. Good.

3.5.3.12. Strategy/procedure
Strategy/procedure questions are those initiation questions requiring students to describe their strategies, procedures or the process of solving problems. It also included those questions asking students to describe the procedures or strategies in other students’ work or presentation.

This question type was mentioned in the research of Hiebert and Wearne (1993) but in this study Strategy/procedure questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Strategy/procedure” questions by the definition of Hiebert and Wearne (1993) might be identified in either the initiation stage or follow-up stage of teacher-student interactions, in my study those “Strategy/procedure” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions. For example, the question “how did you find the answer”, which was coded as a “Describe strategy” question by Hiebert and Wearne (1993), might be coded as a Clarification question (see Section 3.5.4.2) in this study.

Some examples of Strategy/procedure questions are shown below, and the Strategy/procedure questions are highlighted in bold and italic text.

Example 42: CHN1-Lesson03

T: But have a look. If you come across this problem in reality, could you use what we learnt to come up with a solution? But you need to keep in mind that the situation is ideal. The tree was straight and perpendicular to the ground before it fell. The tree was not crooked. Qiao?
S: The angle of ABC is 40 degrees, and tangent of 40 degrees is about 0.839. Then because the angle C is 90 degrees, and AC is 10 meters, we can find the length of BC.

Example 43: CHN2-Lesson07

T: Okay, let us look at the second question. Have a think about how to solve it. Ji?
S: It tells us in this question that the vertex is the point M, one, negative five. According to this, we can use the vertex form to find the equation of the parabola.
T: Okay.

Example 44: AUS1-Lesson04

T: Now how, well, let’s just go through how to work this out. Now I know you guys worked it out differently from what I would work it out actually. So Linda, how did you work it out?
S: I used a formula.
T: You used a formula.

Example 45: AUS2-Lesson07

T: Okay, can I ask you a question? Would I use sin, cos, or tan, to find the missing side lengths in this case?
Ss: [one student] Cos or tan.

3.5.3.13. Understanding check

Understanding check questions are those initiation questions used to check whether students understand or agree with the teacher’s or students’ arguments or statements. This category also includes the questions used to ask students to put their hands up so as to check students’ answers or understanding.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) and Oliveira (2010) but in this study Understanding check questions only cover questions asked in the initiation stage of teacher-student interaction. In other words, while “Understanding check” questions by the definition of Benedict, Kaur and Clarke (2007) and Oliveira (2010) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in my study those “Understanding check” questions asked in the follow-up stage would be coded with follow-up question categories depending on the actual purpose of the follow-up questions, such as Agreement request (see Section 3.5.4.1).

Some examples of Understanding check questions are shown below, and the Understanding check questions are highlighted in bold and italic text.

Example 46: CHN1-Lesson01

T: Now if we choose to use the Pythagoras Theorem to solve this problem, we will have to use the value of c that we got by calculation, won’t we?
Ss: [some students] Yes.

Example 47: CHN2-Lesson01

T: [observes one group’s discussion for a while and then talk to this group] Put it in another way. This part is x, and this part is the same so it is also x. So the width of the inner rectangle is 22-2x, right?
Ss: Yes.

Example 48: AUS1-Lesson05
T: Now we got x times tan of sixteen equals thirty-five, but we want x by itself, not x times tan of sixteen degrees. The way we get rid of times tan of sixteen degrees, is we divide both sides by tan of sixteen degrees. Now these things cancel out, gives us x equals thirty-five over tan of sixteen, yeah?
S: Yeah
T: Then you put that in your calculator.

Example 49: AUS2-Lesson02
T: So here am I, I am just using the same method that I used to find the hypotenuse. Agree?
Ss: [Most students] silent, [some students say] yes.
T: So I always like to start with writing, whatever, theorem, or formula that I am using. [Writes down a^2+b^2=c^2] I like to start with writing that out. So you know what framework you are working in.

3.5.3.14. Variation

Variation questions are those initiation questions requiring students to consider a problem for which certain aspects (such as tasks’ contexts, known variables, the answers or conclusions) vary while the other aspects are kept the same as a previous problem.

This question type is similar to the type of “Generate problem” in the research of Hiebert and Wearne (1993). But Variation questions in this study refer to those questions asked by the teacher to consider the given problem in different angles, whereas “Generate problem” questions by the definition of Hiebert and Wearne (1993) are used to ask students to come up with new problems themselves to satisfy the teacher’s requirements. The naming the Variation questions in this study was informed by the concept of “teaching with variation” proposed by Gu, Huang and Marton (2005) and the Theory of Variation (Lo, Chik & Pang, 2006).

Some examples are shown below, and the Variation questions are highlighted in bold and italic text.

Example 50: CHN1-Lesson01
T: Now if I don’t know this, I don’t know the size of either angle, what do I need to solve the problem?
Ss: Two side lengths.
T: Good. We need two side lengths.)

Example 51: CHN2-Lesson09
T: Now imagine, if the range of x values is not wide enough so that the parabola’s vertex could be included, then could we still use the coordinates
of the vertex to find the value of \( x \) where \( y \) is maximum?

Ss: [some say] No.
T: Therefore, when dealing with the real-life problems, we need to cautious about the range of the independent variables.

Example 52: AUS2-Lesson05

T: ...So if they are not the same, what does that tell you about the triangles you’ve drawn?
Ss: [some students] they are congruent.
T: No.
Ss: [some others] They’re similar.
T: They are not similar. Good. What do you need is to go back and check your triangles.

3.5.4 The coding schemes for follow-up questions

As discussed in the preceding section, Figure 3.5 presented the fourteen subcategories of initiation questions that emerged from the four participating teachers’ classes. Figure 3.7 shows the ten subcategories of follow-up questions occurring in the same classes of the four participating teachers. This sub-section provides detailed descriptions and examples for each of these ten categories. In the examples, all the students’ names are pseudonyms. In the transcripts, the letter “T” indicates the teacher, “S” is used for the individual student, and “Ss” for choral responses or different but simultaneous student responses. Where a category or code has been published in the report of a previous research study the relevant reference is given. However, the distinction between initiation questions and follow-up questions does not appear to have been rigorously pursued in previous studies, so even where a category or code has been employed in a previous study, it is unlikely that it has been used for the specific coding of follow-up questions in the way in which the analysis has been undertaken for this study.

In addition, the naming of the categories for follow-up questions employed in this study mainly reflected the purpose of asking the follow-up questions. In almost every case, the question purpose could be inferred by considering the context of teacher-student interaction where the follow-up questions were asked. In other words, the initiation questions and student responses before the follow-up questions were taken into consideration to determine the purpose of the follow-up questions, such as clarification of a student’s response or extension of the topic under discussion. Therefore, two follow-up questions with the same wording might be coded with two different categories depending on the context in which the two follow-up questions were asked. This makes clear the importance for this study of situating a question in context before classifying it. It is
possible that this consideration of context should be treated with greater care in other studies where teacher questions are classified.

Given the above discussion, the naming of the categories for follow-up questions followed a different process to what was used in the naming of initiation questions. In the latter, the naming of all the categories except the Variation category reflects what the initiation question are looking for, such as giving a result or demonstrating a strategy. That is, the question’s purpose could be inferred from consideration of the question alone, without particular attention to the context in which the question was asked. So the naming for initiation categories did not necessarily need to consider the utterances before the initiation questions.

This difference in contextual dependence for the identification of follow-up questions as distinct from initiation questions, made it advantageous to employ quite distinct classificatory systems for each. Therefore, there are no overlaps between the codes for initiation questions and those for follow-up questions.

```
1. Agreement request
2. Clarification
3. Cueing
4. Elaboration
5. Extension

Initiation questions

6. Justification
7. Refocusing
8. Reformulation request
9. Repeat/rephrase
10. Supplement
```

*Figure 3.5* The subcategories of follow-up questions.

3.5.4.1. Agreement request

*Agreement request* questions are those follow-up questions that are used to elicit students’ agreement on the solutions, ideas, or comments given by some students. The solutions, ideas, or comments in this situation are students’ responses to the initiation
questions or follow-up questions asked by the teacher in the last turn. In some cases, when the teacher asks an initiation question but there are no students’ responses, the teacher sometimes provides an answer and asks a follow-up question to check whether students whether they agree or not. The follow-up question in these cases will also be categorised as Agreement request questions.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) and Oliveira (2010) but in this study Agreement request questions only cover questions asked in the follow-up stage of teacher-student interaction. In other words, while “Agreement request” questions by the definition of Benedict, Kaur and Clarke (2007) and Oliveira (2010) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in my study those “Agreement request” questions asked in the initiation stage would be coded with initiation question categories, such as Understanding check question (see Section 3.5.3.13).

Example 53: CHN1-Lesson06

T: Okay, let us see Zhang’s idea.  
IQ: **Strategy**

S: [Zhang] Construct through the point B a perpendicular line to AD at E. then, in the triangle ABE, its, this angle is 30 degrees. Thus this angle is 60 degrees. Then the length of AE is 15, the length of BE is 15 times square root of 3, then in this triangle.

T: You can label the triangles [with these values].

S: Where should I label?

T: Just the values.

S: This one is 15, and this one is 15 times the square root of 3. Then this angle is a right angle, and this angle EAM is 15 degrees. Thus, this angle is 75 degrees. Since this part is 30 degrees, the remaining is 45 degrees. So this right triangle is an isosceles right triangle. So the length of ED is also 15 times the square root of 3. Therefore, the length of AD is the sum of 15 and 15 times the square root of 3. And because the triangle ABC is a special right triangle with a 30-degree angle, we could use the ratios of the three sides to find AC.

T: Okay. Does Zhang’s idea make sense to everyone?

IQ: **Agreement request**

Ss: [silent]

T: Let us have a look....

Example 54: CHN2-Lesson07

T: What is the axis of symmetry for this [pointing to the expression of the quadratic function]? Xu?

IQ: **Link/Application**
S: [student Xu] the axis of symmetry, we can use the formula of the vertex, uh, we can use the formula of the axis of symmetry to find it.
T: Okay.
S: [student Xu] the formula of the axis of symmetry’s coordinates is that \( x = \frac{-b}{2a} \).
T: The formula of the axis of symmetry’s coordinates?
S: [student Xu] just the straight line, \( x = \frac{-b}{2a} \). Then we can substitute \( a = \frac{4}{5} \) and \( b = \frac{-2}{5} \) into the formula. So we have negative two over five, then the two negative signs cancel out. [The teacher writes down the equation and the process of substitution]. It gives us five over two, divided by five over two. It is 1.
T: Is this correct? 
Ss: Yes.
T: Please be seated.

Example 55: AUS2-Lesson06

T: Yes yours is three decimal places. And yours are a bit more accurate than mine. So what do we notice happens to those sine values?
S: [student Judy] they go up.
T: They go up as ...?
S: [one student Judy] the angle increases.
T: As the angle size increases. Would everyone agree with Judy?
Ss: Yes.
T: Yes.

3.5.4.2. Clarification

Clarification questions are those follow-up questions requiring students to show more details about their answers, solutions, strategies of problem-solving, or comments. The answers, solutions, strategies of problem-solving, or comments in this situation are responses to the teacher’s initiation question or follow-up questions in the last turn.

This question type was mentioned in the research of Oliveira (2010) but in this study the meaning of this question type was reconceptualised to designate only those follow-up questions aiming to request one student’s confirmation of his or her previous utterances.

Example 56: CHN1-Lesson01

T: Now I have got a question. For a right triangle, apart from the condition of the right angle, what else do we need to find the remaining side lengths and angle sizes? What else do we need to find the remaining elements? Pi?
S: [student Pi] I think, for a right triangle, apart from the condition of the right angle, we need to
know the size of another angle or the length of one side.

T: **How should interpret the word “or” in your explanation? Does it mean I could find the remaining elements as long as I know the size of another angle? Or the size of another angle?**

FQ: **Clarification**

S: [student Pi] and one side length.

T: And one side length, both of the two needs to be...

FQ: **Elaboration**

S: [student Pi] known.

T: Good.

**Example 57: CHN2-Lesson05**

T: This student, he explained it graphically, Okay? Now let us think about it algebraically. [The teacher points to the coordinates of the vertices of three parabolas written a minute ago]. For example, what changes does the value of k bring to the vertex? [The teacher points to one student Zhang] would you like to make any comments?

FQ: **Review**

S: [student Zhang] it changes the coordinates, uh, the y-coordinate.

T: The y-coordinate of which point?

FQ: **Clarification**

S: The vertex.

T: Okay.

**Example 58: AUS1-Lesson02**

T: **So what would, what might’ve caused it to be a little bit off?**

FQ: **Reflection**

S: Bad measurements.

T: **What would have been bad about the measuring?**

FQ: **Clarification**

S: I might’ve done a little bit off, or like something inaccurate

T: **What is not accurate? What is not accurate about it?**

FQ: **Clarification**

S: Drawing and measurement

T: What..., okay...

**Example 59: AUS2-Lesson01**

T: ...So what I want to, why would I get you to draw squares? What is this theory about?

FQ: **Explanation**

S: squares

T: **What sort of squares?**

FQ: **Clarification**

Ss: silent.

T: **Where are the squares?**

FQ: **Cueing**

S: [one student] right there

T: No. Here [The teacher points to the $3^2+4^2=5^2$ on the board], I’ve squared the side lengths.

3.5.4.3. **Cueing**
**Cueing** questions are those follow-up questions used to direct students to focus on key elements or aspects of the problem situation so as to reduce the cognitive workload, which in turn enable students’ problem-solving, especially when the students fail to make progress or when students give the incorrect responses.

This question type is a bit similar to the type of “Orienting and focusing” question in the research of Boaler and Brodie (2004). While the “Orienting and focusing” questions by Boaler and Brodie’s (2004) definition might be identified in either the initiation stage or the follow-up stage of teacher-student interaction, **Cueing** questions, for the purpose of this study, only cover the questions asked in the follow-up stage. In addition, **Cueing** questions’ purposes are to reduce the cognitive workload, which does not necessarily apply to the “Orienting and focusing” questions.

**Example 60: CHN2-Lesson02**

T: A lot of students wrote that the graph of \( y = -x^2 \) is, the whole graph is in the third and the fourth quadrants. **Is this correct?** IQ: Evaluation

Ss: silent

T: **the points on the x-axis and y-axis, do they belong to any of the four quadrants?** [points to one student] IQ: Cueing

S: [one student]No.

T: So can we say all the points of the parabola, are in some quadrant? IQ: Elaboration

S: [one student]No.

T: Please be seated.

**Example 61: AUS1-Lesson02**

T: What we do is [inaudible] two steps. Once you’ve done the two steps, [inaudible], I want to do very [inaudible] and sine of sixteen point two degrees. The reason that works is you [inaudible] divide it by n, when we get [inaudible] on the top, multiply those sides by [inaudible], so we get the m times sine sixteen point two degrees, equals sixty-four. Now we’ve got m times sine sixteen point two. How do we get, how do we cancel that out times? IQ: Review

S: silent

T: **what’s the inverse of times?** IQ: Cueing

S: uh, divide.

T: so divided by sine sixteen point two.

**Example 62: AUS2-Lesson02**

T: have a look. Have a look at the left-hand side \( \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} = c \). Guys, what common error
will people make with that thinking there is one more step? What would they do? \[Q: \text{Generation}\]
Ss: [one student says] square root c [others are silent].
T: Can I just get rid of those squares from the square root? [which means the squares in the left-hand side] \[Q: \text{Cueing}\]
Ss: someone says “yes”; others are silent.
T: Can I? \[Q: \text{Justification}\]
T: I can’t.

3.5.4.4. Elaboration

Elaboration questions are those follow-up questions used to guide students towards a more comprehensive response by building on students’ existing responses, especially when the teacher’s initiation question or follow-up question in the last turn had not elicited responses that are as rich as they were expected to be by the teacher.

This question type was mentioned in the research of Boaler and Brodie (2004) and was usually combined with “Explanation” questions. In this study Elaboration questions only refer to questions asked in the follow-up stage of teacher-student interaction. In other words, while “Elaboration” questions by the definition of Boaler and Brodie (2004) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in this study those “Elaboration” questions asked in the initiation stage would be coded with initiation question categories, such as Explanation (see Section 3.5.3.4).

Example 63: CHN1-Lesson02

T: What kinds of basic knowledge does this need? What kinds of basic knowledge does this require to solve the right triangle? He?

\[Q: \text{Review}\]
S: It needs the sum of the interior angles of the triangle.
T: the sum of the interior angles of the triangle. In other words, taken away the ninety degrees, the two remaining acute angles in the triangle are? \[Q: \text{Elaboration}\]
S: complementary
T: Uh, the two acute angles are complementary.

Example 64: CHN2-Lesson02

T: Now the second question, his drawing is relatively smooth. Now have a look, how do you like his drawing? Any comments? [inviting a student who puts up his hand] \[Q: \text{Evaluation}\]
S: I think he should have extended the graph a bit because there are ellipses in the table.

T: Why are there ellipses in the table?  
FQ: Elaboration

S: Because the value of x is, it could be any real numbers, instead of these seven values listed in the table.

T: Is it correct?  
FQ: Agreement request

Ss: Yes.

T: So the graph needs to be extended.

Example 65: AUS1-Lesson05

T: Anyone wants to write down some information where you saw it. How far away from the plane you saw the whale? How might we know, how might we work this out? Or what sort of information could we tell from the plane? What sort of information could we have from the plane?  
FQ: Generation

S: how high it is.

T: Okay, we might have the altitude. We call that, that is the word we use. We might have the altitude. [writes down “Altitude”]

S: do we need to write this down?

T: Not this. You don’t need to write this down. You might have the altitude of the plane, or the height above the ground, or, sea [writes down “(Height)”next to “Altitude”]. So altitude is just another word for height. That’s height of something that’s flying in the air. [asks one student who hands up to give an answer]

S: speed

T: We might have the speed of the plane, but is that going to be too important to where the whale is? When we’re moving, we sort of want to take a measurement right now. Speed would be helpful if we want to take a measurement every minute. [asks one student who hands up to give an answer]

S: we can measure the distance between your distance and the whale.

T: How do we do that? We get out a laser pointer and take a measurement?  
FQ: Clarification

S: [silent]

T: [asking one student who hands up to give an answer]

S: the latitude of …

T: We know where up the plane is. Is that the sort of what you mean?  
FQ: Clarification

S: yeah

T: Okay, so we can know where our plane is. We probably know that. [writes down “where is the plane?”] We can look that up on the GPS. What else can we tell from the plane about where the whale is? I’ve heard a bit, let’s hear from someone over here if you fellows think about this.  
FQ: Supplement

Ss: [silent]

T: We are looking down, where is it? Is it over there, or over here? [Points to different directions] Where is it?  
FQ: Cueing

S: direction.
T: direction, what sort of information about direction might we know? What sort of information about direction?

S: North, south, east, west.

T: Okay, we could have a compass bearing. Okay, a bearing [writes down “bearing” on the board]

Example 66: AUS2-Lesson07

T: And five, four, three, two, one, eyes this way. [waiting for students to get quiet] Oky, so what sort of representation do I have on the board now?

Ss: [some students] cos, [most] silent

T: No. no. Representation. How will I represent that?

Ss: [one student] triangle

T: Triangle, which is a part of …?

Ss: [silent]

T: The big topic is called…?

Ss: [one student] geometry.

T: So it’s geometric.

3.5.4.5. Extension

*Extension* questions are those follow-up questions used to extend the topics under discussion to other situations or to connect the knowledge under discussion with the students’ prior knowledge. These questions are asked on the basis of students’ responses to the teacher’s initiation question or follow-up question in the last turn.

This question type was mentioned in the research of Boaler and Brodie (2004) but in this study *Extension* questions only cover questions asked in the follow-up stage of teacher-student interactions. In other words, while “Extension” questions by Boaler and Brodie’s (2004) definition might be identified in either initiation stage or follow-up stage of teacher-student interaction, in this study those “Strategy/procedure” questions asked in the initiation stage would be coded with initiation question categories (such as *Variation*).

Example 67: CHN2-Lesson04

T: [presents both of the two students’ graphs]Let’s have a look at Bao’s drawing. It looks a bit different from what Fan draws. [points to one student in the presenting group] would you like to make any comments?

S: [one student] In Fan’s drawing, the graph is extended, a bit more than Bao’s drawing. Therefore, Fan’s drawing is longer.

T: Okay, a bit longer. [inviting another student to answer]. Liu?

67
S: [student Lyu] I think in Fan’s graph, it is extended a bit, whereas Bao’s graph seems to be not extended.

T: [points to Bao’s graph] could it be extended, like what Fan has done?

FQ: Extension

S: Yes.

T: Why?

FQ: Justification

S: Because the parabola is a symmetric shape. When one point on the parabola is given, then its symmetric point across the axis of symmetry can be determined.

T: Is it correct?

FQ: Agreement request

Ss: Yes.

T: Please be seated.

Example 68: AUS2-Lesson06

T: Let’s put those two ideas together. If we know that’s the longest side, and it’s opposite the right angle, what do we know about the right angle, in comparison to the other two angles?

FQ: Link/Application

Ss: [someone] the biggest

T: Yeah, the biggest angle is opposite the biggest side. Yeah? So which means the smallest angle is opposite...?

FQ: Extension

Ss: [some students] the smallest side

T: The smallest side. Good. [writes down “adjacent” to the third side]. Okay.

3.5.4.6. Justification

Justification questions are those follow-up questions requiring students to justify their answers, solutions, or arguments, where the answers, solutions, or arguments are responses to the teacher’s initiation question or follow-up question in the last turn.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) and Boaler and Brodie (2004) and this question type was usually categorised in the same category as ‘Explanation’ questions. But in this study Justification questions only cover questions asked in the follow-up stage of teacher-student interaction whereas Explanation questions only cover questions in initiation stage of teacher-student interaction. In other words, while “Justification” questions by the definition of Benedict, Kaur and Clarke (2007) and Boaler and Brodie (2004) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in this study those “Justification” questions asked in the initiation stage would be coded with initiation question categories, such as Explanation (see Section 3.5.3.4).
Example 69: CHN1-Lesson04

T: the length of BM is 23 meters. If BM is equal to 23, then AM is...?  
Q: Result

S: one-third of twenty-three meters.  
Q: Reformulation request

T: one-third of...?  
Q: Justification

S: one-third of twenty-three.  
Q: Reformulation request

T: why is it one-third of twenty-three?  
Q: Justification

S: uhm, tripped.  
Q: Agreement request

T: The ratio of this one [BM] to this [AM] is 1 to 3. It takes up one share of the whole. That’s what you said. So this is x, then this is 3x. If this is 23, then should this be 3 times 23?  
Q: Agreement request

S: Yes.  
T: Okay.

Example 70: CHN2-Lesson09

T: What restrictions are there for the value of l?  
Q: Explanation

S: l is less than 30, and then greater than zero.  
Q: Justification

T: Why?  
Q: Justification

S: Because the length could be 0, and it also could be 30. If it is 30, then it [the rectangle] does not have a width. If it is 0, then it [the rectangle] does not have a length. 
Q: Agreement request

T: Is he correct?  
Q: Agreement request

Ss: Yes.  
T: Okay. In other words, one side length is l, and then this l should be greater than zero.

Example 71: AUS1-Lesson03

T: So I had this, [draw a new right-angle triangle, but the value of degrees and lengths of sides are the same as the previous one], fifteen degrees, this was four, this was fifteen point four five. If this is fifteen degrees, what’s the angle [the angle between the side 4 and 15.45] here? Jean?  
Q: Review

S: [student Jean]Pardon?  
Q: Repeat

T: If this is fifteen degrees, what it this angle here? 
Q: Repeat

S: [Jean] seventy-five  
Q: Justification

T: Yes, you name it, Jess.  
S: [Jean] was it seventy-five? 
Q: Justification

T: how, why is it seventy-five, Jean? 
Q: Justification

S: [Jean] because in a triangle, all the angles sum up to a hundred and eighty degrees. 
Q: Agreement request

T: That’s right. That’s what’s left.

Example 72: AUS2-Lesson07

T: How would I find x? How would I find it? There're a couple of ways I can do it.  
Q: Strategy

Ss: [one student] swap x and cosine sixty.
T: [to one student] say that again.  
FQ: Reformulation request
S: [one student] swap x and cosine sixty.
T: Why would you do that?  
FQ: Justification
S: [one student] because it’s simpler form.
T: Yes, it is. But explain it to me.  
FQ: Refocusing
S: [one student] I suspected that I just did.
T: All right.

3.5.4.7. Refocusing

Refocusing questions are those follow-up questions used to redirect students to refocus on the essential points of the problem or the topic under discussion, especially when students’ answers, comments or thinking are off the right track. The students’ answers, comments or thinking in this situation are responses to the teacher’s initiation question or follow-up question in the last turn.

This question type was mentioned in the research of Boaler and Brodie (2004) but in this study but in this study Refocusing questions only cover questions asked in the follow-up stage of teacher-student interaction. In other words, while “Refocusing” questions by the definition of Boaler and Brodie (2004) might be identified in either initiation stage or follow-up stage of teacher-student interaction, in this study those “Refocusing” questions asked in the initiation stage would be coded with initiation question categories, such as Progress monitoring (see Section 3.5.3.8) or Information extraction (see Section 3.5.3.5).

Example 73: CHN2-Lesson10

T: [to one student Fan] How to draw connections between the values of a, b, c and the graph?  
FQ: Strategy
S: [student Fan] 4ac minus b squared, all over 4a.
T: 4ac minus b squared, all over 4a, is used to check the sign of c, right?  
FQ: Clarification
S: 4a is less than zero.
T: Yes. [writes it down]
S: [silent]
T: Do you remember the last lesson Liu shared a conclusion with us?  
FQ: Cueing
S: [silent]
T: [to another student] Ji?  
FQ: Supplement
S: [student Ji] Because a is less than zero, and [interrupted by the teacher]
T: Please give me a straightforward answer. What do we need to check the sign of c?  
FQ: Refocusing
S: [silent]
T: [points to another student]  
FQ: Supplement
We can use the intersection point of the quadratic function and y-axis. The coordinates of the intersection point are 0, c. In this question, since c is on the positive y-axis, c is greater than zero.

**Example 74: AUS2-Lesson01**

T: Good. Alright, so I am going to write K equals the squared root of nine thousand eight hundred and fifty-six. [writes down \( k = \sqrt{9856} \)] What form is that in, starts with e?

S: It’s 99.277389

T: Thank you very much. But what form is this written in? starts with e?

Ss: [someone says] Expansion, [someone says] evaluating

T: [writes five short lines “__ __ __ ____” on the board and asks students to guess every single letter in the word]

### 3.5.4.8. Reformulation request

Reformulation request questions are those follow-up questions requiring one student to reformulate his or her answer, especially when the teacher asks a question to a whole class, but a couple of different answers are given simultaneously by various students. By asking the Reformulation request questions, the teacher normally would like to get the whole class’s attention to one particular student’s answers.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) to refer to teachers’ repetition of students’ answers. But in this study, when asking Reformulation request questions, the teacher does not repeat students’ utterances. Rather, the teacher just asked a question requesting the student to repeat his or her answer. For those questions where teacher repeated students’ utterances for verification would be coded as Clarification questions (see Section 3.5.4.2) in this study.

**Example 75: AUS2-Lesson07**

T: Okay. Could I find x using that information?

Ss: [some students] Yes

T: How?

Ss: [one student] Linear equation

T: [to one student] Say that again.

Ss: [one student] Linear equation

T: It’s like a linear equation. It’s like an equation.
3.5.4.9. **Repeat/rephrase**

Repeat/rephrase questions are those follow-up questions where the teacher repeats or rephrases the question asked in the last turn. It could be the teacher’s repeat/rephrase of either an initiation question or a follow-up question. Repeat/rephrase questions are normally asked when students have no responses to the teacher’s initiation question or follow-up question in the last turn. But those questions in the form of repetition but on the purpose of the request for clarification or justification are excluded from this category. Instead, these questions are categorised as *Clarification* (see Section 3.5.4.2) or *Justification* (see Section 3.5.4.6) questions. Refer to Example 80 for more details about this special case.

This question type was mentioned in the research of Benedict, Kaur and Clarke (2007) whose definition was adopted in this study. If the teacher repeats his or her questions is because that he or she doesn’t hear clearly students’ responses, then these repetitions will not be included as questions in this study and thus, will not be categorised as Repeat/rephrase questions.

Example 76: CHN1-Lesson03

| T: | In other words, take the height of the tower as an example, assume that the position of the inclinometer or the height of the person could be negligible. We will look the situation when the height could not be negligible later. So if it is negligible, according to Pi, we know this is angle A, and we know the size of this angle, or we can measure it. **[Q: Progress monitoring] Then what do we need to continue?** |
| S: | [one student] We need to know AD. **[Q: Clarification]** |
| T: | [to one student] we need to know AD. **[FQ: Repeat/Rephrase]** How to get the length of AD? |
| S: | [one student] use the tape measure. **[FQ: Clarification]** |
| T: | Good. Please be seated. We can use the tape measure. But as is the last problem which required us to find the height of the flag pole, there is a lake in this problem and it is a big obstacle. Due to the existence of the lake, we just can’t measure the distance of AD. **[FQ: Refocusing]** So what can we do? |
| S: | [another student] We can get a boat. **[FQ: Repeat/Rephrase]** |
| T: | A boat. Hah. **[FQ: Clarification]** |
| S: | [a third student] We can construct a floating bridge. |
| T: | A floating bridge. It will take too much work and time. We can solve it using some other methods. **[FQ: Repeat/Rephrase]** What should we solve this? |
| Ss: | [silent] |
T: **Any ideas?**

S: [one student] Can we know the length of AC?

T: As said by Zhang, we could not get the length of AC.

Ss: [Some say] Can we measure the time?

T: [Ignore the above questions] **Any other methods? Do you have any ideas, Li?**

S: For example, assuming that there is a man who is 1.5 meters high and he is standing at point A. uh, let us assume it point B, oh, no, point D.

T: Come here and demonstrate your idea. Draw anything you need on the board.

[the students draws on the board]

---

**Example 77: CHN2-Lesson07**

T: So when dealing with the problems involved the vertex of the function’s graph, we usually need to use, [writes this down on the board] **When the problems involve the vertex, which form are we going to use for our guess?**

Ss: [silent]

T: **Which form?**

Ss: The vertex form.

T: The vertex form.

---

**Example 78: AUS1-Lesson01**

T: Now, one last thing is to do with naming conventions. **What do I mean by "conventions", Alan? What is a convention?**

S: [Alan] Not sure.

T: Not sure? What's, **what do I mean by convention?**

[Points at Jim when he puts his hand up]

S: [Jim] Is it the sine, cosine and tangent?

T: No. We've not looked at those yet. We'll look at those later in the week. What's the convention meaning? **What's the word convention meaning?**

S: [Alan] As I can see, the convention is like the-

S: [Derek] party

T: Okay, oh yeah, could be a, like a par-, you say a party. Could be like a festival or something like that. That's not what I mean by this. What I mean is, like a rule. A convention is, is maybe, a rule that’s usually followed. That's what I mean by that.

---

**Example 79: AUS2-Lesson02**

T: So what you have to remember when you do this question is that you know the maths and what you have to do is to figure out which maths you know is useful. **How do you figure out which of what you know is useful?**

Ss: [silent]

T: **How did you know?**

Ss: [Someone says] Keywords. [Others are silent]
T: keyword. Yes. Use the keywords to pick out. Ah, I know about squares.

Ss: [Someone says] That’s why I hate the problem.

T: Okay.

Example 80: AUS2-Lesson02

Note: The last question was coded as a request for clarification instead of a Repeat/rephrase question.

T: Is there any right-angle triangles in a or b? [Q: Information extraction]

Ss: [some students say] Yeah. [Others are silent]

T: Everyone’s eyes on a and b. Ben, eyes on a and b. Is there a right-angle triangle in any of those questions? [FQ: Repeat/Rephrase]

Ss: [most students say] Yes, [someone says] No.

T: Is there? [FQ: Clarification]

Ss: [most students say] Yes.

3.5.4.10. Supplement

Supplement questions are those follow-up questions used to request for a larger variety of opinions, comments, knowledge, examples or approaches so as to supplement existing students’ responses. The existing students’ responses in this situation are the answers to the teacher’s initiation question or follow-up question in the last turn. Supplement questions are used to collect various comments from different students, whereas Extension (see Section 3.5.4.5) questions are used to ask one student for deeper thinking of one topic or the connections between one topic and another. Sometimes when the teacher asks an Extension question to a student, this student, however, could not give an answer. Then the teacher might ask a further Supplement question to ask for some other students’ contribution.

This question type was mentioned in the research of Boaler and Brodie (2004) whose definition was adopted in this study. A similar question type could also be found in the research of Hiebert and Wearne (1993) but these two researchers’ definitions only include questions asking for alternative strategies. In addition to request for different strategies, Supplement questions in this study could also be used to ask for different comments, opinions and so on. In this study, the category Supplement is restricted to only follow-up questions.

Example 81: CHN1-Lesson02

T: So what should you do? There are two options. One is what? [Q: Strategy]
Ss: Constructing.
T: Constructing. If you like the constructing way, will you have to construct a perpendicular line?

FQ: Clarification

Ss: Yes.
T: Then we can put it [the angle EDC] into a right triangle. What if you don’t want to construct the perpendicular line? What could you do?

FQ: Supplement

Ss: Converting.
T: Converting. We can also convert it to an equivalent, right? Do we have the equivalent here in the diagram?

FQ: Clarification

Ss: Angle C.
T: Good.

Example 82: CHN2-Lesson08

T: Now for quadratic equations, no solutions, two equal solutions, or two unequal solutions, how could these situations be determined? Fan?

IQ: Review

S: These could be determined b…
T: think back to the prior knowledge.

FQ: Cueing

S: [silent]
T: [to another student Gu]

FQ: Supplement

S: b squared minus 4ac.
T: Is that correct?

FQ: Agreement request

Ss: Yes.

Example 83: AUS1-Lesson01

T: Bob, which would you call the adjacent side?

IQ: Review

Ss: [one student] p, [another student] c. [teacher is waiting for Bob's reply]
T: can't hear, Ben?
S: [Bob] C
T: C? I’ve got n, m and p.

FQ: Refocusing

S: [Yale] He can’t see. He needs the glasses.
T: Oh, you can’t see? Can you see the board, Bob?
S: [Bob] No
T: Ok, ah, Duncan?

FQ: Supplement

S: [Duncan] Hy-, the hy-, the what?
T: I am asking the adjacent at the moment, but...

FQ: Repeat/rephrase

S: [Duncan] The adjacent is p.
T: OK. Good. [writes that down on the board]

Example 84: AUS2-Lesson06

T: How do I know this is the hypotenuse? There are two ways.

IQ: Review

Ss: [someone] opposite the right angle
T: One of the ways is that is opposite the right angle. What is the other way?

FQ: Supplement
**3.5.5 Reliability check for the coding systems**

One lesson was selected separately from teacher CHN1’s class and teacher AUS2’s class for a reliability check, in which two coders (one of whom was the researcher) in the field of education research independently coded the questions in the transcripts of the selected lessons. Due to the ethical requirement restricting video access to the researcher, the classroom videos could not be watched by any coders other than the researcher. However, coding of teacher questioning could be conducted using the lesson transcripts and also all teaching and learning materials including lesson plans, PowerPoint slides, and copies of student worksheets were available to both coders. Also, teacher questionnaires and classroom observation tables were also given to both coders so as to allow each coder the best possible basis on which to make sense of the instructional settings.

An agreement of 80% was achieved between the two researchers’ coding results. Any inconsistent coding results were discussed and a consensus coding determined. Where coding differences arose from differences in the interpretations of the coding scheme, rather than differences in the interpretation of the data, these differences were resolved by either combining categories to form a new composite code or refining the categories’ descriptions to achieve consensus as to the meaning of the code/category. Afterwards, the researcher coded all the remaining lessons with the revised coding systems. The questions identified within the lesson transcripts were not coded in isolation, disconnected from the interactions of which they were a part. They were instead all coded within the classroom transcripts, where the teacher and students engaged in questioning and answering practices, so that the social context of each exchange could be taken into account, together with actions that immediately preceded or followed the coded exchange. The classroom videos were revisited and checked whenever there was ambiguity.

**3.5.6 Three stages of data analysis**

Three distinct forms of transcript analysis were conducted in this study. The first form addressed the number and proportions of questions asked in each teacher’s class. The number includes the total number of all questions, all initiation questions and all follow-up questions and the proportion involves the proportions of questions used in Q&A question pairs and IRF (single) sequences and the proportions of questions used in IRF
(multiple) sequences. Besides, the proportions of initiation questions and follow-up questions were also examined. In particular, the variations and consistencies regarding these numbers and proportions across the whole unit of consecutive lessons were investigated for each teacher, and the results of this part are presented in Chapter 4. Besides, the ratios of follow-up questions to initiation questions, the variations and consistencies in each teacher’s frequency of use of these categories over the consecutive lessons in each teacher’s class are also reported in Chapter 4.

The second form of data analysis concerned the subcategories of initiation questions and follow-up questions. The coding schemes were applied to all initiation questions and follow-up questions to examine what question types were used as (1) initiation questions in Q&A question pairs and IRF (single) sequence, (2) initiation questions in IRF (multiple) sequences, and (3) follow-up questions. For each participating teacher, the variations and consistencies regarding the selection of questions types over the whole unit of consecutive lessons were also examined. The results of this part are reported in Chapter 5.

In the third form of data analysis, the IRF (multiple) sequences were further explored. This analysis investigated how initiation questions and follow-up questions were sequenced in the IRF (multiple) sequences in each teacher’s class to fulfil different pedagogical purposes over the consecutive lessons. For each teacher, the transcripts of questioning practices were presented with a detailed analysis. The results of this part are presented in Chapter 6.
CHAPTER 4 RESULTS: QUESTION TYPE AND FREQUENCY ACROSS THE FOUR CLASSROOMS

The results of this study are reported in the following four chapters, and this chapter presents the first part of the results of this study. This chapter comprises seven sections, namely two sections regarding organisation and general characteristics of all four teachers’ classes and questioning practices, four sections with detailed descriptions of the frequency of use of different question types by each of the four teachers, and a concluding summary.

4.1 Basic information about the four teachers’ classes

In this section, the unit structure of consecutive lessons taught by the four teachers will be outlined. Information about the practices and basic forms in which mathematics teaching and learning took place in each teacher’s class would also be described.

4.1.1 Organisation of the instruction in the four teachers’ classes

Teacher CHN1’s lessons could be typified by intensive whole class instruction. The teacher did a lot of lecturing and demonstration. The teacher tended to communicate with the whole class, but sometimes the teacher selected one student or a couple of students to speak in public and the communication between the teacher and the selected students was intended to be heard and attended to by the whole class. There were very few chances for students to have discussions or collaborations, and time for student seatwork or pair work was also very limited. Students rarely asked questions in the class, regardless of whether it was the time for whole class instruction or seat work. So teacher questioning practices in the CHN1 class were observed and recorded in a context of whole class instruction. During her teaching, teacher CHN1 usually used PowerPoint slides to present tasks, diagrams and tables to assist her teaching. No calculator of any type was used by the students in the lessons, and calculation work was all done by pencil and paper.

Teacher CHN2’s classroom was characterised by the prevalence of intensive time for student discussions and presentations, while the teacher tended to provide help or guidance for students’ talk and to summarise students’ talk in order to refine their mathematics knowledge. The 46 participating students in this class were divided into eight heterogeneous groups, with each group including students of varying mathematics
ability. 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. In CHN2’s class, there was intensive use of the visual presenter which projects the images of documents placed underneath the camera to a screen through a projector. With the use of the visual presenters, the teacher and students could present written work to the whole class. During group work, the teacher usually walked around in the class and checked the students’ progress, but he normally gave directions or asked stimulating questions which were expected to facilitate students’ thinking rather than to be answered immediately.

During a student’s presentation, the teacher might intervene to ask the presenter some questions or ask the whole class to comment on the presenter’s ideas. Several students might be selected to share their comments in public, and the whole class was expected to pay attention to such public talk. Students sometimes asked questions as comments to the student presenter but barely asked questions of the teacher. On some occasions, students asked questions of the teacher during group work time, and the teacher tended to provide some clues or directions to allow students move forward on their own rather than having extended conversation with the students. Framed by these classroom routines, teacher questioning practices in the CHN2 class were observed and recorded within the context of whole class instruction. Geometer’s Sketchpad and PowerPoint slides were sometimes used to present mathematical tasks or graphs. No calculator of any type was used by the students in the lessons, and the calculation work was all done by pencil and paper.

Teacher AUS1’s class tended to start with a 20-minute lecture or whole class instruction, followed by time for students’ individual seatwork. In some lessons, seatwork activities were assigned to students at the beginning and subsequently the teacher gave a lecture and summarised the new mathematics knowledge. In the last lesson analysed for this current study, students were asked to perform out-of-class activities and to measure the height of objects in the school compound with the use of inclinometers, followed by some calculation work in the classroom after collecting the measurements. During the seatwork time, the teacher usually walked around in the classroom, checking students’ progress and communicating with students. A lot of questions were asked to the individual student or group by the teacher during the seatwork time, and these interactions were mainly for the individual student or group while other students were doing their work within the overall context of the practices and routines just outlined. Teacher
questioning practices in the AUS1 class were observed and recorded in both the whole class instruction and student seatwork time. Graphics calculators were used by the students, and the calculations were done with the help of calculators.

Teacher AUS2’s class was a combination of student activities (principally individual student seatwork and pair work) and teacher-led whole class instruction. At the beginning of the lessons, the teacher usually assigned some activities or tasks for the students to finish independently or to work in pairs, which was followed by some time for whole class instruction. Then some more tasks or activities were assigned to students for seatwork or pair work, which was followed by another round of whole class instruction, and so on. During the seatwork time, the teacher usually walked around in the classroom, checking students’ progress and communicating with students. Most of the questions were asked by the teacher during the whole class interaction, but the teacher posed some questions to the individual student or group during the seatwork time and these interactions were mainly for the individual student or group while other students were doing their work. So teacher questioning practices in the AUS2 class were observed and recorded in both the whole class instruction and student seatwork time. In her lessons, teacher AUS2 used the interactive board and Excel worksheet to present mathematics tasks and to facilitate the investigation of some mathematics ideas. Graphics calculators were used by the students, and each student had one laptop for online learning programs, web browsing, or accessing Word or Excel documents. All the calculations could be done with calculators or laptops. The frequent instructional use of technology in AUS 2’s lessons is an example of a type of contextual attribute likely to have contributed to the form taken by the teacher’s questioning practices.

4.1.2 Organisation of mathematical content in the four teachers’ classes

This subsection presents the unit topics in each participating teacher’s class and how the lessons were organised around the unit topic.

Figure 4.1 shows the topics in the unit of six consecutive lessons taught by teacher CHN1 and the structure by which these lessons were organised. The various components of the lesson sequences (topics) taught by each of the four teachers have been labelled by the researcher in a way that identifies the apparent instructional purpose of that phase of the topic. The topic for this teacher’s unit of consecutive lessons was “Solving right triangles”. For Teacher CHN1, the unit started with an introduction in lesson one about
some essential strategies to find lengths of sides and values of angles in a right triangle. And this was followed by lesson 2 where the essential strategies of solving right triangles were applied to some non-right triangles that could be divided into two or more right triangles. These two lessons were labelled as the Introduction and Strategies phase of the unit. The subsequent two lessons, lessons three and four, covered applications of the above strategies to real-life situations, including the measurement of height and distance, the use of slope angles in building construction, and the planning required for safe marine navigation. Further application problems in mixed scenarios were discussed and solved in lesson five. Lessons 3 to 5 were labelled as the Consolidation and Application phase of the unit. The whole unit ended with a summary and review of the previous five lessons, and the last lesson was labelled as Summarization phase of the unit.

Figure 4.1 The unit structure of six consecutive lessons taught by teacher CHN1.

Figure 4.2 shows the topics in the unit of the ten consecutive lessons taught by teacher CHN2 and the structure by which these lessons were organized. The unit topic of the consecutive lessons was “Quadratic functions”. The unit began with an introduction of quadratic expressions and functions in lesson one, and this lesson was labelled as the Introduction phase of the unit. Then lesson one was followed by activities of sketching the graph of a particular form of quadratic function, $y=ax^2$, and investigation of the
graphs’ properties such as shape, the axis of symmetry and turning point in lesson two. After lesson two, another two forms of quadratic functions, $y=ax^2+k$ and $y=a(x-h)^2$, were explored in lesson three and four. In addition, the connections between $y=ax^2$ and these two functions were also discussed separately in lesson three and four. Subsequently, lesson five covered the exploration in the vertex form of quadratic functions $(y=a(x-h)^2+k)$ and lesson six addressed the investigation in the general form of quadratic functions $(y=ax^2+bx+c)$. Lessons two to six were labelled as the Exploration phase of the unit.

Figure 4.2  The unit structure of ten consecutive lessons taught by Teacher CHN2.
In lesson seven, students learnt how to find the equations of quadratic functions when the coordinates of two or three points on the graph of the quadratic function are known. In lesson eight, connections were drawn between quadratic functions and quadratic equations, and the number of a quadratic equation’s solutions was linked to the number of the corresponding parabola’s $x$-intercepts. Accordingly, lessons seven to eight were labelled as the Strategies phase of the unit.

In lesson nine, students were expected to apply their knowledge of quadratic functions to real-world problems. Although many practical problems had been mentioned and discussed as part of the investigation of quadratic functions in the previous lessons, lesson nine was a lesson with mixed practical problems requiring the comprehensive application of knowledge learnt in the prior lessons. This lesson was accordingly labelled as Consolidation and Application phase of the unit. The whole unit concludes with the chapter review in lesson ten, which was labelled as the Summarization phase of the unit.

Figure 4.3 shows the topic in the unit of six consecutive lessons taught by Teacher AUS1 and the structure by which these lessons were organised.

![Figure 4.3](image-url)  
*Figure 4.3* The unit structure of six consecutive lessons taught by Teacher AUS1.
The unit topic for the consecutive lessons is “Trigonometry”. The unit started with the identification and naming of sides in right triangles in lesson one which was labelled as the *Foundation* phase of the unit. Subsequently, trigonometric ratios were introduced in lesson two which was labelled as the *Introduction* phase of the unit. And the mathematics about trigonometric ratios was applied in lesson three to find the unknown side lengths in right triangles. In lesson four, inverse trigonometric ratios were introduced and used to find angle sizes in right triangles. Lessons three and four was labelled as the *Strategies* phase of the unit.

The following two lessons, lesson five and lesson seven, was concerned with the connections between trigonometric ratios and some real-world situations, including the angles of elevation and depression, and the measurements of heights of objects or buildings with the assistance of inclinometers. These two lessons were labelled as the *Consolidation and Application* phases of the unit.

*Note:* Lesson six was omitted from this analysis because it was mainly about the construction of inclinometers and there were no mathematical interactions between the teacher and his students during classroom instruction.

Figure 4.4 shows the topics in the unit of six consecutive lessons taught by Teacher AUS2 and the structure by which these lessons were organised. The unit topic for the consecutive lessons is “*Pythagoras theorem and trigonometry*”.

For Teacher AUS2, the first two lessons in the unit were mainly about the revision of Pythagoras Theorem and then its further applications in triangles and Cartesian plane. This was followed by the revision of similarity and congruence, which were used in the following lessons to assist students to understand the concepts of trigonometric ratios. These above three lessons were labelled as the *Foundation* phase of the unit.

In lesson five, the history and concepts of trigonometric ratios were introduced, and the relevant properties of trigonometric ratios were then investigated. Lesson five was labelled as the *Introduction* phase of the unit. The concepts and meanings of trigonometric ratios were extended further in lesson six where students were expected to understand the link between using a trigonometric ratio to describe a triangle and using it to define a triangle. Lesson six was labelled as the *Exploration* phase of the unit.
The strategies of using trigonometric ratios to find side lengths and angle values were covered in lesson seven and some simple applications were also mentioned. And this lesson was labelled as the Strategies phase of the unit. (Note: Lesson three was omitted from this analysis because it was mainly about the students’ seat work exercises and no new mathematics was covered. There were no mathematical interactions between the teacher and her students in this lesson.)

4.2 Questioning practices of the four teachers

In this section, the overall results about questions asked by each of the four teachers are outlined. Table 4.1 provides an overview of questioning practices in each of the four classrooms. For each teacher’s case, it shows the total number of consecutive lessons, the total length of time for the consecutive lessons, the total number of questions asked during classroom instruction, and the average frequency of questioning per minute.
Table 4.1

Summary of All Four Teacher’s Classes

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Number of lessons</th>
<th>Total time of lessons (mins)</th>
<th>Total number of questions</th>
<th>Average frequency of asking questions (per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHN1</td>
<td>6</td>
<td>259</td>
<td>434</td>
<td>1.68</td>
</tr>
<tr>
<td>CHN2</td>
<td>10</td>
<td>475</td>
<td>1071</td>
<td>2.25</td>
</tr>
<tr>
<td>AUS1</td>
<td>6</td>
<td>290</td>
<td>272</td>
<td>0.94</td>
</tr>
<tr>
<td>AUS2</td>
<td>6</td>
<td>501</td>
<td>958</td>
<td>1.91</td>
</tr>
</tbody>
</table>

As is shown in Table 4.1, questioning practices vary a lot amongst the four teachers’ lessons. The total length of lesson time analysed also varies, ranging from 259 minutes (Teacher CHN1) to 501 minutes (Teacher AUS2), while the total number of questions spans from 272 (teacher AUS1) to 1071 (teacher CHN2). Meanwhile, the average frequency of asking questions over the consecutive lessons ranged from 0.95 questions per minute (teacher AUS1) to 2.25 questions per minute (teacher CHN2).

Table 4.2 presents a detailed lesson-by-lesson outline of the number of questions posed by each of the teachers. Among the four teachers, the average length of time occupied by each lesson does not vary very much, except the case of teacher AUS2 for whom there were four double lessons and the duration of each double lesson was about 100 minutes. If each double lesson were counted as two lessons with equal length of time, the average duration of each lesson in teacher AUS2’s class would be 50.1 minutes, which was not substantially different from the other three teachers. Since lesson lengths were essentially comparable, the huge differences in the total number of questions (see Table 4.1) were also observed in the average number of questions asked by each teacher. An average of 72.3 questions was posed in each lesson for teacher CHN1, 107.1 questions for teacher CHN2, 45.3 questions for teacher AUS1 and 159.7 questions for teacher AUS2. However, as can be seen from Table 4.2, the number of questions asked by any one teacher varied considerably from one lesson to another (e.g., CHN 1 lesson one included 104 questions, whereas lesson five by the same teacher only included 34 questions). This is strong support for the contention that any study of teacher questioning must be conducted over sequences of consecutive lessons if the teacher’s questioning practices are to be understood.
### Table 4.2
*Number of Questions Asked across the Lessons by All Four Teachers*

<table>
<thead>
<tr>
<th></th>
<th>Lesson topics</th>
<th>Time (mins)</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHN1: Solving right triangles</strong></td>
<td>L1  Solving right triangles</td>
<td>41</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td>L2  Solving non-right triangles</td>
<td>43</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>L3  Applications I: measurements of height and distance</td>
<td>45</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>L4  Applications II: slope angles and marine navigation</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>L5  Mixed application problems</td>
<td>43</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>L6  Chapter review</td>
<td>42</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>43.2</strong></td>
<td><strong>72.3</strong></td>
</tr>
<tr>
<td><strong>CHN2: Quadratic functions</strong></td>
<td>L1  Introduction to quadratic functions</td>
<td>45</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>L2  The graph and properties of (y=ax^2)</td>
<td>41</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>L3  The graph and properties of (y=ax^2+k)</td>
<td>46</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>L4  The graph and properties of (y=a(x-h)^2)</td>
<td>46</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>L5  The graph and properties of (y=a(x-h)^2+k)</td>
<td>45</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>L6  The graph and properties of (y=ax^2+bx+c)</td>
<td>42</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>L7  Finding the equation of quadratic functions</td>
<td>69</td>
<td>196</td>
</tr>
<tr>
<td></td>
<td>L8  Quadratic functions and quadratic equations</td>
<td>51</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>L9  Quadratic functions and real-world problems</td>
<td>47</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>L10 Chapter review</td>
<td>43</td>
<td>154</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>47.5</strong></td>
<td><strong>107.1</strong></td>
</tr>
<tr>
<td><strong>AUS1: Trigonometry</strong></td>
<td>L1  Identifying sides of triangles</td>
<td>51</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>L2  Trigonometric ratios</td>
<td>51</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>L3  Finding unknown lengths in triangles</td>
<td>49</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>L4  Finding angles in triangles</td>
<td>44</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>L5  Angles of elevation and depression</td>
<td>47</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>L7  Measuring height of objects/buildings with inclinometers</td>
<td>48</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>48.3</strong></td>
<td><strong>45.3</strong></td>
</tr>
<tr>
<td><strong>AUS2: Pythagoras theorem and trigonometry</strong></td>
<td>L1  Pythagoras Theorem: revision and its applications in triangles</td>
<td>103</td>
<td>249</td>
</tr>
<tr>
<td></td>
<td>L2  Pythagoras Theorem: applications in the Cartesian plane &amp; real world</td>
<td>48</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td>L4  Revising the concepts of similarity and congruence</td>
<td>100</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>L5  Background and structure of the 3 basic trigonometric ratios</td>
<td>104</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>L6  Relationship between interior angle and side length</td>
<td>54</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>L7  Trigonometric ratios: Further exploration &amp; simple applications</td>
<td>92</td>
<td>218</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>83.5</strong></td>
<td><strong>159.7</strong></td>
</tr>
</tbody>
</table>
4.3 The class of teacher CHN1

This section presents the questioning practices in teacher CHN1’s class.

4.3.1 The number of questions asked across lessons by teacher CHN1

The number of questions asked by teacher CHN1 is presented in Table 4.3 and Figure 4.5.

Over the unit of lessons in teacher CHN1’s classroom, the total number of questions initiated by teacher CHN1 was around 100 during the Introduction and Strategies lessons (lessons 1 and 2). This number then decreased to 69 in the third lesson, which was the beginning of the Consolidation and Application lessons (lessons 3 to 5). The total number of questions per lesson continued falling in the Consolidation and Application lessons and reached a minimum of 34 in the fifth lesson, before climbing back to 58 in the Summarization lesson (lesson 6).

Over the unit of lessons, the number of initiation question was larger than that of the follow-up questions, except in lesson three, where the follow-up questions were observed to be more than the initiation questions. Follow-up questions formed a similar pattern to that documented for questions overall, staying stable around 45 in the Introduction and Strategies lessons (lessons 1 and 2). And then in the Consolidation and Application lessons (lessons 3 to 5), the number of follow-up questions maintained a decreasing trend and reached the lowest number, 10 in lesson 5. This number grew back to 26 finally in the Summarization lesson (lesson 6). The relative variation in the number of overall questions, initiation questions, and follow-up questions per lesson is clearly shown in Figure 4.5.

Table 4.3

*The Number of Questions across the Lessons Taught by Teacher CHN1*

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>57</td>
<td>58</td>
<td>34</td>
<td>43</td>
<td>24</td>
<td>31</td>
<td>247</td>
</tr>
<tr>
<td>FQ</td>
<td>47</td>
<td>42</td>
<td>38</td>
<td>22</td>
<td>10</td>
<td>28</td>
<td>187</td>
</tr>
<tr>
<td>Qs</td>
<td>101</td>
<td>97</td>
<td>69</td>
<td>64</td>
<td>34</td>
<td>58</td>
<td>434</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>41</td>
<td>43</td>
<td>45</td>
<td>45</td>
<td>43</td>
<td>42</td>
<td>259</td>
</tr>
</tbody>
</table>

Note. IQ=Initiation questions; FQ=Follow-up questions; Qs=All questions.
Figure 4.5. The variation in the number of questions across the lessons taught by teacher CHN1.

Note. Qs=All questions; IQ=Initiation questions; FQ=Follow-up questions.

By contrast, the variation in the number of initiation questions was a bit different from that in the above two numbers. It remained steady at around 60 in the Introduction and Strategies lessons (lessons 1 and 2) and then dropped substantially in the lesson 3. However, different from the decreasing trend observed in the number of all questions and follow-up questions, the number of initiation questions maintained relatively steady at around 30 in the Consolidation and Application lessons (lessons 3 to 5) and the Summarization lesson (lesson 6). From Figure 4.5, the distribution of question types in Lesson 3 is anomalous compared with the teacher’s other lessons and requires more fine-grained analysis to identify the reasons for the variation from typical practice for that teacher.

More details about the number of initiation questions are presented in Table 4.4 and Figure 4.6. It can be seen that the number of initiation questions in Q&A pairs and IRF (single) sequences were asked more frequently than that of initiation questions in IRF (multiple) sequences over the whole unit. In particular, the number of initiation questions in Q&A pairs and IRF (single) sequences followed the same pattern of variation as the number of all initiation questions. It stayed table around 40 in the Introduction and Strategies lessons (lessons 1 and 2) and then dropped to 17 in lesson 3, followed by a stable trend around 22 over the Consolidation and Application lessons (lessons 3 to 5) and the Summarization lesson (lesson 6). By contrast,
the number of initiation questions in the IRF (multiple) sequences remained steady at 20 for the Introduction and Strategies lessons (lessons 1 and 2), followed by a gradual dropped in the Consolidation and Application lessons (lessons 3 to 5) before climbing to 15 in Summarization lesson (lesson 6). For the tables and figures in following sections, Q&A (question and answer pairs) will be replaced with QA for simplicity.

Table 4.4
The Number of Initiation Questions across the Lessons Taught by Teacher CHN1

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>57</td>
<td>58</td>
<td>34</td>
<td>43</td>
<td>24</td>
<td>31</td>
</tr>
<tr>
<td>IQ-QA&amp;IRF-s</td>
<td>37</td>
<td>35</td>
<td>17</td>
<td>29</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>IQ-IRF-m</td>
<td>20</td>
<td>23</td>
<td>17</td>
<td>14</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>41</td>
<td>43</td>
<td>45</td>
<td>45</td>
<td>43</td>
<td>42</td>
</tr>
</tbody>
</table>

Note. IQ = Initiation questions; IQ-QA&IRF-s = Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.

Figure 4.6. The variation in the number of initiation questions across the lessons by taught Teacher CHN1.

Note. IQ = Initiation questions; IQ-QA&IRF-s = Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.
### 4.3.2 The proportion of questions asked across lessons by teacher CHN1

Table 4.7 and Figure 4.7 present the proportion of questions asked in Q&A question pairs and IRF (single) sequences, together with the proportion of questions asked in IRF (multiple) sequences.

**Table 4.7**

*The Proportion of Questions across the Lessons Taught by Teacher CHN1 (Part One)*

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qs-QA&amp;IRF-s</td>
<td>36%</td>
<td>35%</td>
<td>24%</td>
<td>45%</td>
<td>53%</td>
<td>29%</td>
</tr>
<tr>
<td>Qs-IRF-m</td>
<td>64%</td>
<td>65%</td>
<td>76%</td>
<td>55%</td>
<td>47%</td>
<td>71%</td>
</tr>
</tbody>
</table>

Note. Qs-QA&IRF-s = All questions in Q&A pairs and IRF (single) sequences; Qs-IRF-m = All questions in IRF (multiple) sequences.

**Figure 4.9.** The variation in the proportion of questions across the lessons taught by teacher CHN1 (Part one).

In general, the proportion of questions used in IRF (multiple) sequences was larger than that of questions used in Q&A question pairs and IRF (single) sequences over the whole unit except lesson 5, the last lesson in the phase of Consolidation and Application. Both proportions were relatively stable in the Introduction and Strategies lessons, followed by great fluctuations in the
phase of Consolidation and Application. During the Consolidation and Application lessons, the proportion of questions used in IRF (multiple) sequences dropped substantially, while the proportion of questions used in Q&A question pairs and IRF (single) sequences increased rapidly. In the Summarization lesson, both proportions returned to the same level as that in the Introduction lessons.

Table 4.7 and Figure 4.9 show the proportion of different types of questions asked by teacher CHN1 and their variations over the six lessons. In general, the proportion of initiation questions in IRF (multiple) sequences experienced an overall stability around 20% over all the six lessons, in spite of slight growth or fall in some lessons.

By contrast, over the consecutive lessons, dramatic fluctuations were observed in the proportion of the follow-up questions and the initiation questions asked in Q&A question pairs and IRF (single) sequences. For the initiation questions asked in Q&A question pairs and IRF (single) sequences, its proportion stayed stable at 35% in the Introduction and Strategies lessons (lessons 1 and 2) and then dropped to 24% in lesson 3. There was a dramatic increase in this proportion over the Consolidation and Application lessons (lessons 3 to 5), and it reached a highest 53% in lesson 5. Then it declined to 29% in the Summarization lesson (lesson 6).

For follow-up questions, its proportion stayed stable at 45% for the Introduction and Strategies lessons (lessons 1 and 2) and then increased to 53% in the lesson 3. Then there was a continuing decline in this proportion over the Consolidation and Application lessons (lessons 3 to 5) and it reached a lowest 29% in lesson 5. Eventually, in the Summarization lesson (lesson 6), the proportion of follow-up questions climbed back to 45%.

Table 4.7
The Proportion of Questions across the Lessons Taught by Teacher CHN1 (Part Two)

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ-QA&amp;IRF-s</td>
<td>36%</td>
<td>35%</td>
<td>24%</td>
<td>45%</td>
<td>53%</td>
<td>29%</td>
</tr>
<tr>
<td>IQ-IRF-m</td>
<td>19%</td>
<td>23%</td>
<td>24%</td>
<td>22%</td>
<td>18%</td>
<td>24%</td>
</tr>
<tr>
<td>FQ</td>
<td>45%</td>
<td>42%</td>
<td>53%</td>
<td>34%</td>
<td>29%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Note. IQ-QA&IRF-s =Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences; FQ=Follow-up questions.
4.3.3 The ratios of questions asked across lessons by teacher CHN1

Table 4.8 and Figure 4.10 show the ratios of follow-up questions to initiation questions in the lessons taught by teacher CHN1.

Table 4.8

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio-F/I</td>
<td>0.82</td>
<td>0.72</td>
<td>1.12</td>
<td>0.51</td>
<td>0.42</td>
<td>0.90</td>
</tr>
<tr>
<td>Ratio-F/I-m</td>
<td>2.35</td>
<td>1.83</td>
<td>2.24</td>
<td>1.57</td>
<td>1.67</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Note. Ratio-F/I = Ratio of follow-up questions to all initiation questions; Ratio-F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

It can be seen that there were no dramatic variations for either of the two ratios. The ratio of follow-up questions to all initiation questions were stable around 0.8 over the unit of consecutive lessons, which means that for every 10 initiation questions asked in teacher CHN1’s lesson, there
tended to be 8 follow-up questions. In contrast, the ratio of follow-up questions to initiation questions in IRF (multiple) sequences maintained steady around 2 over the unit of consecutive lessons, implying that every initiation question in the IRF (multiple) sequences would be followed by two follow-up questions.

![Figure 4.10](image)

*Figure 4.10.* The variation in the ratios of follow-up questions to initiation questions across the lessons taught by teacher CHN1.

Note. F/I = Ratio of follow-up questions to all initiation questions; F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

### 4.3.4 Summary for Teacher CHN1

As instruction progressed in the unit, there was a decreasing trend in the number of questions asked by teacher CHN1. Compared with other lessons, teacher CHN1 asked a larger number of questions in the *Introduction and Strategies* lessons, whereas a smaller number of questions were observed in the *Consolidation and Application* lessons. The largest number of questions, regardless of whether they are initiation questions or follow-up question, was asked in either lesson 1 or lesson 2, which was in the phase of *Introduction and Strategies*. In contrast, the smallest number of questions was asked in lesson 5, which was in the phase of *Consolidation and Application*.

Despite the uniformly decreasing trend in the number of questions, distinct variations were observed in the proportions of different types of questions. Overall, relative to all the questions asked in the lessons, the proportion of questions used in IRF (multiple) sequences was higher.
than that of questions used in Q&A pairs and IRF (single) sequences. And the proportion of questions used in IRF (multiple) sequences was quite low in most of the lessons during the phase of Consolidation and Application, whereas its proportion was relatively high in the Introduction and Strategies lessons, Summarization lesson and the first lesson of Consolidation and Application.

Over the unit of consecutive lessons, initiation questions asked in IRF (multiple) sequences steadily occupied approximately 20% of all the questions asked in each lesson. Meanwhile, during the Consolidation and Application lessons, a dramatic increase occurred in the proportion of initiation questions asked in Q&A pairs and IRF (single) sequences, whereas the proportion of follow-up questions dropped enormously.

A stable trend was also identified in the ratios of follow-up questions to initiation questions. In the IRF (multiple) sequences, every initiation question tended to be accompanied by two follow-up questions that were meant to build upon the students’ responses.

### 4.4 The class of Teacher CHN2

This section presents the questioning practices in Teacher CHN2’s class.

#### 4.4.1 The number of questions asked across lessons by teacher CHN2

Table 4.10 and Figure 4.11 present the number of questions asked by teacher CHN2. A total number of 88 questions were asked in the Introduction lesson (lesson 1) and there was a slight growth in lesson 2, the beginning of the Exploration lessons (lessons 2 to 6). This was then followed by a dramatic decrease in lesson 3 where the least number of questions (55) was asked. Following the substantial drop at the beginning of the Exploration lessons, the total number of questions grew back to 80 in lesson 4 and stayed stable around this number for the remaining lessons (lessons 4, 5 and 6) in the Exploration phase. When the instruction entered into the Strategies phase (lesson 7 and 8), the total number of questions increased rapidly to 196, which was more than twice as many as the number of questions asked in the previous lessons. This number dropped to 113 in lesson 8. During the phases of Consolidation and Application (lesson 9) and the phase of Summarization (lesson 10), the number of questions increased steadily to 154.
The variation in the number of initiation questions and follow-up questions followed the similar pattern as that in the number of all questions, but there were some distinct features observed. In lesson 2, the beginning of the Exploration phase, despite the increase in the total number of questions, the initiation questions were less asked than those in lesson 1. Meanwhile, the number of follow-up questions increased in lesson 2 and outnumbered the initiation questions. It was even noteworthy to see that the number of follow-up questions had been slightly more than that of initiation questions during the whole Exploration phase (lessons 2 to 6). In contrast, the initiation questions were more frequently asked than follow-up questions in all other lessons in the topic sequence (Figure 4.11 sets all this out very clearly).

Table 4.10
The Number of Questions across the Lessons Taught by Teacher CHN2

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
<th>L8</th>
<th>L9</th>
<th>L10</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>59</td>
<td>41</td>
<td>21</td>
<td>42</td>
<td>41</td>
<td>30</td>
<td>107</td>
<td>64</td>
<td>67</td>
<td>84</td>
<td>556</td>
</tr>
<tr>
<td>FQ</td>
<td>29</td>
<td>54</td>
<td>34</td>
<td>38</td>
<td>46</td>
<td>44</td>
<td>89</td>
<td>49</td>
<td>62</td>
<td>70</td>
<td>515</td>
</tr>
<tr>
<td>Qs</td>
<td>88</td>
<td>95</td>
<td>55</td>
<td>80</td>
<td>87</td>
<td>74</td>
<td>196</td>
<td>113</td>
<td>129</td>
<td>154</td>
<td>1071</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>45</td>
<td>41</td>
<td>46</td>
<td>46</td>
<td>45</td>
<td>42</td>
<td>69</td>
<td>51</td>
<td>47</td>
<td>43</td>
<td>475</td>
</tr>
</tbody>
</table>

Note. IQ=Initiation questions; FQ=Follow-up questions; Qs=All questions.

Figure 4.11. The variation in the number of questions across the lessons taught by teacher CHN2.
Note. Qs=All questions; IQ=Initiation questions; FQ=Follow-up questions.

More details about the number of initiation questions are presented in Table 4.11 and Figure 4.12. As is presented in Table 4.11 and Figure 4.12, the variations in the number of either type of initiation questions followed the same pattern as that of all initiation questions. And the initiation questions in Q&A pairs and IRF (single) sequences were more frequently asked than the initiation questions in IRF (multiple) sequences over the whole unit except the lessons in the exploration phase (lessons 2 to 6). In four out of the five lessons in the Exploration phase, the number of initiation questions in IRF (multiple) sequences was higher than or close to that of initiation questions in Q&A pairs and IRF (single) sequences.

Table 4.11
The Number of Initiation Questions across the Lessons Taught by Teacher CHN2

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
<th>L8</th>
<th>L9</th>
<th>L10</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>59</td>
<td>41</td>
<td>21</td>
<td>42</td>
<td>41</td>
<td>30</td>
<td>107</td>
<td>64</td>
<td>67</td>
<td>84</td>
</tr>
<tr>
<td>IQ-QA&amp;IRF-s</td>
<td>41</td>
<td>18</td>
<td>11</td>
<td>27</td>
<td>20</td>
<td>11</td>
<td>70</td>
<td>43</td>
<td>37</td>
<td>48</td>
</tr>
<tr>
<td>IQ-IRF-m</td>
<td>18</td>
<td>23</td>
<td>10</td>
<td>15</td>
<td>21</td>
<td>19</td>
<td>37</td>
<td>21</td>
<td>30</td>
<td>36</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>45</td>
<td>41</td>
<td>46</td>
<td>46</td>
<td>45</td>
<td>42</td>
<td>69</td>
<td>51</td>
<td>47</td>
<td>43</td>
</tr>
</tbody>
</table>

Note. IQ=Initiation questions; IQ-QA&IRF-s =Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.
Figure 4.1.2. The variation in the number of initiation questions across the lessons taught by teacher CHN2.

Note. IQ=Initiation questions; IQ-A&IRF-s =Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.

4.4.2 The proportion of questions asked across lessons by teacher CHN2

Table 4.7 and Figure 4.7 present the proportion of questions asked in Q&A question pairs and IRF (single) sequences, together with the proportion of questions asked in IRF (multiple) sequences.

Table 4.7

The Proportion of Questions across the Lessons Taught by Teacher CHN2 (Part One)

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
<th>L8</th>
<th>L9</th>
<th>L10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qs-QA&amp;IRF-s</td>
<td>47%</td>
<td>19%</td>
<td>20%</td>
<td>34%</td>
<td>23%</td>
<td>15%</td>
<td>36%</td>
<td>38%</td>
<td>29%</td>
<td>31%</td>
</tr>
<tr>
<td>Qs-IRF-m</td>
<td>53%</td>
<td>81%</td>
<td>80%</td>
<td>66%</td>
<td>77%</td>
<td>85%</td>
<td>64%</td>
<td>62%</td>
<td>71%</td>
<td>69%</td>
</tr>
</tbody>
</table>

Note. Qs-QA&IRF-s =All questions in Q&A pairs and IRF (single) sequences; Qs-IRF-m = All questions in IRF (multiple) sequences.

Figure 4.9. The variation in the proportion of questions across the lessons taught by teacher CHN2 (Part one).

Note. Qs-QA&IRF-s =All questions in Q&A pairs and IRF (single) sequences; Qs-IRF-m = All questions in IRF (multiple) sequences.
In general, the proportion of questions used in IRF (multiple) sequences was larger than that of questions used in Q&A question pairs and IRF (single) sequences over the whole unit. In particular, the proportion of questions used in IRF (multiple) sequences was very high (around 80%) during the Exploration lessons, followed by a proportion of approximate 60% in Strategies lessons and 70% in Summarization lesson. By contrast, the proportion of questions used in Q&A question pairs and IRF (single) sequences was nearly 50% in the Introduction lesson and then dropped to a relatively stable level at 20 during the Exploration lessons. This proportion grew back to nearly 40% in the Strategies lessons, followed by a level of 40% in the Consolidation and Application lesson and the Summarization lesson.

Table 4.14 and Figure 4.15 present the proportion of different types of questions asked by teacher CHN2 and their variations over the unit of ten consecutive lessons. It is noticeable that the proportion of the initiation questions asked in the IRF (multiple) sequences stayed steady at around 20% all over the ten lessons, in spite of the slight fluctuations.

The proportion of follow-up questions in the Exploration lessons (lessons 2 to 6) had been stable around 55%, which was much higher than that in any other lessons. This proportion was lowest in the Introduction lesson (33%), whereas it was stable at 45% during the Strategies lessons, Consolidation and Application lesson, and Summarization lesson. By contrast, for the initiation questions asked in Q&A question pairs and IRF (single) sequences, its proportion was the highest in the Introduction lesson (47%) and stayed relatively low (around 20%) in the phase of Exploration. This proportion increased to nearly 40% in the Strategies lessons and then dropped to 30 in the Consolidation and Application lesson, and Summarization lesson.

Table 4.14

| The Proportion of Questions across the Lessons Taught by Teacher CHN2 (Part Two) |
|---------------------------------------------------------------|----------------|
| L1               | L2   | L3   | L4  | L5  | L6  | L7  | L8  | L9  | L10 |
| IQ-QA&IRF-s      | 47%  | 19%  | 20% | 34% | 23% | 15% | 36% | 38% | 29% |
| IQ-IRF-m        | 20%  | 24%  | 18% | 19% | 24% | 26% | 19% | 19% | 23% |
| FQ              | 33%  | 57%  | 62% | 48% | 53% | 59% | 45% | 43% | 48% |

Note. IQ-QA&IRF-s = Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences; FQ = Follow-up questions.
The variation in the proportion of questions across the lessons taught by teacher CHN2 (Part two).

Table 4.15 and Figure 4.16 show the ratios of follow-up questions to initiation questions in the lessons taught by teacher CHN2. For the ratio of follow-up questions to all initiation questions, it stayed relatively stable at 1 over the whole unit, which means that for every initiation question asked in teacher CHN2’s lesson, there tended to be followed by one follow-up question.

In contrast, the ratio of follow-up questions to initiation questions in IRF (multiple) sequences was at below 2 in the introduction lesson and then maintained steady above 2 over the unit of consecutive lessons, implying that every initiation question in the IRF (multiple) sequences would generally be followed with two follow-up questions. In particular, the ratio was above 3 in lesson 3 (exploration phase), which means that every initiation question tended to be followed by three follow-up questions in the IRF (multiple) sequences in lesson 3.
Table 4.1

The Ratio of Follow-up Questions to Initiation Questions across the Lessons Taught by Teacher CHN2

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
<th>L8</th>
<th>L9</th>
<th>L10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio-F/I</td>
<td>0.49</td>
<td>1.32</td>
<td>1.62</td>
<td>0.90</td>
<td>1.12</td>
<td>1.47</td>
<td>0.83</td>
<td>0.77</td>
<td>0.93</td>
<td>0.83</td>
</tr>
<tr>
<td>Ratio-F/I-m</td>
<td>1.61</td>
<td>2.35</td>
<td>3.40</td>
<td>2.53</td>
<td>2.19</td>
<td>2.32</td>
<td>2.41</td>
<td>2.33</td>
<td>2.07</td>
<td>1.94</td>
</tr>
</tbody>
</table>

Note. Ratio-F/I = Ratio of follow-up questions to all initiation questions; Ratio-F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

Figure 4.16. The variation in the ratio of follow-up questions to initiation questions across the lessons taught by Teacher CHN2.

Note. F/I = Ratio of follow-up questions to all initiation questions; F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

4.4.4 Summary for Teacher CHN2

As the instruction progressed in the unit, there was an overall increasing trend in the number of questions asked by teacher CHN2. Compared with other lessons, teacher CHN1 asked a larger number of questions in the Strategies lessons, whereas a smaller number of questions were observed in the Exploration lessons. The largest number of questions, regardless of whether they are initiation questions or follow-up question, was asked in lesson 7, which corresponded to the
Strategies of the unit. In contrast, the smallest number of questions was asked in lesson 3, which was in the phase of Exploration.

Similar to teacher CHN1, the proportion of questions used in IRF (multiple) sequences was much higher than that of questions used in Q&A pairs and IRF (single) sequences. And there was a larger proportion questions were observed to be used in the IRF (multiple) sequences during the phase of Exploration than in any other lessons. Meanwhile, despite the fact that the number of questions was lower in the Exploration lessons, the proportions of follow-up questions in the phase of Exploration were much higher than those in any other lessons. Also, the proportions of initiation questions in Q&A pairs and IRF (single) sequences stayed lower in the Exploration lessons than in any other lessons. Besides, initiation questions asked in IRF (multiple) sequences steadily occupied approximately 20% of all the questions asked in each lesson.

A relative stable trend was also identified in the ratios of follow-up questions to initiation questions. In the IRF (multiple) sequences, every initiation question tended to be accompanied by two follow-up questions which built upon the students’ responses.

4.5 The class of Teacher AUS1

This section presents the questioning practices in Teacher AUS1’s class. Lesson six was eliminated because it was mainly about the construction of inclinometers and there were no mathematical interactions between the teacher and his students during classroom instruction.

4.5.1 The number of questions asked across lessons by Teacher AUS1

Table 4.17 and Figure 4.17 present the number of questions asked by teacher AUS1.

Table 4.17

The Number of Questions across the Lessons Taught by Teacher AUS1

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L7</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>28</td>
<td>41</td>
<td>30</td>
<td>36</td>
<td>29</td>
<td>14</td>
<td>178</td>
</tr>
<tr>
<td>FQ</td>
<td>17</td>
<td>32</td>
<td>7</td>
<td>14</td>
<td>14</td>
<td>10</td>
<td>94</td>
</tr>
<tr>
<td>Qs</td>
<td>45</td>
<td>73</td>
<td>37</td>
<td>50</td>
<td>43</td>
<td>24</td>
<td>272</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>51</td>
<td>51</td>
<td>49</td>
<td>44</td>
<td>47</td>
<td>48</td>
<td>290</td>
</tr>
</tbody>
</table>

Note. IQ=Initiation questions; FQ=Follow-up questions; Qs=All questions.
The total number of questions asked by teacher AUS1 was 45 in the Foundation lesson and then increased dramatically to 73 in the Introduction lesson. During the Strategies lessons, the total number of questions dropped back to a stable level around 45. Then this number dropped again in the Consolidation and Application lessons and reached a lowest 24 in lesson 6.

![Figure 4.17](image)

**Figure 4.17.** The variation in the number of questions across the lessons taught by Teacher AUS1.

Note. Qs=All questions; IQ=Initiation questions; FQ=Follow-up questions.

The number of follow-up questions changed in the similar pattern as that of all questions, whereas the variation in the number of initiation questions was a bit different. The number of initiation questions stayed stable at around 33 over the consecutive lessons, except in the last lesson (phase of Consolidation and Application) where the number of initiation questions was 14, nearly half of those in the prior lessons.

More details about the number of initiation questions are presented in Table 4.18 and Figure 4.18. The number of initiation questions in Q&A pairs and IRF (single) sequences saw a same pattern of variation as the number of all initiation questions. It stayed stable around 25 over the first five lessons and then dropped to 9 in the last lesson. By contrast, the number of initiation questions in the IRF (multiple) sequences stayed relatively steady at 5 over the whole unit.
Table 4.1

The Number of Initiation Questions across the Lessons Taught by Teacher AUS1

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>28</td>
<td>41</td>
<td>30</td>
<td>36</td>
<td>29</td>
<td>14</td>
</tr>
<tr>
<td>IQ-QA&amp;IRF-s</td>
<td>21</td>
<td>31</td>
<td>25</td>
<td>28</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>IQ-IRF-m</td>
<td>7</td>
<td>10</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>51</td>
<td>51</td>
<td>49</td>
<td>44</td>
<td>47</td>
<td>48</td>
</tr>
</tbody>
</table>

Note. IQ=Initiation questions; IQ-QA&IRF-s =Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.

Figure 4.18. The variation in the number of questions across the lessons taught by Teacher AUS1.

Note. IQ=Initiation questions; IQ-QA&IRF-s =Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.

4.5.2 The proportion of questions asked across lessons by teacher AUS1

Table 4.7 and Figure 4.7 present the proportion of questions asked in Q&A question pairs and IRF (single) sequences, together with the proportion of questions asked in IRF (multiple) sequences.
Table 4.7

*The Proportion of Questions across the Lessons Taught by Teacher AUS1 (Part One)*

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qs-QA&amp;IRF-s</td>
<td>47%</td>
<td>42%</td>
<td>68%</td>
<td>56%</td>
<td>53%</td>
<td>38%</td>
</tr>
<tr>
<td>Qs-IRF-m</td>
<td>53%</td>
<td>58%</td>
<td>32%</td>
<td>44%</td>
<td>47%</td>
<td>62%</td>
</tr>
</tbody>
</table>

Note. Qs-QA&IRF-s = All questions in Q&A pairs and IRF (single) sequences; Qs-IRF-m = All questions in IRF (multiple) sequences.

In general, the proportion of questions used in IRF (multiple) sequences was rather larger than that of questions used in Q&A question pairs and IRF (single) sequences. In the phase of *Foundation* and the phase of *Introduction*, the proportion of questions used in IRF (multiple) sequences was higher than that of questions used in Q&A question pairs and IRF (single) sequences. Then in the *Strategies* lessons, the proportion of questions used in IRF (multiple) sequences decreased and stayed lower than that of questions used in Q&A question pairs and
IRF (single) sequences. Finally, in the Summarization lesson, the proportion of questions used in IRF (multiple) sequences climbed back to over 60%, whereas the proportion of questions used in Q&A question pairs and IRF (single) sequences was below 40%.

Table 4.21 and Figure 4.21 present the proportion of different types of questions asked by teacher AUS1 and their variations over all the lessons. It is noticeable that the proportion of the initiation questions asked in the IRF (multiple) sequences stayed steady at around 15% all over the first five lessons before climbing to 20% in the last lesson.

For the proportion of follow-up questions, it was steady at around 40% during the Foundation lessons and the Introduction lesson. Then this proportion dropped substantially and stayed relatively low in the Strategies lessons (lessons 3 and 4) before climbing back in the Consolidation and Application lessons.

For the initiation questions in the Q&A question pairs and IRF (single) sequences, its proportion was stable around 45% during the Foundation lesson and the Introduction lesson. Then this proportion increased to a level around 60% during the strategies lessons, which followed with a gradual decrease in the Consolidation and Application lessons.

Table 4.21

The Proportion of Questions across the Lessons Taught by Teacher AUS 1 (Part Two)

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ-QA&amp;IRF-s</td>
<td>47%</td>
<td>42%</td>
<td>68%</td>
<td>56%</td>
<td>53%</td>
<td>38%</td>
</tr>
<tr>
<td>IQ-IRF-m</td>
<td>16%</td>
<td>14%</td>
<td>14%</td>
<td>16%</td>
<td>14%</td>
<td>20%</td>
</tr>
<tr>
<td>FQ</td>
<td>38%</td>
<td>44%</td>
<td>19%</td>
<td>28%</td>
<td>33%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Note. IQ-QA&IRF-s = Initiation questions in Q&A pairs and IRF (single) sequences; IRF-m = Initiation questions in IRF (multiple) sequences; FQ = Follow-up questions.
Figure 4.21. The variation in the proportion of questions across the lessons taught by teacher AUS1 (Part two).

Note. IQ-QA&IRF-s = Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences; FQ = Follow-up questions.

4.5.3 The ratios of questions asked across lessons by teacher AUS1

Table 4.22 and Figure 4.22 show the ratios of follow-up questions to initiation questions in the lessons taught by teacher AUS1.

Table 4.22
The Ratio of Follow-up Questions to Initiation Questions across the Lessons Taught by Teacher AUS1

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio-F/I</td>
<td>0.61</td>
<td>0.78</td>
<td>0.23</td>
<td>0.39</td>
<td>0.48</td>
<td>0.71</td>
</tr>
<tr>
<td>Ratio-F/I-m</td>
<td>2.43</td>
<td>3.20</td>
<td>1.40</td>
<td>1.75</td>
<td>2.33</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Note. Ratio-F/I = Ratio of follow-up questions to all initiation questions;
Ratio-F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.
**Figure 4.22.** The variation in the ratio of follow-up questions to initiation questions across the lessons taught by teacher AUS1.

Note. Ratio-F/I = Ratio of follow-up questions to all initiation questions; 
Ratio-F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

For the ratio of follow-up questions to all initiation questions, it stayed relatively stable at approximately 0.5 over the whole unit, which means that for every 10 initiation questions asked in teacher AUS1’s lesson, there tended to be followed by 5 follow-up questions.

In contrast, the ratio of follow-up questions to initiation questions in IRF (multiple) sequences was relatively steady around 2 in all lessons except the Introduction lesson where the ratio was 3. This implies that in IRF (multiple) sequences over the consecutive lessons, every initiation question tended to be followed by 2 follow-up questions in most lessons and 3 follow-up questions in the Introduction lesson.

### 4.5.4 Summary for teacher AUS1

As the instruction progressed in the unit, there was neither clear increasing nor decreasing trend in the number of questions asked by teacher AUS1. Compared with other lessons, teacher AUS1 asked a larger number of questions in the Introduction lesson, whereas a smaller number of questions were observed in the Consolidation and Application lessons. The largest number of questions, regardless of whether they are initiation questions or follow-up question, was asked in
the *Introduction* lesson (lesson 1). In contrast, the smallest number of questions was asked in lesson 7, which was in the phase of *Consolidation and Application*.

For the proportion of questions used in IRF (multiple) sequences and that of questions used in Q&A pairs and IRF (single) sequences, neither was observed to be stay higher than the other during the whole unit. And the proportion of questions used in IRF (multiple) sequences was much lower in the strategies lessons than in any other lessons. Over the unit, the proportions of initiation questions in Q&A pairs and IRF (single) sequences in the phase of *Strategies* (lesson 3 and 4) were much higher than those in any other lessons. By contrast, the proportion of follow-up questions was higher in the *Introduction* lesson than in any other lessons. In addition, initiation questions asked in IRF (multiple) sequences steadily occupied approximately 15% of all the questions asked in each lesson.

A relative stable trend was also identified in the ratios of follow-up questions to initiation questions. In the IRF (multiple) sequences, every initiation question tended to be accompanied by two follow-up questions which built upon the students’ responses.

### 4.6 The class of teacher AUS2

This section presents the questioning practices in teacher AUS2’s class. As mentioned earlier in Section 4.1.2, lesson three was not video recorded since the lesson was one for student seat work and there was neither teaching of new mathematics nor mathematical interaction between teacher and student.

#### 4.6.1 The number of questions asked across lessons by teacher AUS2

Table 4.24 and Figure 4.23 present the number of questions asked by teacher AUS2.

Table 4.24

<table>
<thead>
<tr>
<th></th>
<th>L 1</th>
<th>L 2</th>
<th>L 4</th>
<th>L 5</th>
<th>L 6</th>
<th>L 7</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IQ</strong></td>
<td>159</td>
<td>95</td>
<td>68</td>
<td>75</td>
<td>67</td>
<td>142</td>
<td>606</td>
</tr>
<tr>
<td><strong>FQ</strong></td>
<td>90</td>
<td>81</td>
<td>34</td>
<td>35</td>
<td>36</td>
<td>76</td>
<td>352</td>
</tr>
<tr>
<td><strong>Qs</strong></td>
<td>249</td>
<td>176</td>
<td>102</td>
<td>110</td>
<td>103</td>
<td>218</td>
<td>958</td>
</tr>
<tr>
<td><strong>Time (mins)</strong></td>
<td>103</td>
<td>48</td>
<td>100</td>
<td>104</td>
<td>54</td>
<td>92</td>
<td>501</td>
</tr>
</tbody>
</table>

Note. IQ=Initiation questions; FQ=Follow-up questions; Qs=All questions.
The total number of questions asked by teacher AUS2 was highest (249) in the first lesson, which was the first lesson in the phase of Foundation. This number had fallen dramatically during the phase of Foundation and reached the lowest level (102) in lesson 4, which was the last lesson in the phase of Foundation. Then it stayed around 100 in the Introduction lesson and Exploration lesson before rapidly increasing to 218 in the Strategies lesson. Meanwhile, a similar pattern of variation was observed in the number of initiation questions and follow-up questions over the consecutive lessons.

More details about the number of initiation questions are presented in Table 4.25 and Figure 4.24. Once again, the number of both types of initiation questions varied in the same way as that of all initiation questions. Both of initiation questions asked in Q&A question pairs and IRF (single) sequences and initiation questions asked in IRF (multiple) sequences were more frequently asked in Strategies lessons and the beginning of the Foundation phase, but less frequently in Introduction lesson, Exploration lesson and the end of Foundation phase.
Table 4.25

The Number of Questions across the Lessons Taught by Teacher AUS2

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>159</td>
<td>95</td>
<td>68</td>
<td>75</td>
<td>67</td>
<td>142</td>
</tr>
<tr>
<td>IQ-QA&amp;IRF-s</td>
<td>108</td>
<td>56</td>
<td>52</td>
<td>53</td>
<td>46</td>
<td>96</td>
</tr>
<tr>
<td>IQ-IRF-m</td>
<td>51</td>
<td>39</td>
<td>16</td>
<td>22</td>
<td>21</td>
<td>46</td>
</tr>
<tr>
<td>Time (mins)</td>
<td>103</td>
<td>48</td>
<td>100</td>
<td>104</td>
<td>54</td>
<td>92</td>
</tr>
</tbody>
</table>

Note. IQ=Initiation questions; IQ-QA&IRF-s=Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.

Figure 4.24. The variation in the number of initiation questions across the lessons taught by Teacher AUS2.

Note. IQ=Initiation questions; IQ-QA&IRF-s=Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences.

4.6.2 The proportion of questions asked across lessons by teacher AUS2

Table 4.7 and Figure 4.7 present the proportion of questions asked in Q&A question pairs and IRF (single) sequences, together with the proportion of questions asked in IRF (multiple) sequences.

In general, the proportion of questions used in IRF (multiple) sequences was larger than that of questions used in Q&A question pairs and IRF (single) sequences over the whole unit. In particular, the proportion of questions used in IRF (multiple) sequences was about 60% in the
first two lessons of the *Foundation* phase. However, this proportion declined in the last lesson of the *Foundation* phase and stayed relatively stable around 55% in the phase of *Introduction*, phase of *Exploration* and phase of *Strategies*. In contrast, the proportion of questions used in Q&A question pairs and IRF (single) sequences was low in the first two lessons of the *Foundation* phase and then increased to a level around 45% in the last lesson of *Foundation* phase and the following phase of *Introduction*, phase of *Exploration* and phase of *Strategies*.

Table 4.7
*The Proportion of Questions across the Lessons Taught by Teacher AUS2 (Part One)*

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qs-QA&amp;IRF-s</td>
<td>43%</td>
<td>32%</td>
<td>51%</td>
<td>48%</td>
<td>45%</td>
<td>44%</td>
</tr>
<tr>
<td>Qs-IRF-m</td>
<td>57%</td>
<td>68%</td>
<td>49%</td>
<td>52%</td>
<td>55%</td>
<td>56%</td>
</tr>
</tbody>
</table>

Note. Qs-QA&IRF-s = All questions in Q&A pairs and IRF (single) sequences; Qs-IRF-m = All questions in IRF (multiple) sequences.

*Figure 4.9.* The variation in the proportion of questions across the lessons taught by teacher AUS2 (Part one).

Table 4.28 and Figure 4.27 present the proportion of different types of questions asked by teacher AUS2 and their variations over all the lessons. It is noticeable that the proportion of the initiation questions asked in the IRF (multiple) sequences stayed steady at around 20% over all the lessons.
Table 4.2

*The Proportion of Questions across the Lessons Taught by Teacher AUS2 (Part Two)*

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ-QA&amp;IRF-s</td>
<td>43%</td>
<td>32%</td>
<td>51%</td>
<td>48%</td>
<td>45%</td>
<td>44%</td>
</tr>
<tr>
<td>IQ-IRF-m</td>
<td>20%</td>
<td>22%</td>
<td>16%</td>
<td>20%</td>
<td>20%</td>
<td>21%</td>
</tr>
<tr>
<td>FQ</td>
<td>36%</td>
<td>46%</td>
<td>33%</td>
<td>32%</td>
<td>35%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Note. IQ-QA&IRF-s = Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences; FQ = Follow-up questions.

![Chart](chart.png)

*Figure 4.27.* The variation in the proportion of questions across the lessons taught by Teacher AUS2 (Part two).

Note. IQ-QA&IRF-s = Initiation questions in Q&A pairs and IRF (single) sequences; IQ-IRF-m = Initiation questions in IRF (multiple) sequences; FQ = Follow-up questions.

For the initiation questions in Q&A question pairs and IRF (single) sequences, its proportion was relatively stable at around 45% over the whole unit except lesson 2 where the proportion dropped to 32%. In contrast, the proportion of follow-up questions stayed steady at 35% in all lessons but lesson 2 where the proportion increased to nearly 50%.
4.6.3 The ratios of questions asked across lessons by teacher AUS2

Table 4.29 and Figure 4.28 show the ratios of follow-up questions to initiation questions in the lessons taught by teacher AUS2.

Table 4.29
The Ratio of Follow-up Questions to Initiation Questions across the Lessons Taught by Teacher AUS2

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L4</th>
<th>L5</th>
<th>L6</th>
<th>L7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio-F/I</td>
<td>0.57</td>
<td>0.85</td>
<td>0.50</td>
<td>0.47</td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td>Ratio-F/I-m</td>
<td>1.76</td>
<td>2.08</td>
<td>2.13</td>
<td>1.59</td>
<td>1.71</td>
<td>1.65</td>
</tr>
</tbody>
</table>

Note. Ratio-F/I = Ratio of follow-up questions to all initiation questions; Ratio-F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

Figure 4.28. The variation in the ratio of follow-up questions to initiation questions across the lessons taught by Teacher AUS2.

Note. F/I = Ratio of follow-up questions to all initiation questions; F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

The ratio of follow-up questions to all initiation questions were stable at around 0.5 over the unit of consecutive lessons, which means that for every 10 initiation questions asked in teacher AUS’s lesson, there tended to be 5 follow-up questions. Similarly, the ratio of follow-up questions to initiation questions in IRF (multiple) sequences maintained steady at around 2 over the unit of consecutive lessons, implying that every initiation question in the IRF (multiple) sequences would be followed by two follow-up questions.
4.6.4 Summary for Teacher AUS2

As the instruction progressed in the unit, there was a relative decreasing trend in the number of questions asked by teacher AUS2. Compared with other lessons, teacher AUS2 asked a larger number of questions in the Strategies lesson and the first lesson of Foundation phase, whereas a smaller number of questions were observed in the Introduction lesson, Exploration lesson and the last lesson of Foundation phase.

Overall, the proportion of questions used in IRF (multiple) sequences was higher than that of questions used in Q&A pairs and IRF (single) sequences. And the proportion of questions used in IRF (multiple) sequences was much higher in the first two lessons of the Foundation phase than in any other lessons. Over the unit, the proportions of initiation questions in Q&A pairs and IRF (single) sequences and the proportions of follow-up questions stayed relatively stable except in the lesson 2, which was the second lesson in the phase of Foundation. In lesson 2, the proportion of follow-up questions was far higher, but the proportion of initiation questions in Q&A pairs and IRF (single) sequences was far lower, compared with all other lessons.

A relative stable trend was also identified in the ratios of follow-up questions to initiation questions. In the IRF (multiple) sequences, every initiation question tended to be accompanied by two follow-up questions which built upon the students’ responses.

4.7 Summary of four teachers’ classes

As a summary of the results regarding questioning practices in the four cases, the key findings are presented as follows.

1. Regarding the number of questions asked in the four teachers’ classes, the patterns varied a lot across the units of consecutive lessons. As is shown in the Figure 4.29, for each of the four teachers, the number of questions experienced substantial variations across the lessons and meanwhile the patterns of variation are distinctly different from one another for the four teachers, regardless of whether the teaching topics are different or not. For example, although the lesson topics for teachers CHN1, AUS1 and AUS2 were all related to the knowledge of trigonometry, the variations of questioning practices have distinct features for different teachers.
Teacher CHN1 tended to ask more questions in the *Introduction and Strategies* lessons, while the questions were more frequently used by teacher CHN2 in *Strategies* lessons, *Consolidation and Application* lesson, and *Summarization* lesson. For teacher AUS1, more questions were observed in the *Introduction* lesson, whereas teacher AUS2 tended to use more questions in *Foundation* lessons and the *Strategies* lesson.

![Graph](image.png)

*Figure 4.29* The number of questions across consecutive lessons in four cases

2. Looking at the proportion occupied separately by the questions used in IRF (multiple) sequences and the questions used in Q&A question pairs and IRF (single) sequences, a different picture of teacher questioning strategies could be obtained. As is shown in Figure 4.29 and Figure 4.30, for most teachers, the lesson with a larger number of questions was normally not the one with a higher proportion of questions used in IRF (multiple) sequences.

For teacher CHN1, the proportion of questions used in IRF (multiple) sequences tended to be high at the beginning of *Consolidation and Application* lesson and the *Summarization* lesson. Then for teacher CHN2, higher proportions of questions used in IRF (multiple) sequences were observed in the *Exploration* lessons. In teacher AUS1’s class, the questions used in IRF (multiple) sequences tended to occupy a larger proportion in *Foundation* lesson, *Introduction* lesson and the last lesson in the *Consolidation and Application* phase. In teacher AUS2’s class, the questions used in IRF (multiple) sequences tended to occupy a larger proportion in the *Foundation* lessons.
3. Out of all questions asked by each of the four teachers, the proportion of initiation questions in IRF (multiple) sequences maintained relatively stable across the unit of consecutive lessons. As is shown in Figure 4.31, for teachers CHN1, CHN2 and AUS2, the initiation questions in IRF (multiple) sequences occupied around 20% of all questions across the consecutive lessons, while for teacher AUS1, the number is around 15%.

Figure 4.31  The variation in the proportion of questions across the lessons taught by four teachers (Part Two).

Note.  IQ-QA&IRF-s =Initiation questions in Q&A pairs and IRF (single) sequences; IRF-m = Initiation questions in IRF (multiple) sequences; FQ=Follow-up questions.
4. For the ratios of follow-up questions to initiation question in IRF (multiple) sequences, there is an overall trend of stability across the lessons. As is shown in Figure 4.32, the ratio of the number of follow-up questions to the number of initiation questions stayed relatively stable – at around 2 – for all four teachers.

Figure 4.32  The ratios of follow-up questions to initiation question in IRF (multiple) sequences across consecutive lessons in four cases

Note. Ratio-F/I = Ratio of follow-up questions to all initiation questions; Ratio-F/I-m = Ratio of follow-up questions to initiation questions in IRF (multiple) sequences.

In summary, this chapter mainly reports each teacher’s use of initiation questions and follow-up questions, and the variations and consistencies regarding the frequency of asking questions. Chapter 5 will examine the specific subcategories for the initiation questions and follow-up questions.
CHAPTER 5 RESULTS: SUBCATEGORIES OF TEACHER QUESTIONS

The previous chapter reported the analysis and results regarding two categories of teacher questions, initiation questions and follow-up questions. This chapter will examine the subcategories for the initiation questions and follow-up questions. This chapter will start with an overall introduction of question subcategories used in the four teachers’ classes. Then the following sections will look at three aspects in each teacher’s class: (1) distribution of subcategories for initiation questions asked in Q&A pairs and IRF (single) sequences; (2) distribution of subcategories for initiation questions asked in IRF (multiple) sequences; and (3) distribution of subcategories for follow-up questions.

5.1 Introduction

This section outlines the three aspects regarding each teacher’s questioning practices: the total number and distribution of initiation questions asked in Q&A pairs and IRF (single) sequences for each lesson, the total number and distribution of initiation questions asked in the IRF (multiple) sequences for each lesson, and the total number and distribution of follow-up questions in each teacher’s class.

5.1.1 Distribution of sub-categories for initiation questions (1)

Figure 5.1 shows the total number of initiation questions asked in Q&A pairs and IRF (single) sequences for each lesson taught by the four participating teachers. It represents a review of the results in the last chapter; for more details, please refer to the last chapter.

Figure 5.1 The variation in the number of initiation questions in Q&A pairs and IRF (single) sequences
The number of each initiation question type is summarised and listed in Table 5.1.

Table 5.1 Distribution of Subcategories of Initiation Questions in Q&A pairs and IRF (single) sequences across the Lessons for All Teachers

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Und</th>
<th>Rev</th>
<th>Eva</th>
<th>Inf</th>
<th>Rsl</th>
<th>Str</th>
<th>Exp</th>
<th>Proc</th>
<th>Com</th>
<th>Ref</th>
<th>Var</th>
<th>Lin</th>
<th>Gen</th>
<th>Coj</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHN1</td>
<td>L1</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>L3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>L4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>L5</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>L6</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>CHN2</td>
<td>L1</td>
<td>14</td>
<td>10</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>L3</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>L4</td>
<td>3</td>
<td>8</td>
<td>9</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>L5</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>L6</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>L7</td>
<td>7</td>
<td>21</td>
<td>17</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>L8</td>
<td>1</td>
<td>11</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>L9</td>
<td>2</td>
<td>11</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>L10</td>
<td>2</td>
<td>19</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>AUS1</td>
<td>L1</td>
<td>5</td>
<td>12</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>2</td>
<td>14</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>L3</td>
<td>2</td>
<td>13</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>L4</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>L5</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>L7</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>AUS2</td>
<td>L1</td>
<td>9</td>
<td>20</td>
<td>7</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>8</td>
<td>11</td>
<td>0</td>
<td>7</td>
<td>16</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>L4</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>L5</td>
<td>1</td>
<td>22</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>L6</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>L7</td>
<td>12</td>
<td>22</td>
<td>9</td>
<td>5</td>
<td>4</td>
<td>13</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>12</td>
<td>0</td>
<td>96</td>
</tr>
</tbody>
</table>

Note: Und=Understanding check; Rev=Review; Eva=Evaluation; Inf=Information extraction; Rsl=Result; Str=Strategy/procedure; Exp=Explanation; Proc=Progress monitoring; Com=Comparison; Ref=Reflection; Var=Variation; Lin=Link; Gen=Generation; Coj=Conjecture.
Please note that not every type of initiation question appeared in each lesson. In this chapter, a closer examination will be conducted on the sub-categories of questions used as initiation question asked in Q&A pairs and IRF (single) sequences and the relevant variations and consistencies over the lesson sequence.

5.1.2 Distribution in sub-categories for initiation questions (2)

In Figure 5.2, the total number of initiation question asked in the IRF (multiple) sequences for each lesson delivered by the four participating teachers is presented. Figure 5.2 is just a review of the results in the last chapter; for more details, please refer to the last chapter. For each lesson, the number of each initiation question type is summarised and listed in Table 5.2. Perhaps understandably so, not every type of initiation question appeared in each lesson. Indeed, for example, teacher CHN1 did not appear to have employed in any of her six observed lessons Understanding check, Evaluation, Explanation, Comparison, Generation and Conjecture types of initiation questions.

![Figure 5.2 The variation in the number of initiation questions in IRF (multiple) sequences](image)
Table 5.2 Distribution of Subcategories of Initiation Questions in IRF (multiple) sequences across the Lessons for All Teachers

<table>
<thead>
<tr>
<th></th>
<th>Und</th>
<th>Rev</th>
<th>Eva</th>
<th>Inf</th>
<th>Rsl</th>
<th>Str</th>
<th>Exp</th>
<th>Pro</th>
<th>Com</th>
<th>Ref</th>
<th>Var</th>
<th>Lin</th>
<th>Gen</th>
<th>Coj</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHN1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>L2</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>L3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>L4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>L5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>L6</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td><strong>CHN2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>L2</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>L3</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>L4</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>L5</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>L6</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>L7</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>L8</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>L9</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>L10</td>
<td>0</td>
<td>6</td>
<td>10</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td><strong>AUS1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>L2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>L3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>L4</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>L5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>L7</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td><strong>AUS2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>1</td>
<td>14</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>51</td>
</tr>
<tr>
<td>L2</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>L4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>L5</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>L6</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>L7</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>46</td>
</tr>
</tbody>
</table>

Note: Und=Understanding check; Rev=Review; Eva=Evaluation; Inf=Information extraction; Rsl=Result; Str=Strategy/procedure; Exp=Explanation; Pro=Progress monitoring; Com=Comparison; Ref=Reflection; Var=Variation; Lin=Link; Gen=Generation; Coj=Conjecture.
It was reported in the last chapter that the proportion taken up by all initiation questions in the IRF (multiple) sequences in each lesson, relative to all the questions in the corresponding lesson, was consistent across the lesson sequence, despite the great variation in the number of these questions as is shown in the Figure 5.2. In other words, regardless of how many questions the participating teachers asked in each lesson of the sequence, a particular proportion of these questions tended to be used to initiate the IRF (multiple) sequences (see section 4.6 in the last chapter for more details).

In this chapter, a closer examination will be conducted on the sub-categories of questions used as initiation question asked in IRF (multiple) sequences and the relevant variations and consistencies over the lesson sequence.

### 5.1.3  Distribution in sub-categories for follow-up questions

Figure 5.3 shows the variation in the total number of follow-up questions in each teacher’s class. It is evident that for each teacher the total number of follow-up questions fluctuated greatly over the consecutive lessons. Figure 5.3 is just a review of the results in the last chapter and for more details, please refer to the last chapter. For each lesson, the number of each follow-up question type is summarised and listed in Table 5.3. Please note that not every type of follow-up question appeared in each lesson.

![Figure 5.3 The variation in the number of follow-up questions](chart.png)
Table 5.3 Distribution of Subcategories of Follow-up Questions across the Lessons

<table>
<thead>
<tr>
<th></th>
<th>CLA</th>
<th>JUS</th>
<th>ELA</th>
<th>EXT</th>
<th>SUP</th>
<th>CUE</th>
<th>REP</th>
<th>AGG</th>
<th>REC</th>
<th>RER</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHN1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>20</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>L2</td>
<td>13</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>13</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>L3</td>
<td>13</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>L4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>L5</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>L6</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>CHN2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>L2</td>
<td>4</td>
<td>1</td>
<td>17</td>
<td>0</td>
<td>11</td>
<td>9</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>L3</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>L4</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>L5</td>
<td>11</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>11</td>
<td>2</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>L6</td>
<td>5</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>L7</td>
<td>16</td>
<td>5</td>
<td>12</td>
<td>2</td>
<td>12</td>
<td>8</td>
<td>11</td>
<td>18</td>
<td>5</td>
<td>0</td>
<td>89</td>
</tr>
<tr>
<td>L8</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>49</td>
</tr>
<tr>
<td>L9</td>
<td>11</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>4</td>
<td>11</td>
<td>4</td>
<td>18</td>
<td>1</td>
<td>0</td>
<td>62</td>
</tr>
<tr>
<td>L10</td>
<td>15</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>9</td>
<td>14</td>
<td>9</td>
<td>8</td>
<td>0</td>
<td>70</td>
</tr>
<tr>
<td>AUS1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>L2</td>
<td>18</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>L3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>L4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>L5</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>L7</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>AUS2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>24</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>18</td>
<td>11</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>L2</td>
<td>22</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>14</td>
<td>18</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>81</td>
</tr>
<tr>
<td>L4</td>
<td>8</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>L5</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>13</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>L6</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>L7</td>
<td>11</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>13</td>
<td>24</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>76</td>
</tr>
</tbody>
</table>

Note: CLA=Clarification; JUS=Justification; ELA=Elaboration; EXT=Extension; SUP=Supplement; CUE=Cueing; REP=Repeat; AGG=Agreement; REC=Refocusing; RER=Reformulation request.
To gain a comprehensive understanding of teacher questioning strategies, it is necessary to examine what follow-up question types were selected by the participating teachers and how these question types distributed over the consecutive lessons.

In this chapter, a closer examination will be conducted on the sub-categories of questions used as follow-up questions in IRF (single) sequences and the relevant variations and consistencies over the lesson sequence.

In the following sections of this chapter, more details about initiation questions and follow-up questions will be unpacked, and subcategories of initiation questions and follow-up questions will be reported for each participating teacher.

5.2 The class of teacher CHN1

This section will focus on the distribution of subcategories for initiation questions and follow-up questions in teacher CHN1’s class.

5.2.1 Initiation questions in QA and IRF (single) sequences

This subsection will present how initiation questions were distributed in the context of Q&A pairs and IRF (single) sequences. Figure 5.4 shows the variation regarding the distribution of initiation questions in Q&A pairs and IRF (single) sequences across the six consecutive lessons delivered by teacher CHN1. For all the six lessons, Conjecture, Generation and Comparison questions were not recorded as initiation questions in Q&A pairs and IRF (single) sequences.

It can be seen that two question types, Result/product and Strategies questions, were commonly used as initiation questions in Q&A pairs and IRF (single) sequences in all lessons, whereas other question types were used in various ways for different lessons.

For both of the two lessons in the Introduction and Strategies phase, Review questions occupied a substantial proportion (nearly 30%) of all initiation questions. Variation questions took up nearly 20 percent of all initiation questions in the first lesson of the Introduction and Strategies phase.

In contrast, for the Consolidation and Application lessons, no Variation questions was asked as initiation questions in Q&A pairs and IRF (single) sequences, and Review questions were also
barely asked. Rather, Link/application, Information request and Progress monitoring questions were used substantially in lesson 3, Link/application, and Explanation questions were asked in a relatively high proportion in lesson 4, while Evaluation and Information request questions took up a relatively high proportion in lesson 5.

The Summarization lesson was a bit similar to the Introduction and Strategies lessons in that Review questions also represented a high proportion, and perhaps understandably so given the general purposes of these lessons. But on the other hand, the proportions of Link/application and Information request questions were separately more than 10 percent.

Figure 5.4 The variation in the distribution of initiation questions in Q&A pairs and IRF (single) sequences in teacher CHN1’s class

Note: COM=Comparison; COJ=Conjecture; EVA=Evaluation; EXP=Explanation; INF=Information extraction; GEN=Generation; LIN=Link/application; PRO=Progress monitoring; REF=Reflection; RSL=Result; REV=Review; STR=Strategy/procedure; UND=Understanding check; VAR=Variation.

I&S= Introduction & strategies lessons; C&A= Consolidation & application lessons; S= Summarization lesson.
5.2.2 Initiation questions in IRF (multiple) sequences

Figure 5.5 shows the variation regarding the distribution of initiation questions in IRF (multiple) sequences across the six consecutive lessons delivered by teacher CHN1. For all the six lessons, Conjecture, Generation, Comparison, Explanation, Evaluation, and Understanding check questions were not recorded as initiation questions in IRF (multiple) sequences.

Across the whole unit, it is evident that both of Strategy/procedure and Result/product questions were asked as initiations in IRF (multiple) sequences, while other question types were used in different ways for different lessons.

![Figure 5.5 The variation in the distribution of initiation questions in IRF (multiple) sequences in teacher CHN1's class](image)

Note: COM=Comparison; COJ=Conjecture; EVA=Evaluation; EXP=Explanation; INF=Information extraction; GEN=Generation; LIN=Link/application; PRO=Progress monitoring; REF=Reflection; RSL=Result; REV=Review; STR=Strategy/procedure; UND=Understanding check; VAR=Variation.

I&S= Introduction & strategies lessons; C&A= Consolidation & application lessons; S= Summarization lesson.
During the Introduction and Strategies phase, Variation and Reflection questions were used in high proportions (about 35% altogether) in lesson 1, while the proportion of Review questions was nearly 40 percent in lesson 2.

In the Consolidation and Application phase, no Review question was observed in all three lessons. Progress monitoring questions took up nearly 20 percent in lesson 3, while Link/application questions occupied nearly 30 percent in lesson 4 and the proportions of Link/application and Reflection questions altogether represented more than 30 percent.

In the Summarization phase, Link/application and Review questions altogether represented more than 30 percent of all initiation questions in IRF (multiple) sequences.

5.2.3 Follow-up questions in IRF (multiple) sequences

Figure 5.6 shows the variation regarding the distribution of follow-up questions across the six consecutive lessons delivered by teacher CHN1.

![Figure 5.6 The variation in the distribution of follow-up questions in teacher CHN1’s class](image)

Note: AGG=Agreement; CLA=Clarification; CUE=Cueing; ELA=Elaboration; EXT=Extension; JUS=Justification; REC=Refocusing; RER=Reformulation request; REP=Repeat; SUP=Supplement.

I&S= Introduction & strategies lessons; C&A= Consolidation & application lessons; S= Summarization lesson.
Over the whole unit, three question types, *Clarification, Supplement*, and *Cueing* questions were used in each lesson of the unit. Meanwhile, *Repeat* questions were used in most of the lessons except lesson 4, and *Agreement request* questions were observed in IRF (multiple) sequences in all lessons but lesson 2. The total proportions occupied by the above five question types were more than 90 percent in all the six lessons except lesson 4, where *Justification* lessons took up about 20 percent.

5.3 The class of teacher CHN2

This section will focus on the distribution of subcategories for initiation questions and follow-up questions in teacher CHN2’s class.

5.3.1 Initiation questions in QA & IRF (single) sequences

Figure 5.7 shows the variation regarding the distribution of initiation questions in Q&A pairs and IRF (single) sequences across the ten consecutive lessons delivered by teacher CHN2. For all the ten lessons, *Conjecture, Generation* and *Progress monitoring* questions were not recorded as initiation questions in Q&A pairs and IRF (single) sequences.

It can be seen that one question type, *Review* questions, was commonly used as initiation questions in Q&A pairs and IRF (single) sequences in all the ten lessons. *Evaluation* questions were also used very frequently and were observed in all lessons except lesson 3, and *Understanding check, Result/product*, and *Link* questions were recorded in all lessons but lessons 3 and 7. The exceptions for the use of *Evaluation, Understanding check, Result/product*, and *Link* questions all occurred in the *Exploration* phase. Apart from the relatively common use of the above five question types in most lessons, other question types were used differently in different lessons.

In the *Introduction* lesson, *Information request* questions took up more than 10 percent of all initiation questions asked in IRF (multiple) sequences.

The similar situation was also observed in lessons 2 and 4 (exploration phase) where the proportions of *Information request* questions were separately 20 and 15 percent respectively. But for the rest of lessons in the *Exploration* phase, no *Information request* question was recorded. In lesson 3, *Comparison, Strategy/procedure*, and *Reflection* questions respectively represented
about 10 percent of all initiation questions in Q&A pairs and IRF (single) sequences. And in lesson 5, *Explanation* questions were observed with a proportion of 10 percent.

For both of the two lessons in the *Strategies* phase, more than 90 percent of all initiation questions in Q&A pairs and IRF (single) sequences consisted of 9 commonly used question types: *Review, Evaluation, Understanding check, Link/application, Result, Information request, Explanation, Reflection* and *Strategy/procedure* questions. This situation was also observed in the *Consolidation and Application* phase and *Summarization* phase. Out of the 9 question types above, *Explanation, Strategy/procedure* and *Reflection* questions were barely observed in the phases of *Introduction* and the phase of *Exploration* for teacher CHN2.

![Figure 5.7 The variation in the distribution of initiation questions in Q&A pairs and IRF (single) sequences in teacher CHN2’s class](image)

**Figure 5.7 The variation in the distribution of initiation questions in Q&A pairs and IRF (single) sequences in teacher CHN2’s class**

Note: COM=Comparison; COJ=Conjecture; EVA=Evaluation; EXP=Explanation; INF=Information extraction; GEN=Generation; LIN=Link/application; PRO=Progress monitoring; REF=Reflection; RSL=Result; REV=Review; STR=Strategy/procedure; UND=Understanding check; VAR=Variation.

I = Introduction lesson; E= Exploration lessons; St= Strategies lessons; C&A= Consolidation & application lesson; Su= Summarization lesson.
5.3.2 Initiation questions in IRF (multiple) sequences

Figure 5.8 shows the variation regarding the distribution of initiation questions in IRF (multiple) sequences across the ten consecutive lessons delivered by teacher CHN2. For all the ten lessons, *Conjecture* questions were not recorded as initiation questions in IRF (multiple) sequences.

![Figure 5.8 The variation in the distribution of initiation questions in IRF (multiple) sequences in teacher CHN2’s class](image)

Note: COM=Comparison; COJ=Conjecture; EVA=Evaluation; EXP=Explanation; INF=Information extraction; GEN=Generation; LIN=Link/application; PRO=Progress monitoring; REF=Reflection; RSL=Result; REV=Review; STR=Strategy/procedure; UND=Understanding check; VAR=Variation.

I = Introduction lesson; E = Exploration lessons; St = Strategies lessons; C&A = Consolidation & application lesson; Su = Summarization lesson.

It can be seen that *Explanation* and *Evaluation* questions were asked in every lesson of the sequence. On the other hand, *Review* questions were observed in all lessons except lesson 2, and
Link/application questions were used in all lessons but lesson 8. Apart from the above four question types, the other question types were used in different ways in different lessons. In the Introduction lesson, each of the three question types, namely Comparison, Understanding check and Result questions, separately represented about 10 percent of all initiation questions in IRF (multiple) sequences. During the Exploration phase, Comparison and Understanding check questions were rarely used in most lessons. Reflection questions occupied more than 25% in lesson 2, whereas Result questions took up 25% of all initiation questions in IRF (multiple) sequences in lesson 5. And in lesson 6, Strategy/procedure and Reflection questions separately occupied 10% of all initiation questions in IRF (multiple) sequences. For both of the lessons in the Strategies phase, Information, Strategy/procedure, and Reflection questions altogether occupied around 50% of all initiation questions in IRF (multiple) sequences.

For the Consolidation and Application lesson and the Summarization lesson, Variation, Strategy/procedure, Result and Reflection questions were commonly used and the total proportion of these question types took up about 30% in both lessons.

5.3.3 Follow-up questions in IRF (multiple) sequences

Figure 5.9 shows the variation regarding the distribution of follow-up questions across the ten consecutive lessons delivered by teacher CHN2.

Over the whole unit, six question types, namely, Agreement request, Clarification, Elaboration, Cueing, Justification and Refocusing questions, were commonly used in all ten lessons. Meanwhile, Supplement questions were used in most of the lessons except lesson 1, and Repeat questions were observed in IRF (multiple) sequences in all lessons but lesson 4. The total proportions occupied by the above eight question types were more than 90 percent in all the ten lessons.
Figure 5.9 The variation in the distribution of follow-up questions in teacher CHN2’s class

Note: AGG=Agreement; CLA=Clarification; CUE=Cueing; ELA=Elaboration; EXT=Extension; JUS=Justification; REC=Refocusing; RER=Reformulation request; REP=Repeat; SUP=Supplement.

I = Introduction lesson; E= Exploration lessons; St= Strategies lessons; C&A= Consolidation & application lesson; Su= Summarization lesson.

5.4 The class of teacher AUS1

This section will focus on the distribution of subcategories for initiation questions and follow-up questions in teacher AUS1’s class.

5.4.1 Initiation questions in QA&IRF (single) sequences

Figure 5.10 shows the variation regarding the distribution of initiation questions in Q&A pairs and IRF (single) sequences across the ten consecutive lessons delivered by teacher AUS1. For all the six lessons, Conjecture, Variation and Comparison questions were not recorded as initiation questions in Q&A pairs and IRF (single) sequences.
It can be seen that Review and Understanding check questions were commonly recorded in all the six lessons. And Information request questions were used in all the lessons but lesson 7. Apart from the above three question types, other question types were used differently in different lessons. In the Introduction lesson, Reflection, Progress monitoring and Result questions were observed with a high proportion and these three question types altogether represented nearly 40 percent of all initiation questions asked in Q&A pairs and IRF (single) sequences. No Progress monitoring questions were observed in any other lessons. In the second lesson (lesson 4) of the Strategies phase, Strategy/procedure, Link/application and Result questions separately occupied more than 10 percent and altogether they constituted more than 40 percent of all the initiation questions in Q&A pairs and IRF (single) sequences. During the Consolidation and Application
phase, \textit{Link/application} and \textit{Result} questions separately represented about 25\% and 15\% in lesson 5, while \textit{Evaluation}, \textit{Strategy/procedure}, and \textit{Link/application} questions respectively accounted for 10\%, 30\% and 10\% of all the initiation questions in Q&A pairs and IRF (single) sequences. Among the questions used with high proportions in the \textit{Strategies} phase and the \textit{Consolidation and Application} phase, \textit{Link/application}, \textit{Strategy/procedure} and \textit{Evaluation} questions were not observed in the \textit{Foundation} phase and the \textit{Introduction} phase.

\subsection*{5.4.2 Initiation questions in IRF (multiple) sequences}

Figure 5.11 shows the variation regarding the distribution of initiation questions in IRF (multiple) sequences across the six consecutive lessons delivered by teacher AUS1.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.11}
\caption{The variation in the distribution of initiation questions in IRF (multiple) sequences in teacher AUS1's class}
\end{figure}

Note: COM=Comparison; COJ=Conjecture; EVA=Evaluation; EXP=Explanation; INF=Information extraction; GEN=Generation; LIN=Link/application; PRO=Progress monitoring; REF=Reflection; RSL=Result; REV=Review; STR=Strategy/procedure; UND=Understanding check; VAR=Variation.

F= Foundation lesson; I = Introduction lesson; S= Strategies lessons; C&A= Consolidation & application lesson.
It is obvious that over the whole unit of six consecutive lessons there was not one question type having been commonly used as initiation questions in IRF (multiple) sequences. And Review questions were observed in all the lessons but lesson 5. Apart from Review questions, other question types were used in different ways in different lessons.

In the Foundation lesson, Understanding check, Explanation, and Information request questions respectively accounted for 15%, 30% and 30%. Then in the introduction lesson, the proportion of Reflection, Comparison, and Result questions were respectively 20%, 20%, and 40%. Apparently, the majority of initiation questions asked in IRF (multiple) sequences in the Foundation lesson were substantially different from those in the Introduction lesson.

During the Strategies phase, Review questions took up high proportions (approximately 60% and 35%) in both of lesson 3 and lesson 4. Besides, each of Information request and Result questions took up 20% of initiation questions asked in IRF (multiple) sequences for lesson 3, whereas Generation, Explanation, Strategy/procedure, and Link/application questions altogether represented more than 60 percent. In other words, more than half of all initiation questions in IRF (multiple) sequences consisted only of four questions types.

During the Consolidation and Application phase, Link and Strategy/procedure questions were commonly used in both lesson 5 and lesson 7, representing a total approximate proportion of 65% and 40% respectively. Apart from this question type, Generation, and Information request questions constituted the initiation questions in IRF (multiple) sequences in lesson 5, whereas in lesson seven the remaining question types included Result and Review questions.

5.4.3 Follow-up questions in IRF (multiple) sequences

Figure 5.12 shows the variation regarding the distribution of follow-up questions across the six consecutive lessons delivered by teacher AUS1.

Over the whole unit of six consecutive lessons, four question types, Clarification, Supplement, Cueing and Repeat/rephrase questions were commonly used in all six lessons. And the total proportions occupied by the above four question types were more than 70 percent in all the six lessons. In other words, more than half of all initiation questions in IRF (multiple) sequences consisted only of four questions types.
Apart from these four question types, *Refocusing* questions took up about 25% and 20% separately in the *Foundation* lesson and the *Introduction* lesson. The proportions of *Elaboration* questions were about 10% in the *Consolidation and Application* lessons and the first lesson (lesson 3) of the *Strategies* phase. Besides, in lesson 3, *Justification* questions also took up about 15% of all initiation questions asked in IRF (multiple) sequences.

![Figure 5.12 The variation in the distribution of follow-up questions in teacher AUS1’s class](image)

*Note: AGG=Agreement; CLA=Clarification; CUE=Cueing; ELA=Elaboration; EXT=Extension; JUS=Justification; REC=Refocusing; RER=Reformulation request; REP=Repeat; SUP=Supplement.*

F= Foundation lesson; I= Introduction lesson; S= Strategies lessons; C&A= Consolidation & application lesson.

**5.5 The class of teacher AUS2**

This section will focus on the distribution of subcategories for initiation questions and follow-up questions in teacher CHN2’s class.
5.5.1 Initiation questions in QA&IRF (single) sequences

Figure 5.13 shows the variation regarding the distribution of initiation questions in Q&A pairs and IRF (single) sequences across the ten consecutive lessons delivered by teacher AUS2. All the question types appeared in teacher AUS2’s class. It can be seen that six question types, namely Result, Review, Understanding check, Link/application, Explanation and Reflection questions, were commonly used as initiation questions in Q&A pairs and IRF (single) sequences in all the six lessons. The total proportions of these six question types were over 70% for the Foundation lessons and the Introduction lesson, but only 50% and 60% in the Exploration lesson and the Strategies lesson.

![Figure 5.13](image)

**Figure 5.13 The variation in the distribution of initiation questions in Q&A pairs and IRF (single) sequences in teacher AUS2’s class**

Note: COM=Comparison; COJ=Conjecture; EVA=Evaluation; EXP=Explanation; INF=Information extraction; GEN=Generation; LIN=Link/application; PRO=Progress monitoring; REF=Reflection; RSL=Result; REV=Review; STR=Strategy/procedure; UND=Understanding check; VAR=Variation.

F= Foundation lessons; I = Introduction lesson; E= Exploration lesson; S= Strategies lesson.
Information request questions were used with nearly 15 percent, relative to all the initiation questions, in lesson 2, the second lesson of the Foundation phase. And the proportion of Conjecture questions was approximately 20 percent in the Exploration lesson. Then in the Strategies lesson, Evaluation and Strategy/procedure questions separately took up 10% and 15% of all initiation questions asked in Q&A pairs and IRF (single) sequences.

5.5.2 Initiation questions in IRF (multiple) sequences

Figure 5.14 shows the variation regarding the distribution of initiation questions in IRF (multiple) sequences across the six consecutive lessons delivered by teacher AUS2.

---

Figure 5.14 The variation in the distribution of initiation questions in IRF (multiple) sequences in teacher AUS2’s class

Note: COM=Comparison; COJ=Conjecture; EVA=Evaluation; EXP=Explanation; INF=Information extraction; GEN=Generation; LIN=Link/application; PRO=Progress monitoring; REF=Reflection; RSL=Result; REV=Review; STR=Strategy/procedure; UND=Understanding check; VAR=Variation.

F= Foundation lessons; I = Introduction lesson; E= Exploration lesson; S= Strategies lesson.
It can be seen that one question type, *Review* questions, was commonly used as initiation questions IRF (multiple) sequences in all the six lessons. The teacher AUS2 asked *Explanation* questions in IRF (multiple) sequences for all the lessons but lesson 6, whereas *Result* questions were recorded in all the lessons but the *Introduction* lesson (lesson 5). And *Evaluation* questions were used as initiation questions IRF (multiple) sequences in all the lessons except lesson 2, the second lesson in the *Foundation* phase. Besides, *Strategy/procedure* and *Information request* questions were observed in all the lessons except lesson 4, the last lesson in the *Foundation* phase. Apart from the above question types, other question types were used differently in different lessons.

During the *Foundation* phase, *Generation* questions were commonly used in all the three lessons. And *Progress monitoring* questions took up about 10 percent in both of lessons 1 and 2, whereas in lesson 4 *Comparison* questions occupied 30%.

*Link* and *Variation* questions were commonly used in the phases of *Introduction*, phase of *Exploration* and phase of *Strategies*, accounting for 15% and 5% separately. Besides, *Comparison* and *Conjecture* questions occupied approximately 15% and 10% of all the initiation questions IRF (multiple) sequences in the *Exploration* lesson.

**5.5.3 Follow-up questions in IRF (multiple) sequences**

Figure 5.15 shows the variation regarding the distribution of follow-up questions across the six consecutive lessons delivered by teacher AUS2.

Over the whole unit, six question types, *Clarification*, * Cueing* and *Repeat/rephrase*, *Supplement*, *Refocusing* and *Agreement request* questions were commonly used in all six lessons. The teacher AUS2 asked *Justification* questions as follow-up questions in all the lessons but lesson 4, whereas *Elaboration* questions were used in all the lessons but lesson 5. And the total proportions occupied by the above six question types were more than 90 percent in all the six lessons.
5.6 Summary of the four teachers’ classes

In four teachers’ lessons, aligned with the different lesson goals, teacher questioning practices showed some variations.

For the four participating teachers, the employment of initiation questions varied greatly in the constitution of subcategories and these categories’ proportions across the consecutive lessons. And the variations were observed for both the initiation questions in Q&A question pairs and IRF (single) sequences and the initiation questions in IRF (multiple) sequences.

In each teacher’s class, there were several questions types that were employed commonly and frequently, but the composition of the remaining questions in each lesson tended to be different.

Figure 5.15 The variation in the distribution of follow-up questions in teacher AUS2’s class

Note: AGG=Agreement; CLA=Clarification; CUE=Cueing; ELA=Elaboration; EXT=Extension; JUS=Justification; REC=Refocusing; RER=Reformulation request; REP=Repeat; SUP=Supplement.

F= Foundation lessons; I = Introduction lesson; E= Exploration lesson; S= Strategies lesson.
depending on where the lesson is located in the teaching sequence. To fulfil the different pedagogical goals in each lesson of a sequence, not only did the total number of the initiation questions fluctuate as shown in the last chapter (see Section 4.6 in Chapter 4), the distribution of initiation question types in each lesson changed substantially throughout the sequence.

In Chapter 4, the initiation question asked in IRF (multiple) sequences were reported to take up a regular proportion of the total number of questions in each lesson of the whole unit for all four teachers. Here In this chapter, it was found that the breakdown of the initiation questions in IRF (multiple) sequences demonstrates various characteristics across the whole unit. In other words, the teachers tended to use a regular proportion of all the questions in each lesson as initiation question to start IRF (multiple) sequences, but the purposes of starting IRF (multiple) sequences were different, which might reflect teachers’ stable and flexible strategies in using IRF (multiple) sequences.

Nevertheless, in the classes of the four participating teachers, the employment of the follow-up question types was relatively consistent across the consecutive lessons, regardless of where the lesson is located in the teaching sequence. In other words, during extended questioning exchanges in the IRF (multiple) sequences, the participating teachers tended to ask a particular group of follow-up question types to build on students’ responses. Although each teacher employed some question types more frequently than others, the whole sequence of consecutive lessons shared these frequently used questions in common. This suggests that teacher might employ follow-up questions habitually, less dependent on where the lessons are located in the teaching sequence.
CHAPTER 6 RESULTS: THE EMPLOYMENT OF IRF (MULTIPLE) SEQUENCES

In the last two chapters, the first two parts of the research findings have been reported. Chapter 4 presented the variations regarding the number and proportions of the initiation questions and follow-up questions across the consecutive lessons for four participating teachers. Subsequently, Chapter 5 more closely examined the subcategories of the initiation questions and follow-up questions and demonstrates what subcategories constitute the initiation questions and follow-up questions employed across the unit of consecutive lessons in the four teachers’ classes. This chapter focuses on the IRF (multiple) sequences and gives an in-depth examination of the ways by which the four participating teachers employed various subcategories of the initiation questions and follow-up questions in the IRF (multiple) sequences.

6.1 Introduction

In Chapter 4, it was shown that a relatively constant proportion (around 20%) of all questions, in each lesson of the unit sequence, tended to be used by the four participating teachers as IQ-IRF (multiple) questions, by which the teacher-student interaction could be sustained further. And in chapter 5, a closer examination of the subcategories of the initiation questions reveals that the subcategories for initiation questions in the IRF (multiple) sequences varied across the lessons within the unit sequence, whereas the subcategories for the follow-up question were relatively consistent over the whole unit of consecutive lessons. Teachers’ strategic utilisation of IRF (multiple) sequences is important and worthy of closer examination because only in the questioning sequences can the teachers possibly use specific types of questions intentionally to “guide students through the thinking necessary to generate deep understanding of the content and its implications” (Marzano & Simms, 2012, p.10). There is actually no need to vilify questions asking students to review prior knowledge or to glorify the so called “high-order” questions, since each specific question has a place in the questioning sequence and can make a difference in promote students’ thinking.

This chapter will particularly present the ways in which these question subcategories were combined in the IRF (multiple) sequences by the participating teachers in each lesson of the unit sequence.
Three kinds of IRF (multiple) sequences were identified in the participating teachers’ classes and outlined in Figure 6.1. The detailed descriptions of the three kinds of IRF (multiple) sequences are as follows.

**Figure 6.1** The three types of IRF (multiple) sequences

**Leading sequences:** The teacher is presenting the knowledge, and the teacher questions are mainly asked so as to guide students to follow his/her directions. The students are usually asked whether they agree with the teacher or asked to fill in a few words to the teacher’s questions. Students’ responses were constrained and short. This sequence usually occurred in the interaction between a teacher and an individual student (in public or in private), or between a teacher and the whole class with choral responses.

**Facilitating/probing sequences:** The teacher is striving to provide students with opportunities to express their thinking and develop mathematics knowledge. The teacher asks questions to provide clues or simpler tasks so that the students could move forward to complete the expression of their mathematical thinking; the teacher is trying to allow students to demonstrate and present more details of students’ mathematical ideas or claims. Students’ responses were relatively less constrained and tended to be longer. Similarly to the leading sequences, facilitating/probing sequences sequence also occurred in the interaction between a teacher and an individual student (in public or in private), or between a teacher and the whole class with choral responses.
Orchestrating sequences: The teacher allows several students to make contributions and then addresses each student’s talk. The teacher asks questions so that different students’ ideas, thinking, or reasoning could be displayed or discussed. The orchestrating sequences normally occurred in a whole class interaction where various students’ responses rather than choral responses could be elicited. Sometimes this sequence could also be observed when the teacher is talking with multiple students (pairs, groups, etc.).

In the following sections, the use of the leading sequences, facilitating/probing sequences, and orchestrating sequences across the consecutive lessons in each teacher’s class will be presented together with detailed corresponding examples.

6.2 The class of teacher CHN1

Figure 6.2 shows how teacher CHN1 used questioning strategies in the IRF (multiple) sequences across the six lessons.

Figure 6.2. The IRF (multiple) sequences in teacher CHN1’s class

Note: I&S= Introduction & strategies lessons; C&A= Consolidation & application lessons; S= Summarization lesson.
The dotted line represents the variation regarding the total number of IRF (multiple) sequences as they emerged in each lesson within the unit sequence. And each bar depicts what proportions of the IRF (multiple) sequences in each lesson were used for leading, facilitating/probing and orchestrating purposes. For example, in lesson one, there were a total number of 20 IRF (multiple) sequences, out of which leading sequences occupied around 55 percent, facilitating/probing sequences nearly 30 percent, and orchestrating sequences approximately 15 percent.

In Figure 6.2, it can be seen that leading sequences in the Introduction and Strategies lessons (lesson 1 and 2) occupied nearly 60 percent of the IRF (multiple) sequences while the facilitating/probing sequences and orchestrating sequences separately represented about 30 percent and 10 percent. In contrast, facilitating/probing sequences were predominantly observed in the Consolidation and Application lessons (lessons 3, 4, and 5) except lesson four where leading sequences took up around 50 percent of all the IRF (multiple) sequences. Meanwhile, there was a higher proportion of orchestrating sequences in the Consolidation and Application lessons than in any other lessons. In the Summarization lesson (lesson 6), leading sequences and facilitating/probing sequences equally accounted for 50 percent of the IRF (multiple) sequences, whereas no orchestrating sequence was observed here in lesson 6. The following paragraphs will present the transcripts of the selected episodes and detailed descriptions about how the IRF (multiple) sequences were used in the lesson sequence. More details will be presented in the following sections.

6.2.1 The Introduction and Strategies lessons

In teacher CHN1’s lesson unit, the first two lessons covered the Introduction and Strategies about solving right triangles and non-right triangles. The majority of IRF (multiple) sequences in these two lessons were observed as leading sequences. The examples of the leading sequences in these two lessons are shown in Episode 6-1 and Episode 6-2. Subsequently examples for facilitating/probing sequences and orchestrating sequences are shown in Episode 6-3 and Episode 6-4.

In the following transcripts, the letter “T” is short for the teacher, “S” for the individual student, and “Ss” short for choral responses. All the students’ names are pseudonyms.
**Leading sequences**

*Episode 6-1 Leading sequence, CHN1-Lesson 1, 0:39:20-0:40:18*

![PowerPoint slide](image)

**Figure 6.3** Teacher CHN1’s PowerPoint slide used for example 3 in lesson 1

T: Okay. Now let’s have a look. [Based on our discussion] I need to find the value of angle DAC. Now pick one, pick one trig ratio. Which one? Zhang, I have outlined here the ideas for the solution. [The teacher presents the slide as below] **Firstly, the angle C is ninety degrees, so...?**

IQ: Strategy/procedure

S: [Zhang] So sine A, sine of the angle DAC equals AC over AD.

T: **Is it sine?**

IQ: Clarification

S: [Zhang] cosine.

T: **Cosine of the angle DAC equals AC over AD, so...?**

IQ: Supplement

S: [Zhang] It equals the square root of 3 over 2.

T: **Square root of 3 over 2, so the angle DAC equals...?**

IQ: Supplement

S: [Zhang] 30 degree.

T: **30 degrees, so...?**

IQ: Supplement

S: [Zhang] BAC equals 60 degrees.

T: BAC equals 60 degrees. **If BAC is known, what could be said about the angle B?**

IQ: Supplement

S: [Zhang] 30 degrees.

T: 30 degrees.

In Episode 6-1, teacher CHN1 asked the student questions so as to go through the procedures of solving the problem. Since this example as shown in Figure 6.3 was a sophisticated task in the first lesson of the unit, the teacher had already guided students to analyse and discussed the direction of the strategies. Afterwards, she outlined the ideas about the solutions in the PowerPoint slide, and a student (Zhang) was asked to describe the solutions and add full details.
of the procedure according to the outline. Instead of allowing the student to express the strategies in a complete way, she asked a few question and merely asked the student to give some very short answers.

**Episode 6-2 Leading sequence, CHN1-Lesson 2, 0:13:19-0:14:35**

**Figure 6.4** Teacher CHN1’s PowerPoint slide used for example 2 in lesson 2

<table>
<thead>
<tr>
<th>T:</th>
<th>So what should you do? There are two options. <strong>One is what?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ: Strategy/procedure</td>
<td></td>
</tr>
<tr>
<td>Ss:</td>
<td>Constructing.</td>
</tr>
<tr>
<td>T:</td>
<td><strong>If you like the constructing way, will you have to construct a perpendicular line?</strong></td>
</tr>
<tr>
<td>FQ: Clarification</td>
<td></td>
</tr>
<tr>
<td>Ss:</td>
<td>Yes.</td>
</tr>
<tr>
<td>T:</td>
<td>Then we can put it [the angle EDC] into a right triangle. <strong>What if you don’t want to construct the perpendicular line? What could you do?</strong></td>
</tr>
<tr>
<td>FQ: Supplement</td>
<td></td>
</tr>
<tr>
<td>Ss:</td>
<td>Converting.</td>
</tr>
<tr>
<td>T:</td>
<td>Converting. We can also convert it to an equivalent, right? <strong>Do we have the equivalent of that angle [angle EDC] here in the diagram?</strong></td>
</tr>
<tr>
<td>FQ: Clarification</td>
<td></td>
</tr>
<tr>
<td>Ss:</td>
<td>Angle C.</td>
</tr>
<tr>
<td>T:</td>
<td>Good. Is angle C the equivalent? Why? Is the side length of DE equal to that of EC? <strong>Reason? What is the reason?</strong></td>
</tr>
<tr>
<td>FQ: Justification</td>
<td></td>
</tr>
<tr>
<td>Ss:</td>
<td>The median on the hypotenuse of a right triangle equals one-half the hypotenuse.</td>
</tr>
<tr>
<td>T:</td>
<td>Good. The median on the hypotenuse of a right triangle equals one-half the hypotenuse. In this way, we can find it [tan∠DEC] by converting it to tanC.</td>
</tr>
</tbody>
</table>

In Episode 6-2, the teacher was leading the whole class to analyse how to solve the second part of the task, namely to find the tangent of angle EDC which was not in any right triangle in the given diagram. Before this example, the ideas of constructing and converting had been introduced as two main directions for solving similar questions involving non-right (or oblique) triangles. Based on these two ideas, here the teacher asked the students to think about the
possible strategies. She did not select any individual student or ask for volunteers to answer the questions, but posed questions to the whole class and elicited the choral responses. What the students needed to do were give short responses to the teacher’s questions which requested only to fill the blank or to answer yes or no. The only exception was the last question which asked the students to justify their claim. For this question, the whole class was so familiar with the patterns in right triangles that they uniformly replied with the content of a theorem about the median on the hypotenuse in a right triangle.

**Facilitating/probing sequences**

*Episode 6-3 Facilitating/probing sequence, CHN1-Lesson 1, 0:12:36-0:14:02*

T: Now I have one more question for all of you. What mathematics knowledge is involved in solving right triangles? *What mathematics have you used when solving right triangles?*

Ss: [silent]

T: Who can say something? *What mathematics is used?* Zhu, *what mathematics is used?*

S: [Zhu] firstly, trig ratios are used.

T: Firstly trig ratios, *then?* *FQ: Supplement*

S: [Zhu] then to find the ratios of side lengths.

T: *ratios of the side lengths?* *FQ: Clarification*

S: [Zhu] Yes.

T: *What does that mean? Can I interpret that as the relations between side lengths in right triangles?* *FQ: Clarification*

S: [Zhu] just use the trig ratios to find the relations between side lengths, and then substitute one known side length into relations, and then we can find the unknown side length.

T: Ok. In another way, for example, if I am given two side lengths *if I am given the lengths of two legs, can I find the relations between side lengths without using trig ratios?* *FQ: Extension*

S: [Zhu] Yes.

T: *How should I make it?* *FQ: Clarification*

S: [Zhu] Pythagoras’ Theorem.

T: Okay.

In Episode 6-3, the teacher required the students to reflect on what mathematics had been used in solving right triangles. To do this, she selected one student (Zhu) to share his ideas, and a few questions were asked to probe and facilitate this student’s thoughts and articulation. When the student gave a vague statement, he was allowed to clarify and present more details of his thinking. Building on the student’s clarification, the teacher further developed the student’s
thinking by asking for the alternative strategy and thereby elicited the Pythagoras’ Theorem that was crucial in solving right triangles. Here when the teacher asked questions, rather than imposing strong control over the direction of students’ responses as shown in the leading sequences, she provided the student with more chances to express his mathematics thinking.

**Orchestrating sequences**

**Episode 6-4 Orchestrating sequence CHN1-Lesson 1, 0:32:33-0:35:02**

T: Okay, the next is the second category, which is when one side length and one angle size are known. Obviously, this known angle is an acute angle in the triangle. One side length and one acute angle size. One side length and one acute angle size. Then is the known side a leg or the hypotenuse? Are there two cases again? For example, if one leg a and one acute A are known, how would we find the remaining side lengths and angle sizes? Jiang?

T: **what could we know at once, if the angle is known?**

S: [Jiang] we could know angle B.

T: **equals...?**

S: it is 90 degrees minus angle A. Then because of the trig value of the angle A, no, use the trig relationship to find, hum...

T: **Look at the two examples I have shown above. Could you tell us more details?**

Figure 6.5 Teacher CHN1’s PowerPoint slide used for summary in lesson 1

S: [Dong] hum...

S: [Dong] hum... let me think about this [alone], Miss.

T: Okay, think about it. **Who can help him? Zhang?**

S: [Zhang] we can use, sine A equals a over c, to find c. Then we can use Pythagoras’ Theorem to find b. Or we can
sine sine again. Cosine B equals sine A, thus we can find A, hum, find B.

T: Good, very good.

In Episode 6-4, the teacher asked the students to summarise the cases and the corresponding solutions in the problems of solving right triangles. As shown in the PowerPoint slide, two cases had been displayed and discussed as the models about how to construct the summary. For the third case, the teacher selected one student (Dong) to express his ideas. However, this student could not well develop his expression or thinking after a few attempts. And he might feel so stressed that he requested for time to think alone rather than continuing to make attempts in public. Due to the student’s request, the teacher did not make attempts to push or direct him. Neither did the teacher tell the class straightforward how to construct the summary for this case. Instead, she invited a volunteer (Zhang) from the class to help continue the construction of the summary that had not been completed by the previous student (Dong). The second student (Zhang) succeeded in constructing the summary. Overall, in this episode, the teacher attempted to allow various students’ participations in classroom interaction and to avoid the dominance of the capable students in talking and answering questions in public. Although this purpose was not fully achieved, the teacher indeed strived to orchestrate students’ talk in the classroom.

6.2.2 The Consolidation and Application lessons

In the Consolidation and Application lessons (lesson 3, 4 and 5), right and non-right triangle were presented in the context of real-world problems, and those strategies learnt in the first two lessons of the teaching unit were applied to solve these application tasks. Some new mathematics knowledge was also introduced to enable the students to make sense of the real-world context. In lesson 3, angles of elevation and depression were introduced and in lesson 4, the knowledge about bearings, angle of inclination, and slope were covered.

Compared with the two lessons (lesson 1 and lesson 2) in the Introduction and Strategies phase, a larger proportion of IRF (multiple) sequences was used as facilitating/probing sequences and orchestrating sequences in the Consolidation and Application lessons where the proportion occupied by leading sequences were relatively smaller. Lesson 4 was the only exception in that leading sequences accounted for almost 50 percent of all IRF (multiple) sequences. The examples of facilitating/probing sequences are shown in Episode 6-5, Episode 6-6, and Episode
6-7, followed by the example of orchestrating and leading sequences in Episode 6-8 and Episode 6-9.

**Facilitating/probing sequences**

*Episode 6-5 Facilitating/probing sequence, CHN1-Lesson 3, 0:08:40-0:09:36*

*Figure 6.6 Teacher CHN1’s PowerPoint slide for height measuring task in lesson 3*

T: Okay, **who would like to share some results of your discussion? Some of you might have thought about this before. Liu?**

S: [Liu] Imagine the sun shines down on the building, and then the building casts a shadow on the ground. The building is perpendicular to its shadow, and then we can get a right triangle.

T: For example, if this is the building we would like to measure, [draw a vertical line segment to represent the building] the building could be viewed as this line segment here. Then sunlight comes from this direction, and it casts a shadow with this length. [draw a horizontal line segment to represent the shadow of building] Then [join the endpoints of the two line segments], **do you mean this [right triangle]?**

S: [Liu] Yes.

T: Okay.

In Episode 6-5, the teacher asked the student (Liu) to share his strategies about how to measure the height of an object in real-world context. The student articulated his thinking in a clear way but without any visual demonstrations. To help the whole class understand his idea, the teacher visualised this student’s descriptions by drawing a triangle on the board, which was followed by a question to clarify whether the student’s idea was visualised correctly. Although this episode is not very long, it is obvious that the teacher intended to assist the student in presenting his ideas more clearly.
Episode 6-6 Facilitating/probing sequence, CHN1-Lesson 4, 0:10:06-0:11:37

The entrance of an underground garage is as shown. There is a vehicle ramp slope AB, and the ramp slope ratio is $i=1:1.5$, then $AB=\_\_\_m$.

![Diagram of a ramp with a point A and B, and a height of 2m underground garage.]

Figure 6.7 Teacher CHN1’s PowerPoint slide 1 for garage task in lesson 4

T: this might be rather familiar to you. There are underground garages in many apartment buildings. In the entrance of an underground garage, if there is a ramp slope and the ramp slope ratio $i=1:1.5$, then AB is how long? Actually, if you are asked to find the angle of the inclination, where is it? Li, tell us the ramp slope angle is...?  
IQ: Link/application

S: [Li] angle A.

T: angle A, is it here? [Pointing to the letter A]

IQ: Clarification

S: [Li] Yes.

T: but actually if this is the ramp slope, we need to extending this line like this, right?

IQ: Agreement request

![Diagram showing the extended line from point A to B.]

Figure 6.8 Teacher CHN1’s PowerPoint slide 2 for garage task in lesson 4

S: [Li] the two angles [angle A and angle B] are the same.

T: the two angles are the same.

In Episode 6-6, the teacher asked a student to find where the angle of inclination was. In the beginning, the student simply pointed out an angle that was equal to the target angle, for which the teacher further asked a Clarification question and subsequently an Agreement request question to probe student’s thinking. Eventually, the student stated that he was clear about the
equivalence between the angle A and angle B. Here through the teacher’s facilitating/probing sequence, the student was provided with opportunities to clarify his mathematical thinking.

**Episode 6-7 Facilitating/probing sequence, CHN1-Lesson 5, 0:36:49-0:37:48**

![Diagram](image1)

**Figure 6.9** Teacher CHN1’s task for example 4 in lesson 4

**T:** *Liu, could you come to the board and demonstrate your idea?*

**S:** [Liu] through the point A, make a perpendicular line of BN at M. According to the information given in this task, AB is 3km. Then this line is parallel to BM, so we could know the angle ABM is 30 degrees. So the right triangle has special angles, 30 and 60 degrees. We can use the pattern of the side length relationship in the special triangle.

![Diagram](image2)

**Figure 6.10** Student’s demonstration for example 4 in teacher CHN1’s lesson 4

**T:** Good. We could use the pattern of the side length relationship, or we would use trig ratios. *What are you going to find eventually?*

**S:** [Liu] The side length of AM.
T: Okay, the side length of AM.

In the Episode 6-7, the teacher asked one student (Liu) to demonstrate this idea on the board. The student added some auxiliary lines to the given diagram and described his strategies. Since the task was a real-world problem, the student reformulated it into a mathematics problem by constructing right triangles. However, he focused so much on the procedure that he forgot to complete the reformulation of the Mathematics problem. In other words, he forgot to make it explicit what to find in the mathematics problem so as to solve the real-world problem. Therefore, the teacher asked one Clarification question to facilitate the student’s articulation of his thinking.

**Orchestrating sequence**

*Episode 6-8 Orchestrating sequence, CHN1-Lesson 3, 0:40:09-0:44:51*

T: As you can see in the slide, surveyors need to collect some data to calculate the width of the river. What data are they collecting here? We are talking about an ideal situation where the banks of the river are parallel. Who has any ideas? [One student hands up] Hu, you come to the board and demonstrate your idea. [Q: Strategy/Procedure]

S: [Hu] Select one point A at one side of the river, and then use some instrument to measure the angles.

T: you need a goniometer, assuming this instrument is powerful enough to measure the angles you want.

![Figure 6.11 Teacher CHN1’s PowerPoint slide for river task in lesson 3](image)

S: [Hu] [draw a diagram] assume this is a 30-degree angle. This line crosses the other side of the river at point B. People at each side of the river could communicate to get the distance between A and B. Since this angle is 30 degrees, we can finally find the width of the river.
Figure 6.12 Student’s demonstration 1 for river task in teacher CHN1’s lesson 4

T: Okay. Have a look at his idea. He said people at each side of the river need to communicate, which means there have to be surveyors at both sides of the river. The perpendicular line requires a ninety-degree at C, and this could be made by using the goniometer. For the 30 degrees, one person could hold the goniometer and another person could move his position so as to find the point B which makes A 30 degrees. Then use the length of AC to find the length of BC. *Is everyone OK with this idea?*  
FQ: Agreement request  
Ss: Yes.  
T: Okay. *Are there any alternative ways? Wang, come to the board.*  
FQ: Supplement

Figure 6.13 Student’s demonstration 2 for river task in teacher CHN1’s lesson 4

S: [Wang] the river is flat like this, and this is a perpendicular line. A person is here and gets one angle measurement, and then here, gets another angle measurement. Just like the strategy in the last task.  
T: *What is next? You need a distance.*  
FQ: Supplement  
S: [Wang] Right, then measure this distance [between A and B]. We also know the distance of the goniometer above the ground.  
T: *So has this angle to be a right angle or any angle size?*  
FQ: Clarification  
S: [Wang] this has to be a right angle.  
T: Okay.

In Episode 6-8, the teacher posed a task relating to river width for the whole class to think about, before asking for volunteers to share their strategies to solve this real-world problem. Since the teacher clarified that the two sides of the river could be viewed as two parallel lines,
the real-world task was a bit easily to be converted to a mathematics problem to find the distance between two parallel lines. The challenging part was that there was no information given and thus the students needed to figure out what information should be collected. The first student (Hu) proposed a plan about information collection and the corresponding problem-solving strategy. As a response, the teacher gave some comments to this student’s plan and asked for a choral agreement, which was followed by the teacher’s request for any other alternatives. The second student (Wang) then demonstrated another way of measuring angles and calculating the width, and as was stated by the student this alternative way was quite similar to the strategies used and summarised in the last task in lesson 3 (see Figure 6.14). Building on this student’s answer, the teacher asked a Supplement question to help this student complete his strategies. Here in this episode, the teacher orchestrated two student’s talk to express their thinking about the same task.

- **Figure 6.14** Teacher CHN1’s summarization for height problems in lesson 3

**Leading sequence**

**Episode 6-9 Leading sequence, CHN1-Lesson 4, 0:42:10-0:42:41**

**T:** talking about one student’s work] he constructed a line segment BC with a length of 200.

**S:** [Zheng] How did he do that?

**T:** [to the whole class] here is one question, how he did it. Is this easy to do? How should we describe the procedure of making BC? **What could I do if I would like to make the length 200? I can place the compasses’ point on.?**

**IQ:** Link/Application

**Ss:** on the point B as the centre of the circle

**T:** **Then set.**? **FQ:** Supplement

**Ss:** 200 as the radius.

**T:** we can construct a circle.
In Episode 6-9, one question was posed by a student when the teacher was talking about a problem strategies proposed previously by some other student. Interrupted by this question, the teacher then initiated a question to ask the whole class for more details about the procedure of constructing a line segment with a given length, 200. The teacher did not select an individual student or ask for volunteers to add more details. She instead led the whole class and asked for choral responses. Although the whole class got two chances to answer the teacher’s question, what they said were simply short words to fill some blanks in the teacher’s questions.

### 6.2.3 The Summarization lesson

The *Summarization* lesson (lesson 6)’s goal was to summarise and review all the knowledge and skills about solving right and non-right triangles. Leading sequences accounted for one-half of all the IRF (multiple) sequences in this lesson, while the other half was taken up by facilitating/probing sequences. No orchestrating sequences were observed in the *Summarization* lesson. The examples of leading sequence and facilitating/probing sequence are separately shown in Episode 6-10 and Episode 6-11.

**Leading sequences**

**Episode 6-10 Leading sequence, CHN1-Lesson 6, 0:02:49-0:04:04**

T: For solving right triangles, there are two cases depending on what are given. **What are the two cases?**

Ss: [silent]

T: *given*...?

Ss: two side lengths.

T: *given two side lengths and*...?

Ss: given one side length and one angle size.

T: given one side length and one angle size.

In Episode 6-10, the teacher led the whole class to recall the cases of problems in solving right triangles. After the teacher had initiated the first question, the whole class seemed to be a bit reluctant to respond. Therefore the teacher repeated the question and the choral response was elicited but the responses were not complete. Then the teacher requested for a supplement from the whole class whose responses achieved the teacher’s eventual expectations.
Facilitating/probing sequences

Episode 6-11 Facilitating/probing sequence, CHN1-Lesson 6, 0:13:19-0:14:36

In Episode 6-11, the teacher presented a task and asked a volunteer (Wang) to share their strategies in public. At the very beginning, the student did not have any difficulties in expressing his strategies until he attempted to continue with the use of sine of the angle BCE. The student assumed the side length of AE as \(a\) and then jumped to use sine of the angle BCE which did not straightforward involve AE. Here the student started to become unclear about the side length.
relationships. The teacher thereby asked the student to slow down and to recheck his thinking process. With the teacher’s facilitation, the student finally got back to the right track and figured out the correct results that could be derived from sine of the angle BCE. In this episode, the student got struggled with his thinking, but the teacher did not interrupt the student’s thinking by, for example, telling the correct answer straightforward. She instead asked a few questions to facilitate the student’s mathematical thinking and articulation.

6.2.4 Summary of teacher CHN1’s class

Overall in teacher CHN1’s class, the use of IRF (multiple) sequences varied across the consecutive lessons and the proportions represented by the three different kinds of sequences were substantially dependent on the location of the lesson in the unit.

For the Introduction and Strategies lessons (lesson 1 and 2), teacher CHN1 tended to use leading sequences to request an individual student’s short responses or choral responses so as to present the correct ways of thinking and solving problems. To do this, teacher CHN1 tended to control the direction of classroom interaction, and the students were usually given few opportunities to express or discuss their thinking. Besides, there were a few facilitating/probing sequences and orchestrating sequences observed, but these sequences just took up small proportions of the IRF (multiple) sequences.

For the Consolidation and Application lessons (lesson 3, 4 and 5), teacher CHN1 moved beyond the leading mode as in the introduction and strategies lessons and larger proportions of IRF(multiple) sequences were used as facilitating/probing sequences. Meanwhile, there was an increase in the proportion taken up by the orchestrating sequences, compared with those in the Introduction and Strategies lessons. The students were provided with more opportunities and time to express their thinking and strategies about solving real-world problems.

For Summarization lesson (lesson 6), the teacher one-half of the IRF (multiple) sequences as leading purpose and another half as facilitating/probing purposes. The leading sequences were mainly used to help students review the prior knowledge and skills, and the facilitating/probing sequences were primarily employed to assist students’ articulation and development of their thinking in solving mathematics tasks.
6.3 The class of teacher CHN2

It is presented in Figure 6.16 how teacher CHN2 used questioning strategies in the IRF (multiple) sequences across the ten lessons. For example, in the lesson one, there were a total number of 18 IRF (multiple) sequences, out of which leading sequences occupied around 35 percent, facilitating/probing sequences nearly 55 percent, and orchestrating sequences approximately 10 percent.

In the Introduction lesson (lesson 1), a majority of the IRF (multiple) sequences consisted of the facilitating/probing sequences which took up over 50 percent. By contrast, the leading sequences only represented around 30 percent, and the remaining 10 percent was occupied by the orchestrating sequences.

Figure 6.16 The IRF (multiple) sequences in teacher CHN2’s class

Note: I = Introduction lesson; E= Exploration lessons; St= Strategies lessons; C&A= Consolidation & application lesson; Su= Summarization lesson.
For the *Exploration* lessons (lessons 2 to 6), the leading sequences accounted for a large proportion of the IRF (multiple) sequences in the beginning (lesson 2) and end (lesson 6) of the exploration phase. By contrast, in the middle of the *Exploration* (lesson 3, 4 and 5), facilitating/probing sequences were the predominant component of the IRF (multiple) sequences. Besides, the proportions taken up by the orchestrating sequences were much higher in all *Exploration* lessons but lesson 5.

In the *Strategies* lessons (lesson 7 and 8), there was no predominance of either leading sequences or facilitating/probing sequences. In lesson 7, the leading, facilitating/probing and orchestrating sequences respectively took up around 30 percent of all IRF (multiple) sequences. Then in lesson 8, both the leading and facilitating/probing sequences separately represented about 40 percent of all IRF (multiple) sequences, while the remaining ten percent was taken up by the orchestrating sequences.

In the *Consolidation and Application* lesson (lesson 9), over 50 percent of all the IRF (multiple) sequences were made up of the facilitating/probing sequences. And then in the *Summarization* lesson (lesson 10), the leading sequences became the major component of the IRF (multiple) sequences. Meanwhile, the proportion taken up by the orchestrating sequences grew smaller in lesson 9 and 10 than in the *Exploration* lessons (lessons 2 to 6) and the *Strategies* lessons (lessons 8 and 9). More details will be presented in the following sections.

### 6.3.1 The Introduction lesson

In the *Introduction* lesson (lesson 1), the IRF (multiple) sequences were mainly used as facilitating/probing purposes. The example of the facilitating sequence is shown in Episode 6-12.

**Episode 6-12 Facilitating sequence, CHN2-Lesson 1, 0:03:36-0:05:03**

![Image](image.jpg)

*Figure 6.17 Teacher CHN2’s task for functions in lesson 1*
In Episode 6-12, student (Zhang) was asked to explain how to check whether the fourth curve in the task was a function or not. The curve was printed on a piece of worksheet which was projected on the board via visual presenter, and the student was asked to demonstrate his thinking by using the visual presenter. The student demonstrated the process of applying “vertical line test” to this curve and claimed that some part of the curve intersected the vertical line at more than one point. But the teacher did not stop the conversation. He further asked the student to elaboration on the contradictions that the failure of the “vertical line test” had with the definition of a function. In this episode, the teacher facilitated the student to make his arguments more comprehensive so as to allow the whole class have a deeper understanding of the definition of a function.

6.3.2 The Exploration lessons

There are five lessons (lessons 2 to 6) in the Exploration phase of teacher CHN2’s unit. The first lesson and the last lesson in the Exploration lessons had similarities regarding the use of IRF (multiple) sequences: the leading sequences occupied a larger proportion than any other two. In contrast, the lessons in the middle of the Exploration lessons saw a larger proportion of facilitating/probing sequences. Meanwhile, the proportions occupied by the orchestrating sequences substantially increased in the Exploration lessons than in the Introduction lesson.

6.3.2.1 The opening of the exploration
Lesson 2 is the first lesson in the Exploration phase, and thus it set a basis regarding the methods and directions of exploring quadratic graphs. The examples of leading sequence and orchestrating sequence are separately shown in Episode 6-13 and Episode 6-14.

**Leading sequences**

*Episode 6-13 Leading sequence, CHN2-Lesson 2, 0:24:35-0:25:34*

T: **What is the alternative way of interpreting the vertex, looking at its position? Wang?**

S: [Wang] the Origin.

T: The Origin. So you put it on the Cartesian plane. For the parabola, the vertex point. **Why did you get its [the parabola] minimum a moment ago?**

S: [Wang] because it is above the x-axis and cuts the x-axis at the Origin.

T: **Then what about all the other points in relation to it [the Origin]?**


T: Above. **What about itself [the Origin]?**

S: [Wang] the bottom.

T: the bottom. Thus it could be interpreted as the parabola’s lowest point.

In Episode 6-13, the teacher intended to develop students’ understanding of the turning point of a quadratic function. He asked one student (Wang) to think further about the meaning of the vertex, but the student failed to give the answer expected by the teacher. Then the teacher started to ask a few follow-up questions which were less challenging, requiring the student to recall the prior task and to describe the positions of the vertex and other points on the parabola. In this process, the teacher did not make explicit the connections among these follow-up questions and what the student did was simply answering each of the questions given by the teacher without necessarily thinking about the links among these questions.

**Orchestrating sequence**

*Episode 6-14, Orchestrating sequence, CHN2-Lesson 2, 0:32:49-0:34:13*

T: **Jiang, could you clarify the meaning of “it is opposite”**

S: [Jiang] it, the position, on the opposite side.

T: [to the class] **any comments?**

Ss: [silent]
Figure 6.18 Student’s answers presented in teacher CHN2’s lesson 2

T: Then if I put the graphs together, [working on Geometer’s Sketchpad], look at this. I am drawing the graphs. The bottom one is \( y = -x^2 \). Now have a look. **What characteristics do the two graphs have? Can anyone in your group [Jiang’s group] answer this?**

Figure 6.19 Teacher CHN2’s demonstration in lesson 2

S: [Li] The two graphs are symmetrical across the x-axis.
T: **Is he correct?**
Ss: Yes.

In Episode 6-14, the teacher required a student (Jiang) to clarify the meaning of the words she had used in her public presentation before the conversation. The student clarified the meaning but with some everyday words rather than strict mathematics language. The teacher did not give clues to this student or push her to use mathematics language. Instead, he threw the question to the whole class and invited another student to join in the classroom talk. Without receiving any responses from the whole class, the teacher demonstrated the graphs of two parabolas in Geometer’s Sketchpad, hoping the accurate graph in the Geometer’s Sketchpad could help to elicit responses from a group where the first student (Jiang) was in. Eventually, another student (Li) in the group used the mathematics language to describe the relationships between the two parabolas before a choral agreement check. Here in this episode, the teacher
avoided telling the students the correct answers or asking less challenging questions. He used questioning strategies to orchestrate student’s talk and give students more opportunities to present their mathematical thinking.

### 6.3.2.2 The middle of the exploration

The middle of the Exploration phase involves three lessons: lessons 3, 4 and 5. The examples of the facilitating/probing sequences in these lessons are shown in Episode 6-15, Episode 6-16, and Episode 6-17, followed by the examples of the orchestrating sequences in Episode 6-18 and Episode 6-19.

#### Facilitating/probing sequences

**Episode 6-15 Facilitating/probing sequence, CHN2-Lesson 3, 0:21:22-0:23:44**

T: Have you ever thought about this? It is a special type of quadratic function. *So is the value of k here [in y=ax^2+k] an equivalent of the value c in the standard form [y=ax^2+bx+c]?* [A student Huang hands up, and the teacher asks him to answer].

[q: Link/application]

S: [Huang] because k and c both are real numbers. There is an independent variable in the term bx, and c is just a constant. So is k. k is also a constant like c. Therefore c could be equal to k.

T: *So in what conditions will the standard form become this special form?* [q: Refocusing]

S: [Huang] when b equals 0.

T: *What if b is not equal to 0?* [q: Extension]

S: [Huang] when b is not equal to 0, it should be ax^2, plus bx, plus c.

T: *So would the coordinates of the vertex still be (0,c)?* [q: Elaboration]

S: [Huang] Yes. The coordinates of the vertex is (0,c). Because bx is 0 reflects that [the x-coordinate] is 0. [For y=ax^2+k,] the x-coordinate of the vertex is 0, then the y-coordinate is the value of k.

T: *I am asking you, what if b is not equal to 0.* [q: Refocusing]

S: [Huang] if [the point (0,c)] is not [the vertex] if b is not 0.

T: Please be seated.

In Episode 6-15, the teacher posed a challenging question about the relationships between the quadratic function’s standard form y=ax^2+bx+c and the special form y=ax^2+k. Before this episode, some investigation had been conducted for these two forms and students knew that the
vertices of the two parabolas could be expressed as \((-b/2a, (-b^2+4ac)/4a)\) and \((0, k)\). At the beginning of the episode, the teacher asked the class to think about whether \(k\) is equivalent to \(c\) and one student volunteered to share his thinking. The student stated that \(k\) and \(c\) could be the same value since they were both constants, which was a correct statement but did not really answer the teacher’s question, because the teacher requested whether \(k\) and \(c\) was the same in general. For this reason, the teacher started to facilitate his development of thinking in this issue. The teacher facilitated the student with thinking about the relationships between the two forms and eventually the student realized that although the values of the \(c\) and \(k\) could be same, their meaning was not: \((0, k)\) was always the vertex of \(y=ax^2+k\), while \((0, c)\) could be the vertex \(y=ax^2+bx+c\) of only when \(b\) is 0. In this episode, the student was given opportunities to express and develop his mathematical thinking.

**Episode 6-16 Facilitating/probing sequence, CHN2-Lesson 4, 0:39:17-0:40:29**

**Figure 6.20** Teacher CHN2’s summary task in lesson 4

T: [to Wang] **could you answer this question by drawing an analogy between this question and “determination by k” in the last lesson?** [Q: Link/application]

<table>
<thead>
<tr>
<th>What is the relationship between parabolas (y=ax^2+k) and (y=ax^2)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The value of (k) determines the direction of shift. Specifically,</td>
</tr>
<tr>
<td>if (k&gt;0), the graph (y=ax^2) is shifted (k) units upwards</td>
</tr>
<tr>
<td>if (k&lt;0), the graph (y=ax^2) shifted (</td>
</tr>
</tbody>
</table>

**Figure 6.21** The summarization of “determination by \(k\)” in teacher CHN2’s lesson 3

S: [Wang] when \(h\) is greater than 0, the parabola is shifted to the right. When \(h\) is less than 0, the parabola is shifted to the left. This could be called “determination by \(h\)”.

T: **How far [is it] shifted?** [FQ: Clarification]

S: [Wang] [it is] shifted \(h\) units.

T: Okay. **What is the next [when \(h\) is a negative number]?** [FQ: Supplement]

S: [Wang] the absolute value of \(h\), units.
Right, since $h$ could be either positive or negative. **Then what would we have after these kinds of shifts?**

[Elaboration]

Wang: $y=a(x-h)^2$. [the teacher is writing]

T: It is also a special type of quadratic function.

In Episode 6-16, the teacher asked a student (Wang) to describe how to transform the graphs of $y=ax^2$ so as to obtain the graph of $y=a(x-h)^2$. Since a similar task had been presented and discussed in the last lesson (see Figure 6.21), an analogy was encouraged to be used in answering this question. The student stated the direction of the translation for different values of $h$ without specifying the distance of translation. So the teacher asked the student to add more details, facilitating the student to complete his statement of “determination of $h$”. In this episode, the student was provided with opportunities to express his thinking.

**Episode 6-17 Facilitating/probing sequence, CHN2-Lesson 5, 0:05:06-0:06:31**

![Figure 6.22 The mind map used in teacher CHN2’s lesson 5](image)

T: The question is, for these three special types of parabolas, if we look at the direction of opening, the vertex, and the axis of symmetry, and then think about the effects that the values of $a$, $h$ and $k$ have on the parabolas. **What are the corresponding relationships?** Li?

[Review]

S: when $h$ is greater than 0, shift $h$ units to the left, we will have the parabola $y=a(x-h)^2$.

T: **what question did I ask you?** [Refocusing]

S: [silent]

T: **What I asked is, the direction of opening, vertex, and the axis of symmetry, the relationship between them and the values of $a$, $h$, and $k**. [Cueing]

S: the open directions [of the three parabolas] are all related to the value of $a$.

T: Yes, good.

S: then their...hum...

T: **What about the vertex?** [Cueing]

S: the vertex, their vertices are related to the value of $h$. The vertices are shifted $h$ units to the left or right.

T: **does it have to be left or right?** [Clarification]
S: Or, upwards or downwards.
T: So the vertex, it has coordinates. That is an ordered pair. What you have said is about its position. **Now, what if we look at its coordinates?**

S: y-coordinate, hum,
T: Okay. Please be seated. Let’s have a look at this.

In Episode 6-17, the teacher asked the student to recall the conclusions that had been achieved in the last few lessons and to put these conclusions together. At the beginning of this episode, the teacher specified the three aspects: the direction of opening, the vertex, and the axis of symmetry. But the student (Li) answered the question from the perspective of graph translation. Therefore the teacher interrupted this student’s talk and redirected the student to the right track. On the right track, the student described the direction of opening independently and then the vertex with the teacher’s assistance. Then the teacher asked a further question to request for the description of the parabolas’ vertices by looking at the coordinates. Although the student failed to give answers to the teacher’s last question, the teacher had made a lot of efforts in facilitating this student’s articulation of mathematical knowledge.

**Orchestrating sequence**

**Episode 6-18 Orchestrating sequence, CHN2-Lesson 3, 0:29:52-0:32:02**

![Table and Diagram]

Figure 6.23 Student’s drawing presented in teacher CHN2’s lesson 3

T: Okay, this is another one. This is Xu’s work. I wrote the comments “on-again-off-again”. The three graphs are separate here at the bottom but joined here at the top. **How do you think of this? Li?**
S: [Li] If they have any points of intersection, it means the two parabolas are identical.

T: The points of intersection means the two parabolas are identical? FQ: Clarification

S: [Li] Yes. But apparently, apparently, they are not identical.

T: What does that mean? FQ: Clarification

S: [Li] [silent]

T: Please sit down. Who else can explain this? Zhang?

S: [Zhang] These parabolas were obtained by the translations of one parabola. If there are any points of intersection, it will contradict with the property of graph translation.

T: What property is it? FQ: Clarification

S: [Zhang] The graph obtained by translation, for example, two straight lines obtained by translation, it is impossible for them to have points of intersection.

T: Don’t get away from my question. Who can help with this? Liu, can you help him to explain the property of graph translation? FQ: Supplement

S: [Liu] The property of graph translation, is, hum,

T: What is the relationship between the graph before the translation and the one after? FQ: Cueing

S: [Liu] The graphs are congruent.

T: The graphs are congruent, which means their shapes and sizes are? FQ: Elaboration

S: [Liu] The same.

T: Then is it possible for the two graphs to intersect with each other? FQ: Elaboration

S: [Liu] No.

T: OK. Please sit down.

In Episode 6-18, the teacher presented a student’s drawing to the whole class and requested students’ comments on the drawing. There were three students participating in the conversation. The first student (Li) pointed out that these parabolas could not go through the same point unless they coincided, but failed to provide more details to support this argument. Then the teacher requested other students to give comments. The second student (Zhang) stated the property of graph translation but could not articulate the reasoning quite fluently. Finally, the third student (Liu) was asked to contribute the discussion, and he completed the expression of the property of graph translation with the teacher’s facilitation. Here in this episode, all three students were given opportunities to express their won thinking, and the teacher’s responsibility was to orchestrate these students’ talk.

Episode 6-19 Orchestrating sequence, C HN2-Lesson 4, 0:27.57-0:30:01
Figure 6.24 Drawing task in teacher CHN2’s lesson 4

<table>
<thead>
<tr>
<th>$x$</th>
<th>...</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y = \frac{-1}{2}(x+1)^2$</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>$y = \frac{1}{2}(x-0)^2$</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Figure 6.25 Drawing Students Bao (left) and Fan (right) in teacher CHN2’s lesson 4

T: Now have a look Bao’s work. How about this? It looks different from Fan’s work. [Presenting both of the two students’ graphs]. Do you have any comments? [pointing to one student Wang].

S: [Wang] Fan extended her graph a bit more than Bao. So Fan’s graph looks longer than Bao’s.

T: Okay, a bit longer. [inviting one student to answer] Zhong?

S: [Zhong] I think Fan extended her graph but Bao did not.

T: [pointing to Bao’s graph] Could he extend the graph and make it the same as the graph of Fan?

S: [Zhong] Yes.

T: Why?

S: [Zhong] because parabola is a line of symmetry, we can draw the graph by finding points that are symmetric.

T: Is he correct?

Ss: Yes

T: Please be seated.
In Episode 6-19, two students’ graphs (Bao and Fan) were presented in public and the teacher asked the students to the two students’ graphs. In Bao’s work, some of the parabolas were not asymmetric, while all the parabolas drawn by Fan were symmetric. Actually in the task (see Figure 6.24), the values given for x were not distributed evenly about the axis of symmetry for either $y=\left(-\frac{1}{2}\right)(x-1)^2$ or $y=\left(-\frac{1}{2}\right)(x+1)^2$. In other words, the graphs of $y=\left(-\frac{1}{2}\right)(x-1)^2$ or $y=\left(-\frac{1}{2}\right)(x+1)^2$ were supposed to be asymmetric if students sketched and joined the points according to the given x values.

Two students were asked by the teacher to make verbal contributions in this conversation. The first student pointed out that Fan extended her graph into the symmetric shape and thus Fan’s graphs were longer. The teacher then asked for other alternative comments but received similar responses from the second student (Zhong). Then the teacher probed the second student’s thinking by asking a few follow-up questions and by doing so the teacher elicited a deeper statement about drawing parabolas. Here the teacher made efforts to allow more students’ voices to come up in the public talk and avoided directly telling the results to the whole class.

### 6.3.2.2 The closure of the exploration

Lesson 6 was concerned with the closure of the Exploration phase. The examples of the leading sequences and orchestrating sequences are separately shown in Episode 6-20 and Episode 6-21.

#### Leading sequences

**Episode 6-20 Leading sequence, CHN2-Lesson 6, 0:20:01-0:21:50**

T: *Now have a look, for the standard form [of the quadratic function], can we say the vertical shift is exclusively determined by the value of c?*

IQ: Evaluation

Ss: No.

T: *What is it [vertical shift] related to?*

FQ: Elaboration

Ss: a, b, c all matter.

T: *They all matter, don’t they?*

FQ: Agreement request

Ss: yes.

T: [pointing to the graph $y=ax^2+k$] *in this special form, what does b equal?*

FQ: Extension

Ss: 0

T: it is when b equals 0.
In Episode 6-20, the teacher asked whole class to think whether the value of c in the standard form of a quadratic function \(y=ax^2+bx+c\) determined the parabola’s vertical translation. By asking a sequence of questions, the teachers simply elicited a few short choral responses. The flow of the conversation was dominantly controlled by the teacher, and no opportunity was given to the students to articulate their thinking. Instead of allowing the students to independently summarise how the vertical translation of a parabola related to the corresponding equation of the quadratic function, the teacher divided the question into several sub-questions requesting short and quick answers.

**Orchestrating sequence**

*Episode 6-21 Orchestrating sequence, CHN2-Lesson 6, 0:32:36-0:36:48*

T: [to Liu] can we go deeper? What would it like if I draw the graph [using the values "...-3,-2,-1, 0, 1, 2, 3..."]? I can make the sketching grid big enough. **What would it like if I draw it?**

S: [Liu] it will extend towards this direction [the direction of top left].

T: **What will it be? Could it reveal the whole features of the graph?**

---

**Figure 6.26 Drawing task in teacher CHN2’s lesson 6**

**Figure 6.27 Student’s work on the drawing task in teacher CHN2’s lesson 6**
S: [Liu] yes, it could.
T: **it could, any different opinions?** [Inviting one student to answer]  
FQ: **Supplement**  
S: [Zhang] I don’t think it could. The equation could be transposed into $y=1/2(x-6)^2+3$, then we can get the coordinates of the vertex, and we can also get the axis of symmetry. But the axis of symmetry is the straight line $x=6$. There is no 6 in the given $x$ values, so there is no axis of symmetry in the drawn graph. Then the graph is meaningless.

T: Now have a look, there is no axis of symmetry. **Where are the given values of $x$ actually distributed?**

FQ: **Elaboration**

S: [Zhang] [silent]
T: in which side of 6?
FQ: **Cueing**

S: [Zhang] the left-hand side.

T: **Just imagine. What the graph will be?**

FQ: **Elaboration**

S: [Zhang] as $x$, $x$ increases, the value of $y$ is decreasing.
T: [to the class] isn’t it? **Then could it reveal the whole features of the parabola?**

FQ: **Elaboration**

Ss: No.
T: Please be seated. Very good.

In Episode 6-21, the teacher discussed with the students the selection of $x$ values when sketching the graph of $y=(1/2)(x-6)^2+3$. In the previous drawing tasks, $x$ values were always given as “…-3,-2,-1, 0, 1, 2, 3…” to assist the student to plot the corresponding points. But there was no clarification of why these values were selected for the sketching of the graphs. By contrast, when drawing the graph of $y=(1/2)(x-6)^2+3$, a set of the given values of $x$ were “3, 4, 5, 6, 7, 8, 9” which were different from those in the previous tasks. In this task, students were required to think what would happen if using the $x$ values “…-3,-2,-1, 0, 1, 2, 3…” to draw the parabola.

There were two students involved in this episode. The first student (Liu) clarified that the graph would be extended to the left since the set of values “…-3,-2,-1, 0, 1, 2, 3…” were located to the left of the values “3, 4, 5, 6, 7, 8, 9”. To elicit more details about the student’s thinking, the teacher asked him a follow-up question requesting whether different values would affect the visualisation of the parabola. The student did realise that the symmetry of the graph would be missing if the $x$ values changed. The teacher then requested for any alternative opinion from the rest of the class and the second student (Zhang) succeeded in hitting the key point. Then the teacher pushed the student further and elicited that the obtained graph using values “…-3,-2,-1, 0,
1, 2, 3…” would be only half of the parabola. In this episode, the teacher allowed the students to express their mathematical thinking by orchestrating the two students’ comments.

6.3.3 The Strategies lessons

The Strategies lessons (lessons 7 and 8) included how to find the equation of quadratic functions and how to use the connections between quadratic functions and quadratic equations to solve sophisticated tasks, most of which were the tasks in past high-stakes exams. The leading sequences and facilitating/probing sequences were observed with similar proportions in these two lessons. The orchestrating sequences represented about 30 percent of all IRF (multiple) sequences in lesson 7, and this proportion halved in lesson 8. The examples of leading sequences are shown in Episode 6-22 and Episode 6-23, followed by the examples of facilitating/probing sequences in Episode 6-24 and Episode 6-25. Then the Episode 6-26 and Episode 6-27 illustrate the examples of orchestrating sequences.

Leading sequences

Episode 6-22 Leading sequence, CHN2-Lesson 7, 0:34:40-0:36:33

<table>
<thead>
<tr>
<th>山东中考题</th>
<th>Past exam question</th>
</tr>
</thead>
<tbody>
<tr>
<td>抛物线 ( y = ax^2 + bx + c ), 经过点A (-2, 7), B (6, 7), C (3, -8), 则该抛物线上纵坐标为-8的另一点D的坐标是________.</td>
<td>( \text{The parabola } y = ax^2 + bx + c \text{ goes through the points A} (-2, 7), B(6, 7), C(3, -8). \text{ so the other point on the parabola where } y\text{-coordinate is -8 has coordinates } ( ). )</td>
</tr>
</tbody>
</table>

Figure 6.28 Example of past exam question in teacher CHN2’s lesson 7

T: \text{Okay, } \textbf{keep going [with your presentation]}

IQ: \text{Strategy}

S: \text{[Zhao] Then, we need to find the other point on the parabola where } y\text{-coordinate is -8. The point is the symmetric of it [point C] with respect to the straight line } x=2. \text{ The point is, the same } y\text{-coordinate, and } x\text{-coordinate is -1.}

T: \text{is it correct?}

FQ: \text{Agreement request}

Ss: \text{[silent]}

T: \text{think about this. The axis of symmetry is the straight line } x=2. \text{ Here the } x\text{-coordinate is 3. } \textbf{How far is it from the axis of symmetry?}

FQ: \text{Elaboration}

S: \text{[Zhao] 1}

T: \textbf{How far is the symmetric of it from the straight line } x=2?

FQ: \text{Elaboration}

S: \text{[Zhao] the distance between the symmetric and the straight line } x=2 \text{ is 1.}
In Episode 6-22, the teacher resumed a student’s (Zhao) presentation of his solutions to the past examinations question. The student roughly outlined his strategies about using the symmetry of the parabola to find the point D’s coordinates. Then the teacher requested for a choral agreement check but received no response, which reflected that the most of the student might not follow the student’s (Zhao) ideas. Rather than allowing Zhao to clarify more details about his strategies, the teacher asked a few follow-up questions requiring Zhao to fill up some blanks in these questions. Although the whole class got the point in Zhao’s strategies, the teacher did not provide much space for Zhao to independently articulate his ideas in a clearer way.

**Episode 6-23 Leading sequence, CHN2-Lesson 8, 0:31.25-0:32:05**

![Figure 6.29 Student’s solutions of one task (question 1) in teacher CHN2’s lesson 8](image)

In Episode 6-23, the teacher presented a student’s solution to the first question in the task which required the students to find the solutions of the quadratic equation graphically rather than
algebraically. From the solutions presented by the teacher, it could be seen that the student used the wrong method despite the correct results. Here in this episode, the teacher firstly asked the whole class whether the results were correct and then he requested for agreement on the statement about the method used in this student’s solution. In this episode, the teacher did not ask students to express their thinking about the presented solutions and the choral responses elicited by teacher questions were simply yes or no answers.

**Facilitating/probing sequences**

*Episode 6-24 Facilitating/probing sequence, CHN2-Lesson 7, 0:59:10-01:02:03*

![Figure 6.30 Teacher CHN2’s slide for a task in lesson 7](image)

T: **How do you interpret this part “the distance between these two intersection points is 4 units”?** [one student Liu hands up, and the teacher asks him to answer]  

S: [Liu] the distance between one of the two points and the line [axis of symmetry] is 2 units.  

T: Is he correct? This is four units. This is the axis of symmetry and this is two units. **What about the coordinates?**  

S: [Liu] I plus, since it moves forward by two units, 1 plus 2 gives us the intersection point with x-axis. The y-coordinate is 0. So it is 2, hum, 3, 0.  

T: **And the other one?**  

S: [Liu] the other one is 1 minus 2. It is -1, 0.  

T: **Is it on the left [hand side]?**  

S: [Liu] Yes.  

T: Please be seated.

In Episode 6-24, a student (Liu) volunteered to share his ideas about the presented task. He drew the connections between the distance of two x-intercepts and the distance of one x-intercept from the axis of symmetry, and thus found the coordinates of the two points. During the questioning sequences in this episode, the student was given opportunities to express his strategies fully and clearly.

*Episode 6-25 Facilitating/probing sequence, CHN2-Lesson 8, 0:32.10-0:33:05*
Figure 6.31 Student’s solutions of one task (question 2) in teacher CHN2’s lesson 8

In Episode 6-25, the teacher presented one student’s solutions to the task and asked the class for comments. Without receiving students’ responses, the teacher selected one student (Jiang) to share her thinking. Based on her initial responses, the teacher asked a few follow-up questions, allowing the student (Jiang) to gradually express her thinking independently. By answering the teacher’s question, the student needed to present her thinking clearly and completely rather than simply giving short answers.

**Orchestrating sequences**

**Episode 6-26 Orchestrating sequence, CHN2-Lesson 7, 01:03:30-01:06:29**

T: Now let’s look back. In this task, we should have set up the Cartesian coordinate system. It is a problem in the real world, so we should have set up the Cartesian coordinate system by ourselves. But the system is given. Why is it [the given Cartesian coordinate system] set up in this way? Shen?
S: [Shen] Because this is a real-world problem, it is impossible to have negative numbers in the system.

Because a company would like to build a water pool. A fountain jet is to be built in the centre of the water pool and it sprays water in a parabolic arc. The water spray is expected to reach a maximum height at a horizontal distance of 1 meter away from the centre of the water pool. The maximum height is expected to be 3 metres and the water should land 3 metres away from the centre of the water pool. Find the height of the fountain jet.

Solutions:
Set up a Cartesian coordinate system as shown

Figure 6.32 The application task in teacher CHN2’s lesson 7

T: Really? Now, in this task we assumed [the vertex is] 1, 3. Why did we can say this 1 is the x-coordinate, and this 3 is the y-coordinate?

S: [Shen] Because it says, the horizontal distance is 1 meters, and it is 3 meters when it reaches the highest. The vertex of the parabola is its maximum height. Therefore it is 1, 3.

T: So which is the Origin in this Cartesian coordinate system?

S: [Shen] [silent]

T: [to another student] Zhang?

S: [Zhang] hum, the water stream reaches the maximum height at a horizontal distance of 1 meter from the centre of the water pool. So the Origin is the centre of the water pool.

T: Is he correct?

Ss: Yes

T: Okay.

In Episode 6-26, the teacher asked the students to reflect on the construction of Cartesian coordinate systems in the application task. The first student (Shen) claimed that there should not be negative numbers since it was an application task, for which the teacher did not evaluate the correctness. Instead, the teacher further asked the student to think about the process in which the coordinates of the vertex were obtained and then pushed the student to consider what the origin was in that process. Having received no response from Shen, the teacher asked another student (Zhang) to make contributions and Zhang clearly pointed out the location of the origin. In this episode, the teacher orchestrated the two students’ talk so as to elicit a deeper understanding of how to construct the Cartesian coordinate system in the real-world context.
Episode 6-27 Orchestrating sequence, CHN2-Lesson 8, 0:43:31-0:44:30

In the following cases, if \( a > 0 \), where is the vertex of the parabola \( y = ax^2 + bx + c \)?

1. The equation \( ax^2 + bx + c = 0 \) has two distinct real solutions;
2. The equation \( ax^2 + bx + c = 0 \) has two same real solutions;
3. The equation \( ax^2 + bx + c = 0 \) does not have real solutions.

What if \( a < 0 \)

The position of the vertex determined the solutions of the quadratic equation. Is this consistent with quadratic discriminant? Justify your conclusion.

Figure 6.33 The link between quadratic functions and quadratic equations discussed in teacher CHN2’s lesson 8

T: Delta is greater than 0. Delta is \( b^2 - 4ac \), which is greater than 0. Are these two descriptions consistent? The first one is that y-coordinate of the vertex is less than 0. The second one is that \( b^2 - 4ac \) is greater than 0. Are these two descriptions consistent? Zhou?

S: [Zhou] they are inconsistent.

T: Why?

S: [Zhou] Because one is [saying] the equation has two distinct roots when [y-coordinate of the vertex] less than 0, and the other is saying is has two distinct roots when the delta is greater than 0.

T: Okay, please be seated. One is less than 0, and the other is greater than 0. Who else have different opinions? [one student (Zheng) hands up, and the teacher asks him to answer]

S: [Zheng] because...

T: first of all, is it consistent?

S: [Zheng] it is consistent.

T: Why?

S: [Zheng] Because here [when y-coordinate of the vertex is less than 0], [the value of] a is greater than 0, and then \( 4ac - b^2 \) over \( 4a \) is less than 0, we can have that \( 4ac - b^2 \) is less than 0. Therefore, \( b^2 - 4ac \) is greater than 0.

T: Is he correct?

Ss: Yes.

T: Good.

In Episode 6-27, the teacher asked the students to reflect on the consistencies between y-coordinate of the vertex of a quadratic function and the discriminant of the corresponding quadratic expression. The use of discriminant in determining the quadratic equations’ solutions had been discussed before this episode, and here the location of the vertex was related to the quadratic equations’ solutions. Two students were involved in the conversation. The first student (Zhou) argued that there were no consistencies, and then the teacher asked him to clarify the
reasons why he made such claims. Following this, the teacher requested supplementary comments and the second student (Zheng) gave a conclusion different from the first student (Zhou). And with the teacher’s assistance, the second student was able to articulate his thinking eventually. Here in this episode, the two students’ talk was orchestrated by the teacher and both of the students were given opportunities to express their mathematical thinking.

6.3.4 The Consolidation and Application lessons

The Consolidation and Application lessons (lesson 9) covered the comprehensive application of quadratic functions’ knowledge and skills in solving a variety of real-world problems. The facilitating/probing sequences constituted the majority of IRF (multiple) sequences, accounting for over 60 percent. For the remaining IRF (multiple) sequences, 30 percent was occupied by leading sequences and 10 percent by orchestrating sequences. The examples of facilitating/probing sequence and leading sequence are separately shown in Episode 6-28 and Episode 6-29.

Facilitating/probing sequences

Episode 6-28 Facilitating/probing sequence, CHN2-Lesson 9, 0:02:01-0:02:30

Suppose a farmer has 60 meters of fencing to enclose a rectangular field. The area of the rectangular field, \( S (\text{m}^2) \), varies according to the rectangle’s one side length, \( l (\text{m}) \). Find the expression for \( S \) in terms of \( l \) and specify the set of all possible values of \( l \).

Figure 6.34 The rectangular filed task in teacher CHN2’s lesson 9

T: [to Yang] What restrictions are there for the values of \( l \)?
S: [Yang] \( l \) is less than 30, and then greater than zero.
T: Why?
S: [Yang] Because the length could be 0, and it also could be 30. [But] If it is 30, then it [the rectangle] does not have a width. If it is 0, then it [the rectangle] does not have a length.
T: Is he correct?
Ss: Yes.
T: Okay. In other words, one side length is \( l \), and then this \( l \) should be greater than zero.

In Episode 6-28, the teacher asked the student (Yang) to consider the restrictions on the values of the side length, \( l \) and the expression of the area, \( S \) had been discussed before this
conversation. The student first stated his answers about the range of the values of l, which was followed by a teacher question asking for justification. Then the student explained the reasons why he thought the values of l should be limited within 0 and 30. In this episode, the teacher provided opportunities for the student to express his thinking.

**Leading sequences**

**Episode 6-29 Leading sequence, CHN2-Lesson 9, 0:45:11-0:45:30**

| T: | So why did I keep saying that we need to write down the restrictions of x values? Firstly let’s look at the summary section. Generally, which means in the general situation, the vertex of a parabola could be viewed as the highest or lowest point on the parabola. The corresponding quadratic function has maximum or minimum value \(4ac-b^2/4a\) when \(x = -b/2a\). Now let’s look back. In this task, we found the value of x, which is between 0 and 8. Does this guarantee that the graph could reach the vertex? |
| --- |
| IQ: Reflection |
| Ss: | [silent] |
| T: | What is the value for x when S is a maximum? |
| FQ: Cueing |
| Ss: | 4 |
| T: | So is the vertex between 0 and 8? |
| FQ: Elaboration |
| Ss: | Yes. |
| T: | OK |

In Episode 6-29, the teacher intended to emphasize the reasons why the restrictions of domain would matter in the maximum/minimum application problems. He went through the summary task and then asked the students to reflect on a task that had just been completed. In the prior task, the domain was restricted between 0 and 8, whereas the x-coordinate of the vertex was 4. So the teacher asked the whole class whether these restrictions would guarantee the maximum. Without receiving any responses from the students, the teacher started to ask several less challenging questions, eliciting short answers from the students. In this episode, the students only filled the blanks or responded yes or no to the teacher’s questions.
6.3.5 The Summarization lesson

In the Summarization lesson (lesson 10) of the whole unit, leading sequences occupied over 50 percent of the IRF (multiple) sequences and facilitating/probing sequences only accounted for 30 percent, whereas the remaining 20 percent were taken up by orchestrating sequences. The example of leading sequence and facilitating/probing sequence are separately shown in Episode 6-30 and Episode 6-31.

Leading sequences

Episode 6-30 Leading sequence, CHN2-Lesson 10, 0:20:01-0:20:30

T: [presenting one student’s work and asking another student, Wu, to give comments] Does this work?  

S: [Wu] No.  

T: This is the fact. [pointing to the solution being presented] Stop thinking about the vertex is (-1/2, -1/4). **If it is (1, 0), is (-1/2, -1/4) still the vertex?**  

Ss: No.

Figure 6.36 Student’s work on a true/false question in teacher CHN2’s lesson 10

T: it is not the vertex. **What would the graph be like?**  

Ss: open downwards.  

T: It just opens downwards.
In Episode 6-30, the teacher was talking about a true/false task in which only one of the two possible answers were given. It was a challenging task for some students since the function \( y = x^2 + x \) satisfied all the requirements given in the task and thereby some students forgot to examine whether this function was the only one satisfying the given requirements. Before this episode, the student (Wu) kept assuming the vertex was \((-1/2, -1/4)\) without realising the x-intercept could be either \((-1, 0)\) or \((1, 0)\). Thus the teacher presented a student’s work in which \( y = -1/3 x^2 + 1/3 x \) was obtained as another possible answer for the true/false task (see Figure 6.36). Then the teacher asked the student (Wu) whether this presented method worked for him. After receiving the student’s response, the teacher became a bit impatient and started a few questions to elicit short answers from the whole class. In this episode, the teacher did not provide opportunities for the student (Wu) to express his misconceptions or to stimulate a classroom discussion by requesting comments from the rest of the class. Although the choral responses from the rest of the class could reveal they did not have the same misconceptions as Wu, the learning opportunities for Wu were constrained.

**Facilitating/probing sequences**

*Episode 6-31 Facilitating/probing sequence, CHN2-Lesson 10, 0:39:16-0:40:00*

![Figure 6.37](image_url) Student’s work on a true/false question in teacher CHN2’s lesson 10

T: Okay, let us look at the next example. This is Li’s work. Who can help with her confusion? [wait a moment] **Li, by what we have discussed, could you solve yourself on your own?** [Q: Strategy]
Because the parabola open downwards, a is less than 0.

Then \(-\frac{b}{2a}\) is less than 0, so...

\(-\frac{b}{2a}\) is what?

\(-\frac{b}{2a}\) is greater than 0.

Why is it greater than 0? How come you are wavering between less than 0 and greater than 0? What is \(-\frac{b}{2a}\)?

its x-coordinate.

the x-coordinate of which?

[silent]

the x-coordinate of which?

The vertex

the vertex’s x-coordinate, or it can be interpreted as the axis of symmetry \(x=-\frac{b}{2a}\).

In Figure 6.37, the teacher presented a student’s (Li) work on a multiple-choice question in which the student made some calculations and labelled some information but failed to get the solution. Since this work had been done before the lesson, the teacher asked the student (Li) whether she could be able to find the solutions after the majority of the lesson had been delivered (the duration of this lesson was 43 minutes, and this episode occurred three minutes before the end of the lesson). In the beginning, the student (Li) correctly talked about the sign of a by looking at the parabola’s direction of opening. Then she stated his conclusions about the sign of \(-\frac{b}{2a}\), which was followed by the teacher’s question for clarification. Instead of providing more details to support her claim the student Li changed her conclusions about the sign of \(-\frac{b}{2a}\). Then the teacher started to facilitate her with the analysis of the meaning of \(-\frac{b}{2a}\) by asking a few questions. The teacher did not directly tell her the correct answer nor simply led her by asking yes or no questions. Instead, he pushed her to think further about the meaning of \(-\frac{b}{2a}\), aiming to elicit and develop more mathematical thinking from her.

6.3.6 Summary of teacher CHN2’s class

Overall, the purposes of IRF (multiple) sequences varied in the teacher CHN2’s unit of consecutive lessons, depending on the location of the lesson in the unit. For the Introduction lesson and the Exploration lessons, facilitating/probing sequences tended to be used in a higher proportion than other sequences. Meanwhile, the orchestrating sequences occupied a relatively larger proportion of IRF (multiple) sequences in the Introduction lesson and the Exploration lessons than those in other lessons. In contrast, in the Strategies lessons, the Consolidation and
Application lessons, and the Summarization lesson, leading sequences took up a substantial proportion of all IRF (multiple) sequences.

Besides, a typical feature for the orchestrating sequences in teacher CHN2’s class is that he tended to stimulate comments or discussion from the whole class by presenting students’ work and responding to various students’ voices so as to develop students’ thinking and understanding.

6.4 The class of teacher AUS1

It is presented in Figure 6.38 how teacher AUS1 used questioning strategies in the IRF (multiple) sequences across the six lessons. For example, in lesson one, there were a total number of 7 IRF (multiple) sequences, out of which facilitating/probing sequences occupied around 55 percent, and orchestrating sequences accounted for approximately 45 percent.

![Figure 6.38 The IRF (multiple) sequences in teacher AUS1’s class](image)

**Note:** F = Foundation lesson; I = Introduction lesson; S = Strategies lessons; C&A = Consolidation & application lesson.

In teacher AUS1’s class, facilitating/probing sequences were dominant in every lesson of the unit. In the **Foundation** lesson (lesson 1), the IRF (multiple) sequences consisted only of
facilitating/probing sequences and orchestrating sequences, each of which representing approximately 50 percent.

Then in the *Introduction* lesson (lesson 2) the majority of IRF (multiple) sequences were facilitating/probing sequences, which accounted for 80 percent. In the *Strategies* lessons (lesson 3 and 4), the facilitating/probing sequences still took up large percentages, but at the same time the proportions leading sequences grew substantially in lesson 4 and represented about 40 percent. In the *Consolidation and Application* lessons (lesson 5 and 7), facilitating/probing sequences took up around 60 percent while leading sequences and orchestrating sequences separately occupied 20 percent.

### 6.4.1 The Foundation lesson

The *Foundation* lesson (lesson 1) covered the knowledge of naming the sides in a right triangle. The facilitating/probing sequences and orchestrating sequences were almost used in equal proportions, and no leading sequences were observed. The example of facilitating/probing sequence is shown in Episode 6-32, and that of orchestrating sequence in Episode 6-33.

**Facilitating/probing sequences**

*Episode 6-32 Facilitating/probing sequence, AUS1-Lesson 01, 0:33:23-0:35:54*

**T:** *How do you know it's the hypotenuse, Amy?*

**S:** [Amy] because, because it's the longest

**T:** *how do you know that's the longest side?*

**S:** [Amy] it's the side that the angle, with the angle, not the straight side.

**T:** they're all straight sides

**S:** [Amy] I know, it's the side that like a different line, it's the side that's not straight.

**T:** *what do you mean by "the side is not straight", the side is not like that (horizontal forearm), or that (vertical forearm)?*

**S:** [Amy] did you, hum...

**T:** *they're all, they're all straight*  

**S:** [Amy] but this one just like, you see, it's like

**T:** we are not talking about horizontal and vertical, because what happens when they're not, none of them is horizontal or vertical

**S:** [Amy] did you, hum...

**T:** Ah, now, the way we, the way we tell it, it is the longest side, we know it's the longest side, Amy,
because it's the side that’s opposite the right angle.
Amy, see, that's on the other side of the right angle.

In Episode 6-32, the teacher was talking with Amy while the rest of the class were doing seatwork involving the naming of the sides of given right angled triangles. When the teacher walked by the student Amy, he asked Amy how she identified hypotenuse. The student expressed her strategy of identifying the hypotenuse, which was followed by the teacher’s further question for more details. Then the student did not provide more details about her strategy but tried to explain the feature of the hypotenuse in a different way. But the student failed again to articulate her argument in a proper way and started to guess the answer to respond to the teacher’s question. Then the teacher directly told her the correct way of identifying the hypotenuse. This was not the new knowledge since the teacher had gone through this during the whole class teaching. In this episode, although the teacher chose to tell the correct answer to the student, he actually made efforts to facilitate the student (Amy) to develop and express her thinking and understanding about the hypotenuse before the direct telling.

Orchestrating sequences

Episode 6-33 Orchestrating sequence, AUS1-Lesson 01, 0:18:44-0:19:44

T: Now, one last thing is to do with naming conventions. What do I mean by "conventions", Aron? What is a convention?
S: [Aron] Not sure.
T: Not sure? What's, what do I mean by convention?
S: [Pointing at John who puts his hand up]
T: [Pointing at John who puts his hand up]
S: [John] is it the sine, cosine and tangent?
T: No. We've not looked at those yet. We’ll look at those later in the week. What's the convention meaning? What's the word convention meaning?
S: [Daniel] party
T: Okay, oh yeah, could be a, like a par-, you say a party. Could be like a festival or something like that. That’s not what I mean by this. What I mean is, like a rule. A convention is, is maybe, a rule that’s usually followed. That's what I mean by that.

In Episode 6-33, the teacher asked the students to think about what would be covered in the lesson by interpreting the term “naming convention”. There are three students in this conversation. The first student was selected by the teacher, while the last two students joined the conversation proactively. There were some other students talking at that moment, but they were
not included since the teacher did not address to them. The first student (Aron) just said not sure, followed by the second student (John) who mentioned trigonometrical ratios. After the teacher had commented on the second student’s answer, the third student (Daniel) started to guess the answer without considering the mathematics. In case of leaving the conversation drifted away from mathematics, the teacher stopped the conversation and told the students the meaning of convention. Here in this episode, the teacher tried to engage various students and to orchestrate their talk.

6.4.2 The Introduction lesson

In the Introduction lesson (lesson 1), the teacher went through the three trigonometric ratios and demonstrated how to find these ratios in a right triangle. The facilitating/probing sequences accounted for the majority (80%) of the IRF (multiple) sequences while orchestrating sequences and leading sequences were seldom used. The example of a facilitating/probing sequence is presented in Episode 6-34.

Episode 0-1 Facilitating/probing sequence, AUS1-Lesson 02, 0:17:05-0:18:29

Figure 6.39 The three triangles drawn by teacher AUS1 in lesson 2

Figure 6.40 Student’s measurement and calculation in teacher AUS1’s lesson 2
T: [to Andy] what would you explain them not being the same?  
FQ: Explanation
S: [Andy] bad measurements
T: bad measurements. So what would be bad about your measurements?  
FQ: Clarification
S: [Andy] hum...
T: I mean you know how to use a ruler. So that is not you mismeasured. But what would have been, what would have been a better measurement?  
FQ: Cueing
S: [Andy] hum...
T: How could you’ve gotten a better answer for this? What would have been the example of a better answer? If this is a 5.7, what would be a better answer?  
FQ: Clarification
S: [Andy] hum...
T: Have a think about that

Before the conversation in this episode, students were required to draw a large triangle with a bottom of 15 centimetres and a flexible height. Then the bottom side was trisected, and two vertical line segments were added at the two trisection points. In this way, three triangles could be obtained (see Figure 6.39). Once the triangles had been drawn, the students were asked to measure the three side lengths and then to calculate the ratios of opposite/hypotenuse, adjacent/hypotenuse and opposite/adjacent with respect to the acute angle between the bottom side and the hypotenuse.

In this episode, the teacher was talking with one student about the ratios obtained from the three triangles, while the rest of the class were doing seatwork of measuring and calculation. Since three pairs of measurements would be obtained for the same type of ratio, there would be three results which were supposed to be the same. This was in the introduction lesson and the teacher did not tell the students the ratios should be the same for the three triangles, but the student Andy’s results were quite close if not exactly the same (see Figure 6.40). And Andy seemed to preview the trigonometric ratios, and he has the assumption that the ratios should have been the same. So when the teacher asked the student (Andy) for comments about his results, he responded with bad measurements, but could not provide more details to clarify his thinking. Then the teacher asked him to consider the issue from another point of view: what would be a better measurement. In this episode, the teacher pushed the student to reflect more on the process and results of the activity by asking a few follow-up questions. Although the student did not articulate very clearly what caused the differences in the results, the teacher provided opportunities for him to think and to develop his thinking.
6.4.3 The Strategies lessons

The Strategies lessons (lesson 3 and 4) involved using trigonometric ratios to find the unknown side lengths when angles were given and using inverse trigonometric functions to find the unknown angle sizes when side lengths were given. In lesson three, 80 percent of the IRF (multiple) sequences were facilitating/probing sequences, and this proportion dropped to around 50 percent in lesson four where leading sequences separately accounted for about 40 percent. The examples of facilitating sequences are shown in Episode 6-35 and Episode 6-36, and the examples of leading sequence are presented in Episode 6-37 and Episode 6-38.

Facilitating/probing sequences

Episode 6-35 Facilitating sequence, AUS1-Lesson 03, 0:14:07-0:15:39

![Figure 6.41 Teacher AUS1’s drawing of right triangle in lesson 3](image)

Figure 6.41 Teacher AUS1’s drawing of right triangle in lesson 3

T: If this is fifteen degrees, what’s the angle [the angle between the side 4 and 15.45] here? Julia? [Q: Review]
S: [Julia] Pardon?
T: If this is fifteen degrees, what it this angle here?
FQ: Repeat rephrase
S: [Julia] seventy five?
T: Yes, you name it, Jess.
S: [Julia] was it seventy-five?
T: how, why is it seventy-five, Jess? [Q: Justification]
S: [Julia] because in a triangle, all the angles sum up to a hundred and eighty degrees.
T: that’s right. That’s what’s left.

Episode 6-35 took place during a whole class instruction time, when the teacher was talking with one student in public. The teacher drew a triangle and specified two side lengths and one angle size. Then he asked about the size of the other acute angle and selected one student (Julia) to answer. The student (Julia) hesitated to respond with the answer “seventy-five”, which was followed by a follow-up question requesting justification. In this episode, with the facilitation by the teacher, the student (Julia) was given opportunities to express and elaborate her ideas.
In Episode 6-36, the teacher was engaged in a private exchange with a student while other students were doing seatwork. The student (James) got some trouble with making progress in this task the teacher gave him some direct explanation before the facilitating sequence as shown in this episode. Although the teacher asked the student basic mathematical operations, the student seemed to be still struggled with these operations. The teacher did not reveal the correct procedures to the student but facilitated the student to figure out and articulate the procedure on his own. In this episode, the teacher provided the student with opportunities to express his thinking, in which the student’s misconceptions were revealed and discussed, so that the student’s mathematics knowledge could be developed and consolidated.
**Leading sequences**

**Episode 6-37 Leading sequence, AUS1-Lesson 03, 0:09:01-0:10:06**

T: We must work it out by now. **Charles, did you get it?**

S: [Charles] No

T: **No, so** [pointing to a group of students]

Ss: [some students] eight point six, [some others] eight point five.

T: Well, **It's either eight point five, or eight point six.**

Ss: eight point six

T: [write down eight point six on the board]

In Episode 6-37, the teacher was talking in public with the student (Charles) and requesting final calculation result from the students. Without receiving the results from the student Charles, the teacher started to ask the whole class for answers. When more than one answer was proposed, the teacher replied that there should only be just one answer. In this episode, although the teacher addressed several students’ talk, the teacher was just requesting for the calculation results and did not push students to think further when more than two results were obtained from the students.

**Episode 6-38 Leading sequence, AUS1-Lesson 04, 0:02:21-0:02:46**

T: [to Ben] **how long is the bottom of my triangle?**

S: [Ben] [silent]

T: too slow. **Emily?**

S: [Emily] [silent]

T: **Just give me a length.**

S: [Emily] fifteen.

T: fifteen. [Label "15" on the bottom side of the triangle]

In Episode 6-38, the teacher was talking to the whole class and requesting values for the triangle. The teacher selected one student (Ben) who did not give any answer. And then the teacher selected another student who eventually gave a value for the side length of the triangle. Again, there were two students involved in this episode, but the teacher led them, aiming to elicit a number from the students. No opportunities were provided for students to express their thinking.
6.4.4 The Consolidation and Application lessons

In the Consolidation and Application lessons (lessons 5 and 7), angles of elevation and depression were introduced, and the relevant real-world tasks were discussed. Meanwhile, a tool of measurement, inclinometer, was constructed and used to measure the height of objects in the campus. Facilitating/probing sequences constituted the majority (60 percent) of the IRF (multiple) sequences, whereas orchestrating sequences and leading sequences separately represented about 20 percent. The example of facilitating/probing sequence is shown in Episode 6-39, and the example of an orchestrating sequence in Episode 6-40, followed by the example of a leading sequence in Episode 6-41.

Facilitating/probing sequences

Episode 6-39 Facilitating/probing sequence, AUS1-Lesson 07, 0:42:00-0:42:44

Figure 6.43 The worksheet used for height measurement in teacher AUS1’s lesson 7

<table>
<thead>
<tr>
<th>T:</th>
<th>so how did you work out the height here Laura?</th>
</tr>
</thead>
<tbody>
<tr>
<td>S:</td>
<td>[Laura] First step, I got this height</td>
</tr>
<tr>
<td>T:</td>
<td>you do.</td>
</tr>
<tr>
<td>S:</td>
<td>[Laura] the number is fifteen centimetres</td>
</tr>
<tr>
<td>T:</td>
<td>Good.</td>
</tr>
<tr>
<td>S:</td>
<td>[Laura] and then I get the formula,</td>
</tr>
<tr>
<td>T:</td>
<td>OK, which formula did you need to use?</td>
</tr>
<tr>
<td>S:</td>
<td>[Laura] tan</td>
</tr>
<tr>
<td>T:</td>
<td>tan</td>
</tr>
<tr>
<td>S:</td>
<td>[Laura] tan thirty</td>
</tr>
<tr>
<td>T:</td>
<td>OK</td>
</tr>
</tbody>
</table>
In Episode 6-39 the teacher was talking with a student (Laura) after she finished the out-of-classroom activity. The whole class was divided into groups of three students, and each group was required to measure three objects and then to document the measurements and complete the calculation in the worksheet (see Figure 6.43). Laura’s group had documented the measurements and came back to the classroom to finish the calculation. The teacher walked by her and asked her about details in her calculation. By asking questions, the teacher probed the student’s thinking and strategies in finding the heights of the objects. At the same time, the student was provided with opportunities to reveal and articulate her mathematical strategies.

**Orchestrating sequences**

*Episode 6-40 Orchestrating sequence, AUS1-Lesson 05, 0:00:37-0:03:20*

T: Okay, I want you to imagine, OK, that you’re scientists. You’re Antarctica, on a plane. What might the scientists be doing in a plane ***in Antarctica? You’re looking for whales, in fact, you want to count whales and find out where they are. You’re with me so far? Whales spotting. So you’re in a light plane, just a small plane, maybe eight, ten,***, looking at the window on the either left or right-hand side of the plane. Just looking for whales. You see one. Anyone wants to write down some information where you saw it. How far away from the plane you saw the whale? *How might we know, how might we work this out? Or what sort of information could we tell from the plane? What sort of information could we have from the plane?*

Q: Generation

S: [John] how high it is.

T: Okay, we might have the altitude. We call that, that is the word we use. We might have the altitude. [writing down “Altitude”]

S: [Lily] do we need to write this down?

T: Not this. You don’t need to write this down. You might have the altitude of the plane, or the height above the ground, or, sea [writing down “(Height)”next to “Altitude”]. So altitude is just another word for height. That’s height of something that’s flying in the air. *Points to another student* [Q: Supplement]

S: [Mark] speed

T: We might have the speed of the plane, but is that going to be too important to where the whale is? When we’re moving, we sort of want to take a measurement right now. Speed would be helpful if we want to take a measurement every minute. *Points to another student* [Q: Supplement]

S: [Andy] we can measure the distance between your distance and the whale.

T: *How do we do that? We get out a laser pointer and take a measurement?* [Q: Clarification]
S: [Andy] yeah
T: [points to another student] 
S: [Julia] the latitude of ....
T: We know where up the plane is. Is that the sort of what you mean? 
S: [Julia] yeah
T: Okay, so we can know where our plane is. We probably know that. [writing down “where is the plane?”] We can look that up on the GPS. What else can we tell from the plane about where the whale is? I’ve heard a bit, let’s hear from someone over here, [pointing to a group of students] if you fellows think about this.

Ss: [silent]
T: We are looking down, where is it? Is it over there, or over here? [Pointing to different directions] Where is it? 
S: [James] direction
T: direction, what sort of information about direction might we know? What sort of information about direction?

S: [James] North, south, east, west.
T: Okay, we could have a compass bearing. Okay, a bearing [writing down “bearing”], what else? Compass bearing only says north, south, east, west. What other directions does it take into account?

S: [Lucas] up and down
T: up and down. And when they’re calling that up and down, our angle of depression, [writing down “Angle of depression”] but we’ll get back to that.

In Episode 6-40, the teacher was talking with the whole class and asking for student’s input into his example. The teacher set a scenario of whales spotting plane and asked the student to brainstorm any information that could be possibly collected from the plane. There were many students making contributions to teacher’s question and the teacher normally asked a follow-up question to each student’s response for further clarification. In this episode, opportunities were given to many students to express their thinking and the teacher here created a very supporting and encouraging environment for students to join in the classroom interaction.

Leading sequences

Episode 6-41 Leading sequence, AUS1-Lesson 07, 0:09.39-0:10.03

T: [to Jason] what are the three things that we need to measure for every set of measurements we take? 
S: [Jason] The angle of elevation
In Episode 6-41, the teacher was talking with one student in public, while the rest of the class was listening to the conversation. The conversation occurred before the students went out of the classroom and measured the height of the objects in the campus and the teacher checked whether the student was clear about the task. The teacher had demonstrated what information should be collected at the beginning of the lesson and also handed out the worksheets (see Figure 6.43 and Episode 6-39) to every student. Here in this episode, the teacher selected one student to repeat the requirement of the task. In this process, the teacher asked two follow-up questions, but all these questions requested were just the repetition of what have been talked by the teacher several minutes before.

**6.4.5 Summary of teacher AUS1’s class**

The teacher AUS1 did not ask a large number of questions across the consecutive lessons in his class. However, when examining the IRF (multiple) sequences observed in his class, a majority of IRF (multiple) sequences consisted of the facilitating/probing sequences. And the predominance of facilitating/probing sequences was observed in every lesson of the teacher AUS1’s class. Besides, most of the facilitating/probing sequences occurred in private interaction when students were doing their seatwork. In contrast, orchestrating sequences and leading sequences normally appeared in a public interaction where the teacher was involved with whole class teaching.

There were some variations in the proportions of orchestrating sequences and leading sequences over the lessons. Orchestrating sequences occupied over 40 percent of the IRF (multiple) sequences in *Foundation* lesson (lesson one), while in the other lessons of the unit, the proportion was just around 15 percent. For leading sequences, it represented nearly 40 percent of the IRF (multiple) sequences in lesson 4, one of the *Strategies* lessons, whereas in the other lessons, the proportion was only around 20 percent. Nevertheless, since the total number of IRF
(multiple) sequences was quite small in teacher AUS1’s class, the variation regarding the proportion could only be a difference of 1 or 2 sequences. So generally speaking, it could be argued that the use of IRF (multiple) sequences in teacher AUS1’s class was relatively stable across the consecutive lessons.

### 6.5 The class of teacher AUS2

It is presented in Figure 6.44 how teacher AUS2 used questioning strategies in the IRF (multiple) sequences across the six lessons. For example, in lesson one, there were a total number of 51 IRF (multiple) sequences, out of which leading sequences represented over 22 percent, facilitating/probing sequences around 65 percent, and orchestrating sequences approximately 13 percent.

![Figure 6.44 The IRF (multiple) sequences in teacher AUS2’s class](image)

In the *Foundation* lessons (lessons 1, 2, and 4) and *Introduction* lesson (lesson 5), facilitating/probing sequences took up over 55 percent of all IRF (multiple) sequences while leading sequences and orchestrating sequences separately represented around 30 and 15 percent. The proportion of orchestrating sequences increased substantially to nearly 40 percent in the
Exploration lesson (lesson 6) where the proportion of facilitating/probing sequences dropped to about 30 percent. Meanwhile, the leading sequences occupied over 30 percent of all IRF (multiple) sequences in the Exploration lesson (lesson 6). This proportion of leading sequences stayed almost the same in the Strategies lesson (lesson 7) where the facilitating/probing sequences took up 60 percent of all IRF (multiple) sequences and orchestrating sequences occupied less than 10 percent.

6.5.1 The Foundation lessons

The Foundation lessons (lessons 1, 2, and 4) revisited the contents and applications of Pythagoras’ Theorem and the properties of similarity and congruence. The majority of the IRF (multiple) sequences were used in facilitating/probing purposes in all three lessons. Leading sequences took up over 20 percent of the IRF (multiple) sequences in lesson 1 and then increased by 10 percent in lesson 2 and 3. In contrast, orchestrating sequences occupied around 15 percent in all three lessons. The examples of facilitating/probing sequences are shown in Episode 6-42, Episode 6-43 and Episode 6-44, and the examples of leading sequences are presented in Episode 6-45 and Episode 6-46, followed by the examples of orchestrating sequences in Episode 6-47 and Episode 6-48.

Facilitating/probing sequences

Episode 6-42 Facilitating/probing sequence, AUS2-Lesson 02, 0:06:15-0:06:30

T: **have I answered this question?**
Ss: [mostly] No
T: **Why would people assume when they got there that they’ve answered the question? Very often when under the**
pressure, people will get this and yeah finish.

FQ: Extension

Ss: [mostly silent] [one student says] no more things like plus, [another one says] no more basic operation

T: Yeah, because there is no more basic operation if you’ve got on one term the other side.

In Episode 6-42, the teacher went through the procedures of calculating the hypotenuse in the right triangle. She stopped to ask student questions after writing down “35197=c^2” on the board. The teacher did not continue with the procedure of finding c. She instead asked a follow-up question requesting students’ talk on the common misconceptions. Here students were given opportunities to reflect on the misconceptions that typically occurred in tests or exercises.

Episode 6-43 Facilitating/probing sequence, AUS2-Lesson 02, 0:07:48-0:08:39,

Figure 6.46 The example and teacher board writing (2) in teacher AUS2’s lesson 2

T: [writes down the square root on the whiteboard]. Okay.

So what if I got a hundred and twenty-seven in that answer? [Q: Variation]

Ss: [mostly] silent; [one student, Mike says] wrong.

T: why is it wrong? [FQ: Justification]

S: [Mike] because it’s a hundred and eighty-seven.

T: yeah. But if you are doing this for the first time, you don’t know what the answer is. You get a hundred and twenty-seven as your answer. Why would you instantly know that’s wrong? [FQ: Refocusing]

Ss: [Mike] less than a hundred and forty-nine

T: good. Because a hundred and twenty-seven is less than a hundred and forty-nine. And that has to be bigger than a hundred and forty-nine. Okay? So make sure that you are checking with your answers that actually make any sense.

In Episode 6-43, the teacher has finished the task of finding hypotenuse in the right triangle. Subsequently, she asked one more question for the whole class to consider. Although the question seemed to be a normal yes/no question, the teacher intended to allow students to use
some sophisticated reasoning and to consider the relationships between the three side lengths. Most students did not get the teacher’s point of asking the question and kept silent after the question. Even for the one student (Mike) who responded to the teacher’s question, he simply stated the differences between the correct answer and the number given by the teacher in her question. Then the teacher adjusted her question and refocused the students so as to allow the students to think about the differences between the correct answer and the number given by the teacher. In this episode, the teacher provided students with opportunities to express their thinking and facilitated the students to think deeper.

*Episode 6-44 Facilitating/probing sequence, AUS2-Lesson 04, 0:50:09-0:50:43*

![Diagram](image)

*Figure 6.47 The online activity and questions before and after the activity in teacher AUS2’s lesson 4*

S: [Kevin] Does that match your definition above? What does that mean?

T: *Does this, what you’ve written here [post-activity question] match what’s in this question? It doesn’t have to be word for word.*

IQ: Evaluation

S: [Kevin] Yeah

T: *But these questions, do they all sort of fit into your definition?*

FQ: Clarification

S: [Kevin] Which?
like, *for instance, if we’re talking about similar shapes, have, and enlargement reduction of each other, does that mean that they have angles of the same size?*

**T:** *but have you said that [in your definition]?

**S:** [Kevin] No.

**T:** So maybe add that in.

**S:** [Kevin] Oh I see

In Episode 6-44, the teacher was talking with a student (Kevin) in private, while the rest of the class was using laptops to do seatwork, an interactive online activity (see Figure 6.47). On the student worksheet, there was one question separately before and after the online activity (see Figure 6.47). The student (Kevin) has answered the pre-activity question and went through the online activity, but felt confused with the post-activity question. So he asked the teacher for help and this constituted this Episode 6-44.

In this episode, the teacher did not provide the student with any straightforward answer. Rather, she rephrased the question from the online activity to help the student make sense of the post-activity question. After receiving a response from the student, the teacher further asked a follow-up question to check the student’s understanding. The student did not answer the teacher’s question but requested the teacher to clarify the question. Eventually, with the teacher’s assistance, the student made sense of the question and could continue with the following task. Here in this episode, the conversation was initiated by the student rather than the teacher. Although the teacher’s question were more like yes/no questions, she made efforts to avoid telling the correct answers to the student and what she did was to rephrase and adjust the questions so that the student could understand and then make progress. The student did not say a lot in her responses, but she indeed expressed her own thinking and confusions in the conversation, and most importantly her confusions got solved through the teacher’s facilitation.

**Leading sequences**

*Episode 6-45 Leading sequence, AUS2-Lesson 01, 0:10:50-0:11:30*

**T:** *So, out of a, b, and c, what does a, b and c mean, Sarah?*

**S:** [Sarah] A is one line, b is the other line. c is the hypotenuse.*
T: Okay. Can you give me a word that describes...? [draws two lines and then erases them] that’s not a right triangle. [then the teacher draws a right angle triangle] Can you give me a word that describes a and b in relation to the hypotenuse?  

FQ: Elaboration  
S: [Sarah] a and b are both connected to the right angle, the angle in the right-angled triangle. That would be a, the bottom one would be b.  

T: Yeah. But does it matter where a and b are?  

FQ: Clarification  
Ss: [Sarah silent], [some students say] No.  
T: No.

Before the conversation in Episode 6-45, the teacher had briefly reviewed the ancient Greek contributions in mathematics and elicited the expression of Pythagoras’ Theorem from the students. Here in this episode, the teacher was talking with the class about the meaning of the Pythagoras’ Theorem. At first, the teacher asked one student (Sarah) to explain the meaning of a, b, and c in the expression “\( a^2 + b^2 = c^2 \)”. And then the teacher requested the student to elaborate more on the relations among the three letters. Although the student (Sarah) provided very rich information in her answer, what the teacher asked the student to give was just one-word answer. In other words, most of the other students would simply respond with “shorter” which might be expected by the teacher. By requesting the student to give one word, the teacher actually constrained the students’ expressions of their thinking and reasoning. Besides, when the student (Sarah) specified the meaning of \( a \) and \( b \), she mistakenly thought \( b \) would have to be the bottom side of the triangle and \( a \) would have to be the other side connected to the right angle. To this mistake, the teacher did not further probe into the answer nor asked for supporting information. Instead, she simply asked a question to request for yes/no answer, which could once again limit the student’s expression of her thinking and reasoning.

Episodes 6-46 Leading sequence, AUS2-Lesson 02, 0:02:36-0:03:09

---

**Figure 6.48** The example and teacher board writing (3) in teacher AUS2’s lesson 2
T: So is everyone OK with how I got from the second line to the third line? Eyes up so you can see. Boys? Is everyone OK, Jasmine, with how I get from the second line to the third line? [Q: understanding checking]

Ss: [mostly silent] [some students say] yeah

T: where, where did the eighty come from?

FQ: Clarification

Ss: [silent]

T: where did the eighty come from? [to one student Jason] Where did it come from? FQ: Repeat/rephrase

Ss: [Jason] four squared plus six squared

T: yeah. Okay.

In Episode 6-46, the teacher was checking whether students followed her instruction after she had demonstrated part of the solutions. The teacher asked the question to the whole class, but only some students responded while others kept silent. Thus the teacher asked a follow-up question about the meaning of 80 in the calculation. Once again the teacher did not receive responses from the students, so she decided to select one student (Jason) who gave the correct answer. In this episode, the teacher’s question simply required the students to repeat the process of the calculation.

**Orchestrating sequences**

*Episode 6-47 Orchestrating sequence, AUS2-Lesson 01, 0:40:12-0:41:12*

![Teacher AUS2’s demonstrations on the board in lesson 1](image)

**Figure 6.49**

T: What doesn’t exist between twenty-five, one twenty-one and one forty-four, that does exist between nine, sixteen and twenty-five? [Q: Comparison]

S: [Richard] a connection

T: Which, what connection was that? FQ: Clarification

S: [Richard] Pythagoras

T: Good. Does a hundred twenty-one plus twenty-five equal one forty-four? FQ: Clarification
S: No
T: No. No. **So does that one conform with Pythagoras’ theorem?**
S: some students said “yes”, one student [Lucas] said “it’s very closer.”
T: [to Lucas] Yes. It is close. But what, which one of those would work that close to that? Shhh, Mike and Belly. **So there is one that is close to 5, 11, 12 that does work?**
S: [Bailey and Lucas]5,12,13
T: 5, 12, 13 does work.

Before the conversation in Episode 6-47, the teacher reviewed the Pythagoras’ Theorem and demonstrated that it worked in the triangle with side lengths of 3, 4 and 5 units. Then the teacher asked the student to consider whether the Pythagoras Theorem would work in the triangle with side lengths of 5, 11 and 12 units. She drew the triangle and the corresponding squares and then calculated the areas of those squares. The purpose of doing this was to demonstrate the test of whether Pythagoras’ Theorem applied to the triangle with side lengths of 5, 11 and 12.

In this episode, the teacher asked the student (Richard) to draw comparisons between the triangle with side lengths of 3, 4, 5 units and that with side lengths of 5, 11, and 12 units. After the student had given his response, the teacher asked him to clarify his claim. Then the second student (Lucas) joined the conversation and expressed his thinking, to which the teacher asked a further question to allow the students to develop the connections between the 5-11-12 triangle and the 5-12-13 triangle. In this episode, the teacher addressed the two students’ responses in public and both students were allowed to express their thinking.

**Episode 6-48 Orchestrating sequence, AUS2-Lesson 02, 0:08:41-0:10:21**

**Question 3**

a. Two points in the x-y plane have coordinates (2, 10) and (6, 2). Find the distance between them using Pythagoras’ Theorem
b. Using the same method to find the distance between the points (248, 897) and (562, 748) without plotting them.
c. What is the distance between points (x₁, y₁) and (x₂, y₂).

**Figure 6.50 The Pythagoras’ Theorem application task in teacher AUS2’s lesson 2**

T: So based on what you did in three (a) and three (b), how could we do three (c)? How could we do three (c)? So what is the distance between any two points, so x one and x., x one, y one and x two, y two? What is the distance between those… What does that even mean? **What does x one, y one even mean?**
[John] the power,  
T: No. what does that mean? Why are those numbers there?  
Where did the x one, y one come from?  
FQ: Supplement  
Ss: [James] “the lowest x size”  
T: Okay, so did anyone hear what James said?  
FQ: Agreement request  
S: [Alex] and me?  
T: No, not you. So what does that one and two signify? The little one and little two that I’ve drawn up here.  
FQ: Supplement  
S: [Alex] the lowest x size.  
T: No. what does that mean?  
FQ: Supplement  
S: [silent]  
T: guys, I want everyone’s eyes to be cornered on the x one, y one and x two y two that I just wrote on the board, everyone’s eyes, everyone’s eyes. Okay. Why are there the ones and twos there all of a sudden? What does that mean?  
FQ: Repeat/Rephrase  
S: [Alex says] the loss of x size.  
T: No. It doesn’t necessarily mean any loss of x size  
S: [Bob says] “x one [inaudible]”  
T: what does that mean? How many points am I drawing if I got that?  
FQ: Cueing  
Ss: [some students say] two, [others are silent]  
T: two. How do I know?  
FQ: Clarification  
S: [Karen] because there is x one.  
T: cause there is one, then there is two. So that x one and y one tells that y belongs to that x. So they go together. So the ones with the little ones on the bottom, they belong together, the one with twos.

In Episode 6-48, the teacher was talking with the students in public about the meaning of $x_1$ and $y_1$ in the third question of the task (see Figure 6.50). Many students made contributions to the conversation. At first, the teacher attempted to elicit the meaning of the pro-numerals in the task, but the first student (John) did not give the correct answer. Then the teacher kept requesting answers from the class. After the second student (James) gave his answer, the teacher would like to arouse the class’s attention, but that intention was interrupted by some other students’ talk. Then the teacher continued her attempts in requesting answers from the class, but it was still challenging for students to come up with more reasonable answers. Finally, the teacher gave some clues to the class to assist students’ thinking about the pro-numerals’ meaning. After the student (Karen) had given the answer, the teacher asked her for more details about her thinking. In the whole episode, the teacher allowed many students to make contributions and responded to these contributions. Although the teacher simply evaluated most of the students’ responses, she indeed attempted to focus more on the responses from James and Karen so as to develop the students’ thinking.
6.5.2 The Introduction lesson

The Introduction lesson (lesson 5) covered the history and definitions of the three trigonometric ratios. The facilitating/probing sequences took up over 50 percent of all the IRF (multiple) sequences, while the leading sequences represented nearly 40 percent and orchestrating sequences accounted for around 10 percent. The example of a facilitating/probing sequence is shown in Episode 6-49, followed by the example of leading sequence in Episode 6-50.

Facilitating/probing sequences

Episode 6-49 Facilitating/probing sequence, AUS2-Lesson 05, 0:11:40-0:12:03

T: Ok. Is there enough information, so the two lines and an angle, is there enough information so as to determine a triangle? What do I mean about that? [IQ: Strategy]

Ss: [silent]

T: All right. Let me ask it in another way. How many triangles can I draw from those two lines? [FQ: Repeat/Rephrase]

S: [Amy] one

T: Why one? [FQ: Justification]

S: [Amy] because we can only have one line between them [inaudible]

T: [labels O, A, B on the diagram] so what Amy says is that I can only really draw one rectangle, [connecting the two ends of the two lines] I can only draw one triangle, sorry, from that information.

In Episode 6-49, the teacher was talking with the whole class about the uniqueness of the triangle determined by two sides and one angle in between. The students did not give any response initially and then the teacher rephrased her question to assist with the students’ understanding of the question. When receiving the answer from the student Amy, the teacher further requested more details to support her claim. In this episode, during the sequence of teacher questioning, the student was given opportunities to articulate her own mathematical thinking.

Leading sequences

Episode 6-50 Leading sequence, AUS2-Lesson 05, 0:12:35-0:13:23
Figure 6.51 The teacher AUS2’s drawing in lesson 5

![30° triangle](image)

The teacher AUS2’s drawing in lesson 5

T: so I was given side, angle, side. [labels S, A, S on the triangle] Is side-angle-side enough information to determine a triangle? **What do you think I mean by “determine a triangle”?**

Ss: [silent]

T: **How many triangles could I draw from that information?**

Ss: one

T: One. When I say determine a triangle, I have actually said the [inaudible] for the triangle, there are no other triangles I can draw from that information. **Does that make sense?**

Ss: yeah.

T: excellent.

In Episode 6-50, the teacher was talking with the whole class, and she checked whether the students make sense of the mathematics language “determine a triangle”. Without receiving any responses from the whole class, the teacher changed her way of asking questions to assist students’ understanding of the question. However, the teacher did not provide more opportunities for students to express themselves before she told the class the correct answer. To the teacher’s questions, what the students needed to do was simply giving either one-word or yes/no response.

### 6.5.3 The Exploration lesson

The *Exploration* lesson (lesson 6) extended on and explored the trigonometric ratios on the basis of the introduction lesson (lesson 5). The orchestrating sequence took up almost 40 percent of all the IRF (multiple) sequences, which was much higher than that of any other lesson. In contrast, the proportion of facilitating sequences was less than 30 percent, while the proportion of the leading sequences stayed stable at 30 percent. The example of an orchestrating sequence is shown in Episode 6-51, followed by the example of leading sequence in Episode 6-52.
Orchestrating sequences

Episode 6-51 Orchestrating sequence, AUS2-Lesson 06, 0:33:57-0:34:52

<table>
<thead>
<tr>
<th>Angle size</th>
<th>Sine</th>
<th>Cosine</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.52 The task in Excel worksheet (1) in teacher AUS2’s lesson 6

T:  **Does it [sine] increase the same rate from zero to ninety?**  [Q: Comparison]
S:  [Hilary] What is sine?
T:  **What is sine?**  [FQ: Clarification]
S:  [Hilary] What does it quantify?
T:  Well, we will do that this afternoon. [to the whole class] waiting, five, four, three, boys. Okay, *if I was to say that the rate of increase is quicker between zero and forty than it is between fifty and ninety, would that be correct?*  [FQ: Refocusing]
S:  [Robert] no
T:  **What do you mean?**  [FQ: Clarification]
S:  [Robert] the same
T:  Is it?  **So if I were to draw a graph of sine, it would be...?**  [FQ: Clarification]
S:  [George] like that [using his hand to draw a rising straight line]
T:  **Would it be a straight line?**  [FQ: Clarification]
S:  [George] yes.
T:  Why don’t we check? [goes back to her laptop and try to present the graph in spread sheet]

In Episode 6-51, the teacher was talking with the whole class about the task in the Excel worksheet. Before the conversation here in this episode, the students had been working on the tasks using their laptops. The teacher was challenging the student to consider the rate of increase of the sine ratio as the relevant angle gets larger. When the teacher initiated her question at the beginning of the episode, what she received was not some possible answers, but a student’s (Hilary) question about the meaning of the sine ratio. The teacher did not get the student’s point until she clarified that with the student. Without giving an answer to the student’s (Hilary)
question, the conversation went back to the original question asked by the teacher. The student Robert proposed an answer arguing the rate of increase for the sine ratio would stay the same as the angle size increased. Then the teacher requested more details about Robert’s claim, which was followed by comments made by another student (George). Here in this episode, several students got involved in the interaction, and the teacher addressed each of the students’ voices, allowing them to express their own thinking.

**Leading sequences**

*Episode 6-52 Leading sequence, AUS2-Lesson 06, 0:32:58-0:33:55*

<table>
<thead>
<tr>
<th>Measurements of side lengths</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of your chosen angle</td>
<td>Dimensions of your opposite side</td>
</tr>
<tr>
<td>10</td>
<td>1.00</td>
</tr>
<tr>
<td>20</td>
<td>2.00</td>
</tr>
<tr>
<td>30</td>
<td>3.00</td>
</tr>
<tr>
<td>45</td>
<td>4.00</td>
</tr>
<tr>
<td>60</td>
<td>5.20</td>
</tr>
</tbody>
</table>

*Figure 6.53* The task in Excel worksheet (2) in teacher AUS2’s lesson 6

T: Yes yours is three decimal places. And yours are a bit more accurate than mine. **So what do we notice happens to those sine values?**

S: [Charles] they go up

T: **They go up as ...?**

Ss: [Charles] the angle increases

T: **As the angle size increases. Would everyone agree?**

Jessica?

S: [Jessica] yes

T: **Yes, what did Charles say?**

S: [Jessica] I agree

T: So don’t agree, because he might have said [inaudible]. **Okay, would you agree that as the angle increases, sine increases as well?**

S: [Jessica] yes

In Episode 6-52, the teacher was talking with the whole class about the variations of the sine values. At first, the teacher asked the class to describe the changes of sine values. When one student (Charles)’s responded, the teacher pushed him to add more details. Then the teacher requested for choral agreement and selected another student (Jessica) to express whether she agreed. In this episode, the teacher was leading the student to come up with short answers. Although the first student expressed his thinking in the beginning, in the following interaction he
only filled a couple of word to the teacher’s question. Besides, the second student was just asked to respond with yes or no answer.

6.5.4 The Strategies lesson

The Strategies lesson (lesson 7) covered some simple applications of the trigonometric ratios into finding unknown side lengths in the right triangle. The facilitating/probing sequences took up nearly 60 percent of all the IRF (multiple) sequences, while the leading sequences stabilised at 30 percent and very few IRF (multiple) sequences were used in orchestrating purposes. The example of a facilitating/probing sequence is presented in Episode 6-53, followed by the example of leading sequence in Episode 6-54.

Facilitating/probing sequences

Episode 6-53 Facilitating/probing sequence, AUS2-Lesson 07, 0:19:00-19.50

\[
\begin{align*}
25 &= \frac{100}{4} \\
4 &= \frac{100}{25} \\
25 \times 4 &= 100
\end{align*}
\]

Figure 6.54 The teacher AUS2’s board writing in lesson 7

T: Okay. **What has happened between the first and the second one?**  
IQ: Reflection

S: [Steven] They have swapped around

T: They have swapped around. **How’ve they swapped around?**  
FQ: Clarification

Ss: [Steven] Algebra.

T: Algebra. Yes, Algebra did it. **What steps in Algebra did we do in order to get from the first one to the second one?**  
FQ: Clarification

S: [Steven] times four

T: **Yeah. Say it again.**  
FQ: Reformulation request

S: [Steven] it times four

T: So I times four, both sides by four.

In Episode 6-53, the teacher talked with a student (Steven) in public and probed the student’s understanding of some calculation skills. At first, the teacher asked the student to reflect on and describe what happened from the first line to the second line of her boarding writing. After the
student had given the response, the teacher asked a few follow-up questions, facilitating the student with the articulation of his understanding, and the student Steven got opportunities in the interaction to express his thinking.

**Leading sequences**

*Episode 6-54 Leading sequence, AUS2-Lesson 07, 0:17:05-17:45*

T: It’s like a linear equation. It’s like an equation. Can you say that sentence using operations? *So if I want to say this sentence, [writing 6=12/2], I would say six equals twelve divided by two. What does that sentence say?*  
IQ: Variation  
S: [William] cos sixty…  
T: *Equals…?*  
IQ: Supplement  
S: [William] four divided…  
T: divided by x. Yeah?  
IQ: Agreement request  
S: yeah  
T: So four divided by x.

In Episode 6-54, the teacher was asking a student (William) in public to translate the algebraic expression into words, while other students were listening to the interaction. But the teacher did not allow the student to articulate this translation but kept asking questions and requesting the student to fill the blank in her questions. What the student responded were simply a couple of words instead of a full sentence.

**6.5.5 Summary of teacher AUS2’s class**

In teacher AUS2’s class, the use of IRF (multiple) sequences was relatively stable over the consecutive lessons, irrespective of the location of the lesson in the unit. All three kinds of IRF (multiple) sequences were observed in all lessons. And in each lesson, the majority of the IRF (multiple) sequences consisted of the facilitating/probing sequences, accounting for around 60 percent, while the leading sequences and orchestrating sequences stayed stable separately at 30 and 10 percent. The only exception was the exploration lesson where the orchestrating sequences represented almost 40 percent of the IRF (multiple) sequences, whereas the leading sequences and orchestrating sequences separately occupied 30 percent.
6.6 Summary

By looking at the used IRF (multiple) sequences over the consecutive lessons, some features regarding each teacher’s questioning strategies are observed and hereby summarized in this section.

For both the two Chinese teachers, the use of IRF (multiple) sequences tended to vary over the consecutive lessons, depending on the location and the pedagogical goals of the lesson. In contrast, in the class of the two Australian teachers, the use of IRF (multiple) sequences tended to stay stable over the consecutive lessons, less depending on the variations regarding the location and the pedagogical goals of the lessons. Besides, both teachers tended to use more IRF (multiple) sequences in facilitating/probing purposes than in any other purposes.

But distinct characteristics could also be found regarding each teacher’s preference in using IRF (multiple) sequences between the classes of the two Chinese teachers. For teacher CHN1, leading sequences are preferable in the Introduction, the Strategies lessons and the Summarization lessons, while more instances of facilitating/probing sequences, and orchestrating sequences were observed in the Consolidation and Application lessons. By contrast, in teacher CHN2’s lesson, facilitating/probing sequences tended to be preferably used in most of the lessons including the Introduction lesson, the Strategies lessons and the Consolidation and Application lessons, whereas the orchestrating sequences were more likely used in the Exploration lessons and the Strategies lessons than in other lessons. The leading sequences were predominantly used at the beginning of the Exploration lessons (lesson 2) and the Summarization lesson. Besides, when using orchestrating sequences, teacher CHN2 usually presented the students’ work as a stimulus to collect students’ various contributions and arouse classroom discussion, while teacher CHN1 normally presented a mathematical task and then requested different solutions or strategies.

Likewise, in the two Australian’s teachers’ classes, there were differences regarding the context of interactions where the facilitating/probing sequences were used. Teacher AUS1 tended to use the facilitating/probing sequences in private interaction with an individual student, while the teacher AUS2 were observed to have more public interactions when using the facilitating/probing sequences. Besides, teacher AUS1 used few leading sequences and
orchestrating sequences, while the proportion of leading sequences stayed at 30 percent in teacher AUS2’s class.
CHAPTER 7 DISCUSSION: VARIATIONS AND CONSISTENCIES

In this chapter, the results reported in Chapters 4 to 6 are explored by taking into consideration some related factors summarised from teachers’ responses in pre-topic and post-topic interviews. Meanwhile, cultural differences in mathematics teaching and planning between Chinese teachers and Australian teachers will also be considered to interpret the results. In particular, Section 7.1 and 7.2 separately focus on the variations and consistencies of questioning strategies emerged in the instruction of a sequence of lessons. Then Section 7.3 discusses the use of IRF (multiple) sequences by referring to the different cultural values which are associated with mathematics education in Australia and mainland China. This chapter ends with a summary section to conclude the main aspects of the whole chapter.

7.1 The variations in questioning strategies

As reported in Chapters 4 and 5, the variations regarding questioning strategies across the consecutive lessons include: (1) number/frequency of questions asked in each lesson; (2) the proportions of questions in IRF (multiple) sequences and the proportions of the questions in Q&A question pairs and IRF (single) sequences; and (3) the use of question types for initiation questions. In the following paragraphs, instructional tasks, tensions and challenges in mathematics classrooms will be offered as factors to interpret these variations noted above.

7.1.1 Factors related to variations in teacher questioning

7.1.1.1 Instructional tasks and classroom interaction

The way of using questioning strategies could be influenced by many factors, such as instructional styles, lesson topics, students’ capabilities, school year levels, etc (Walsh & Sattes, 2016). In this study, each teacher’s unit of consecutive lessons was designed around one common mathematics topic and for each teacher the instruction of the whole lesson sequence was delivered to the same group of students. Therefore, within the lesson sequence, the variations regarding the use of questioning strategies would not be due to differences in the perceived capabilities of different groups of students or to different school levels, and might be
more likely to be attributed to purposeful variation in the teachers’ instructional use of strategies, including their use of instructional tasks and activities.

Across a sequence of lessons, instructional tasks and activities designed by one mathematics teacher usually vary with respect to cognitive demand, context and representations required or employed in order to fulfil various instructional goals of different lessons. It has been reported that teacher-student interaction in mathematics classrooms is significantly shaped by instructional tasks and activities (Doyle, 1988; Henning, McKeny, Foley, & Balong, 2012; Hiebert, & Wearne, 1993; Larsen & Bartlo, 2009; Ni, Li, Zhou & Li, 2014; Stein & Lane, 1996). For example, the concurrence of changes in instructional tasks and classroom discourse was observed in the study conducted by Hiebert and Wearne (1993). They claimed that differences in the nature of instructional tasks could be associated with the length and sophistication of student responses in classroom discourse. Ni and her colleagues (2014) argued that there existed a complex relationship between mathematics classroom discourses (and thus, question types) and three features of instructional tasks, namely high cognitive demands, multiple representations, and multiple solution methods.

7.1.1.2 Tensions and challenges in mathematics classrooms

In the context of classrooms, tensions, or dilemmas, refer to strained state or conditions which usually result from different conflicting or even contradictory pedagogical or societal demands/expectations either originating from inside the classroom (e.g., students’ individual meaningful learning) or outside the classroom (e.g., external high-stakes examinations) (Berry, 2007; Fregola, 2011; Kennedy, 2006). It has been pointed out that the tensions involved in the teaching of mathematics are inevitable and frequently cannot be avoided, and thereby it has been advocated the tensions should be managed instead of attempting to resolve them (Fregola, 2011; Sherin, 2002).

Thus, teachers’ questioning strategies could be associated with their approaches to cope with tensions that emerged in their classroom instruction. For example, Sherin (2002) discussed the instructional changes of a mathematics teacher’s discursive practices when managing the pedagogical tensions between the intention of using students’ ideas as the basis for class discussion and the efforts to ensure that discussion is productive mathematically. As was pointed
out by Stein, et al. (2009, p.35), asking questions that encourage focused discussion is key for the teacher to necessarily direct students’ mathematics talk and discussion while avoiding over-control of classroom interactions. Therefore, the exploration of teachers’ strategies in tension management could help to understand teachers’ questioning practices in mathematics classrooms (Manouchehri & Goodman, 1998).

In the following paragraphs, the changes of instructional tasks and activities, as well as the tensions that emerged in the lesson sequence will be taken into consideration to interpret, in particular, the variations with respect to teacher questioning practices. For each participating teacher, the instructional objectives and tasks, and the potential tensions and challenges identified in teacher interviews will be firstly explored and summarised and then integrated for the purpose of interpreting teacher questioning strategies across the consecutive lessons.

7.1.2 Teacher CHN1

This section will outline teacher CHN1’s instructional objectives and tasks in the lesson sequence, and then the potential tensions and challenges that she needed to cope with. On the basis of these above two aspects (objectives and challenges), a discussion will be made to interpret the variations evident in teacher CHN1’s questioning practices.

7.1.2.1 Instructional objectives and tasks

The topic of the unit was “solving right-angled triangles and its applications”. Teacher CHN1’s teaching placed great emphasis on the selection and design of mathematical tasks and real-life contexts, by which students were expected to establish solid basis on strategies of solving right-angled triangles and oblique triangles, and to develop capabilities in solving real-life application problems. Meanwhile, the pressure of high-stakes examinations and limitation on the time available for curriculum delivery substantially influenced her preparation and implementation of classroom instruction.

In the pre-topic interview, for the question “What are your main objectives in teaching this topic? What do you hope that your students will learn about this topic?” teacher CHN1’s responses are as follows. From the teacher’s responses, the key objectives were the development of problem-solving capabilities either for pure mathematical problems or real-life problems.
The first is to make the students master the relations among sides and angles in the right-angled triangles. The students are expected to apply the Pythagorean Theorem and trigonometric ratios, to solve problems about right-angled triangles. The second one is about the triangles in general. We always start with solving right-angled triangles, but students are also expected to deal with problems involving oblique triangles, or quadrilaterals in which there are some special acute angles (such as 30°, 45°). Students are expected to transform these problems into the problems about solving right-angled triangles by constructing the perpendicular line. The third is get students familiar with such concepts as elevation angles, depression angles, slope and angle of an inclined plane, horizontal distance, and vertical distance in the context of measurements. By doing this, students are expected to understand the background of real-life problems and thereby transform the real-life problems to maths problems, which would help them find the solutions to the maths problems, and then the solutions to the real-life problems. The fourth is to help the students analyse the real-life contexts by applying the mathematical way of thinking, and then solve real-life problems in our society.

Mathematics tasks grew increasingly sophisticated across the lesson sequence since the later lessons in the sequence required a comprehensive application of the knowledge and skills covered in the earlier lessons. Compared with the early lessons, the tasks in the later lessons involved more real-life contexts. Meanwhile, the cognitive load of mathematical tasks increased across the lesson sequence.

These instructional objectives and tasks will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

7.1.2.2 Tensions and challenges

As a response to the pre-topic interview question “what challenges do you think you will [have to] cope with if you want to teach well?” the teacher CHN1 said,

The first is how to help students lay a solid basis in mathematics knowledge. The basic types of problems about solving right-angled triangles are of great
significance. The second is how to select, and design worked tasks as examples for the students. There are so many worked tasks for selection, but we cannot use them all, so we’d better select worked tasks very carefully. And by teaching with variations, students will better understand the problem-solving strategies and strengthen the connections among different problems. The third one is how to select authentic real-life contexts to allow students realise mathematics is important. We could not design some fake or unrealistic contexts simply for applying mathematics. Meanwhile, we should teach students how to transform the various real-life problems into maths problems. In some cases, despite the differences in the contexts, the involved basic mathematics model might be the same, so we need to help the students identify the same mathematical essence shared by seemingly different real-life problems.

In the three challenges, two of them involved the design of worked examples of mathematical problems and real-life problems. It could be inferred that the tasks and examples presented in classroom instruction were designed carefully and strategically. The teacher did not mention the challenges brought by the high-stakes examinations, which, however, were explicit in the post-topic interviews. In the responses to the question “in your teaching of this unit, did you make some significant decisions?” the teacher explained the impact of high-stakes examinations on instructional preparation and implementation.

*I think the most important one [impact] is that I added the content about how to solve the oblique triangles. In the textbook, there is not sufficient explanation on this part or maybe only one example. I spent a lot of time on the transformation from oblique triangles to right-angled triangles. To do this, I went through several worked examples and guided students to construct perpendicular lines. ...I think it is important to emphasise this part since there are some requirements in the high school entrance exam.*

Here “the oblique triangles” did not include all oblique triangles, but only those with special interior angles such as 30° and 45°. There was a lack of examples and elaborations on the oblique triangles in the textbook used by the teacher and the class. But the relevant knowledge was required in the high school entrance examination. Therefore solving non-right-angled
triangles was covered in lesson two of the unit. The influences of high-stakes examinations were elaborated further by teacher CHN1 when talking about the factors that exerted influence on her teaching. In the following quotes, teacher CHN1 talked about more details of the high-stakes examinations and the influences on her teaching.

This is the most important academic year for junior middle school students since this is the last year of their middle school and they are going to take the high school entrance exam. They are studying for the exams every day. [There are two semesters in this academic year] Before the high school entrance exams, there will be an examination in our school district at the end of the first semester and then in the second semester, we will have two district level trial exams as preparations for the high school entrance exams. These have all influenced my teaching plan and the actual teaching.

I believe the high school entrance exam is very important. Teachers will take them as an importance reference or guidance and students also take them seriously. For the students, this exam is an important way to assess them and finally prove them. As a matter of fact, we are quite clear that we should teach mathematics for the purpose of developing mathematics knowledge and thinking, but it is also important for students to prove themselves. They will continue their study and hope to go to their ideal high schools and universities. So its importance is very clear.

Certainly I have to follow the requirement of the high school entrance exam. When I designed the instructional tasks in this topic, I referred to the documents about the high school entrance exam and checked what level was required for this topic.

Here it is obvious that the requirements of high-stakes examinations had huge impact on the design of tasks used in classroom instruction. By saying “As a matter of fact, we are quite clear that we should teach mathematics for the purpose of developing mathematics knowledge and thinking, but it is also important for students to prove themselves”, the teacher made visible the tension between teaching for understanding and teaching for examination preparations.
By taking the examination requirements into consideration, a clearer picture could be obtained about the objectives of the lesson sequence and the challenges faced by the teacher. On the one hand, the teacher would have liked to develop students’ understanding and capabilities in solving right-angled triangles and application tasks. She would like to engage her students in mathematics learning and exploration by strategically designing representative tasks and examples with authentic real-life contexts. On the other hand, she ought to ensure students were well prepared for the high-stakes examinations. To this end, the teacher needed to get students familiar with examination-type tasks. In her classroom instruction, the teacher CHN1 had to cope with the tensions between the above two objectives, in addition to the three challenges mentioned previously.

As a result of the above tensions and challenges, the time limit was mentioned by the teacher. When asked, “The last question of our video recording is ‘Are there other factors that are vital to this chapter? If there are, how do they affect you besides teaching?” in the post-topic interview, the teacher said,

_I think the real-life application is very important in this topic. The textbook design in the real-life contexts is also good. Some well-designed outdoor activities are also provided in the textbook. But due to the limit in time and some other conditions, it is a pity that we didn’t organise outdoor activities for specific measurement investigations._

Here the teacher showed an inclination to skip some time-consuming mathematics investigations so as to save time for accomplishing other aspects of unit objectives, such as the practices and mastery of knowledge and skills for solving examination tasks.

In the post-topic interview, when answering the question “How to cater to the students’ differences?” teacher CHN1 said,

_For example, after they have finished the basic homework, I will give some difficult problems to good students while giving some extra basic exercises to poor students so as to consolidate their knowledge. However, there are some rather complicated cases. For example, if one student is not good at math, maybe he or she is not good at other subjects either. It will take him a lot of_
effort to allocate extra time on each subject. I feel that it will take a long time for them to have a change. Besides, some students are so hopeless that they have already given themselves up. They will not follow teachers’ advice. There are several such students in my class. It is really difficult to handle these situations.

To cope with students’ differences, the teacher mainly focused on how to design homework with various levels of cognitive load. Interview data suggest that the teacher mainly spent after-class time on dealing with the students’ differences, which suggests that there was almost no time for her to consider such issues during classroom instruction.

As a summary, the high school entrance examination is a huge concern in teacher CHN1’s class. However, instead of simply focusing on the preparation of students for the examinations, the teacher made efforts to strike a balance between cramming instruction for examination preparations and teaching for mathematical understanding.

These tensions and challenges will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

7.1.2.3 Variations in questioning strategies

Looking at the total number of questions, we could find that the teacher asked fewer and fewer questions as the instruction proceeded in the lesson sequence. However, by distinguishing initiation questions and follow-up questions, it could be seen that teacher CHN1 employed a strategic regulation process of asking particular types of questions over the unit of consecutive lessons.

In the lesson sequence taught by teacher CHN1, the complexity of contents covered in each lesson increased from pure triangle problems to real-life applications as the instruction proceeded in the unit. Due to the pressure of preparing students for high-stakes exams, teacher CHN1 had to cover a large amount of mathematical knowledge in a fast pace across the lesson sequence. As such, there was a very explicit tension between the fulfilment of pedagogical goals and time available for each lesson.

The teacher CHN1 would be able to complete the instructional content quite easily if she restricted her instruction solely to lecturing in the lessons. But she was making an effort to
engage students in classroom interaction and discussion, rather than leaving students simply sitting and listening. To some degree, the teacher CHN1 endeavoured to strike a balance between the accomplishment of lesson goals and the creation of opportunities for classroom interaction and discussion. The decrease across the lesson sequence in the number of questions asked per lesson (see Figure 4.5 in Chapter 4) might reflect, to some extent, the teacher CHN1’s efforts in maintaining the balance.

The teacher CHN1’s strategy was to pose questions to the whole class and then asked for choral responses, or strategically select students from the whole class to answer the questions. The choral responses tended to be relatively short. By requesting the choral responses, the teacher could implement formative assessment and thereby check the whole class’ understanding. But this could not provide enough opportunities for students to express sophisticated thinking which usually required extended teacher-student interaction. Due to the large class size, it was impossible for every student to express his or her mathematical thinking in public. Therefore, the teacher CHN1 usually strategically selected some students, and the interaction between the teacher and the selected student could function as representative of a key issue or difficulty with the individual student expressing mathematical thinking of the majority students.

In the class of the teacher CHN1, mathematical problems functioned as the platforms where new mathematical knowledge could be developed. Instead of demonstrating the strategies of solving these problems in a straightforward way, the teacher tended to select some students to express their thinking about how to solve the problems. In this process, students were given opportunities to articulate their thinking, and meanwhile, the teacher could also ask several follow-up questions to probe or facilitate students’ expression and construction of mathematical knowledge. Nevertheless, only some students could be selected to participate in such public interactions, but that did not mean the rest of the class could become inattentive. As a matter of fact, more students might be asked to join in the public interaction by supplementing or commenting on the current student’s thinking, which required the whole class to pay close attention to the details of the public interactions. In this way, the teacher strived to maintain the balance between constructing opportunities for students to express mathematical thinking and ensuring the accomplishment of lesson goals.
In the lesson sequence, with the development of mathematical knowledge, the mathematical content in each lesson grew more sophisticated across the unit. And this arguably brought a big challenge to teacher CHN1’s accomplishment of lesson goals. The total number of questions decreased substantially in the unit and this was true for both the number of initiation questions and follow-up questions. More time was used to deliver the mathematical content rather than teacher-student interactions. The proportion of questions used in IRF (multiple) sequences in relation to all questions dropped as well. It can be inferred that the teacher was less interested in promoting student constructed knowledge and more interested in student interpretation of teacher delivered knowledge. It was interesting to note that there was a relative stability in the ratio of follow-up questions to initiation questions in the IRF (multiple) sequences, suggesting that the teacher questioning style was maintained in this respect, although employed less frequently. In addition, a consistent proportion of the questions were used as the questions initiating the IRF (multiple) sequences.

In order to meet the pressure of time constraint on content delivery, the teacher had cut down the number of questions in the lessons, but on the other hand, she managed to use a regular proportion of all the questions to initiate the sustained conversations in which one initiation question tended to be followed by a consistent number of follow-up questions. To fulfil the goals of covering increasingly sophisticated mathematics content across the consecutive lessons, the teacher had to use more time in lecturing and demonstration. But she did not completely give up on the construction of opportunities for students’ expression. Instead, she strategically asked fewer questions, but consistently ensured using a regular proportion of these questions for extended conversations and continuously built upon students’ responses with follow-up questions, aiming to create as sufficient chances as possible to elicit students’ thinking over the consecutive lessons.

7.1.3 Teacher CHN2

This section will outline teacher CHN2’s instructional objectives and tasks in the lesson sequence, and then the potential tensions and challenges that he needed to cope with. On the basis of these above two aspects (objectives and challenges), a discussion will be made to interpret the variations evident in teacher CHN2’s questioning practices.
7.1.3.1 Instructional objectives and tasks

The topic of the unit was “quadratic functions” and teacher CHN2’s instruction focused on developing students’ understanding of quadratic functions, based on which the students were also expected to flexibly apply the knowledge of quadratic functions to solve various real-life problems. In the pre-topic interview, the teacher elaborated the objectives of the unit and his expectations in terms of students’ learning outcomes as follows:

One of my major objectives is to help students draw connections between quadratic functions and the previous functions such as linear functions and inversely proportional functions. I will try my best to introduce the new knowledge on the basis of old knowledge. The second is the development of combing algebraic representations with graphical representations. The graphs are very important in this topic. The integration of the above two representations will help students to explore and understand the quadratic functions in further depth.

Students are expected to master the basic concepts and knowledge of quadratic functions, and the relevant properties. Then students are expected to solve some sophisticated tasks with real-life contexts. We are closer to the final year of junior secondary school, so students are expected to solve some application tasks about quadratic functions. The key thing is applying the mathematics in a flexible way because some students study mathematics in a very inflexible way. The focus on the flexibility actually means the promotion of students’ mathematical capability.

Mathematics tasks grew increasingly sophisticated across the lesson sequence since the later lessons in the sequence required a comprehensive application of the knowledge and skills covered in the early lessons. In particular, the lessons in the phases of Strategies, Consolidation and Application, and Summarisation required a higher level of connection within mathematics and between mathematics and real-life problems. The cognitive load of mathematical tasks in the later lessons was higher than those in the early lessons.
These instructional objectives and tasks will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

7.1.3.2 Tensions and challenges

To the pre-topic interview question “What do you think are the challenges for the teacher in teaching this topic well?” the teacher CHN2 said,

One thing is about the students’ ideas that emerged during the instruction. Sometimes students come up with some seemingly immature ideas. But these ideas are actually their real thinking. It is sometimes very challenging to make preparation for what ideas the students will come up with.

The second one is about the instruction of solving real-life application tasks. The focus should not be how to tell the solutions to the students. But how should a teacher allow the students to explore the task solutions? Or how should a teacher guide the students to find the solutions? It is very challenging to deal with the middle step from ‘I have no ideas what to do’ to ‘I could have a try from here’, especially for the real-life application tasks.

It could be seen that teacher CHN2 valued students’ expression of their thinking and the students’ construction of a deep understanding of mathematical processes.

Regarding the implementation of classroom instruction, the teacher said,

In my class, I would like to make students’ thinking sufficiently visible and explicit. But the school usually specifies each lesson’s workload. I normally could not accomplish the workload. I focus more on making students’ thinking explicit in various ways. Due to the introduction of a new learning model in our school, students need to go through the self-learning guide before the lesson. This model allows me to have more time to focus on students’ thinking. Although it is impossible to allow every student to express his or her thinking in just 40 minutes, there are more opportunities to do this since the introduction of the new [teaching] model.

Regarding the influences of high-stakes examinations, the teacher said,
The exploration of mathematics allows students to have a deeper understanding, which is, in turn, helpful for examination preparation. This might be more effective than one or two lessons focusing on drilling practices of examination-type tasks. I used to use the model of ‘project-based learning’ which usually took a long time. While other teachers started the review and preparation for the exams, my class was still focusing on the project.

The only concern is a time limit. The students sometimes feel they don’t have enough time for examination preparation. Some investigation activities and ‘project-based learning’ impact on students. But students in my class are relatively more capable in mathematics, compared with their counterparts in our school.

Although examination was highly valued by both the teacher and the students, the teacher did not think the examination preparation represented a contradiction with teaching for mathematical understanding. Instead, he believed that students could not be well prepared for examinations without a sufficient and thorough understanding of mathematical knowledge. Because the students in teacher CHN2’s class were more capable in mathematics than those in other classes, the teacher felt more confident to focus on mathematical understanding without worrying that his students would fall behind and achieve lower scores than other students in the school.

In the post-topic interview, when answering the question “How to cater to the students’ differences?” the teacher CHN2 said,

For the group presentation, students in the selected group vary in their mathematical capabilities, but they all have a chance to present. When marking students’ self-learning guide, I usually pay more attention to those less capable students. When I walk around in the class, I tend to check the less capable students’ progress and give them some support or guidance if necessary.

For the homework, I usually ask those less capable students to come to my office and then I mark the homework in front of them to give some individual and immediate support to each of them. If too many students fall behind, I think it
will be impossible to have a good classroom environment for mathematics learning.

I always believe I will do what I could to help those less capable students to move forward. But I am not sure whether I can make it happen, and I don’t know the criteria to judge whether a student has the potential to move forward. Sometimes when I feel I could not do anything else to move the students forward, I will have to choose to give up. I have to make sure the majority of the class are making appropriate progress.

Here it can be seen there were quite limited opportunities during classroom instruction for the teacher CHN2 to cater to students’ differences. In the classroom instruction, the teacher ensured the average students’ demands were satisfied, and appropriate progress could be achieved by the average students. The selected group of students for public presentation consisted of only five or six students, which was a small proportion of all 46 students. Although the teacher paid more attention to the less capable students within the selected group, he did not have much time for the rest of the less capable students. During the group work time, the teacher usually walked around the class to check on students’ progress, but it appeared due to the large class size, he did not have sufficient time for every group.

By contrast, most of the teacher’s efforts occurred after class, directed towards addressing different students’ needs. The teacher would assign personalised homework for those less capable students to complete after class. He would also have one-to-one tutoring with those less capable students after class. But this could not be done during the mathematics instruction.

As a summary, the teacher could confidently manage the pressure resulting from time limit and examinations. Although he tried his best to cater to students’ differences, there were quite limited time and opportunities for the teacher to do this during classroom instruction. The major tension in teacher CHN2’s class is between teacher’s efforts to elicit students’ thinking and teacher’s efficient actions building upon students’ thinking so as to facilitate the construction of knowledge. Students’ expression of their thinking and understanding are quite helpful for students’ construction of mathematical knowledge. But students’ expression itself does not automatically make the knowledge construction happen efficiently, especially when many
students express various opinions that contain both correct and incorrect elements. On the top of students’ expression of mathematics, teachers’ strategic guidance and facilitation are also essential to students’ construction of mathematics.

These tensions and challenges will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

### 7.1.3.3 Variations in questioning strategies

In general, teacher CHN2 aimed to allow as many students as possible to express their mathematical thinking. To do this, he provided students with opportunities to have group discussions and public presentations which might then stimulate whole class discussion. But at the same time, the teacher needed to make sure that there was sufficient teacher guidance and sufficiently frequent summarisations so the students could construct a clear and systematic understanding of what had been discussed and achieved.

Teacher CHN2 tended to discuss mathematics knowledge and problem-solving skills in his class rather than directly demonstrating them via lecturing. In this way, he believed that students could have a deep understanding of mathematics, despite the risk of failure to cover the lesson goals specified by the school. Of course, the adoption of the new teaching model enabled the teacher to have sufficient time to prioritise classroom interaction and discussion.

In this lesson sequence, with the development of students’ knowledge in quadratic functions, the lesson topic grew more sophisticated and comprehensive. Instead of asking fewer questions to save time for lecturing, teacher CHN2 asked an increasing number of questions to keep students engaged in classroom interaction and discussion to get better mathematics understanding rather than simply generating a copy of teacher-delivered procedures.

Nevertheless, to understand the sophisticated lesson topic, more discussion was required to unpack the knowledge. On the other hand, there was also a greater need for higher requirements of necessary guidance and summarisation to ensure the efficiency of interaction and discussion got prominent along the lesson sequence. To strike a balance, the teacher used a smaller proportion of IRF (multiple) questions.
Indeed, the proportion of questions used in IRF (multiple) sequences in relation to all the questions dropped from a very high level in the exploration phase to a relatively low level in the phases of strategies, consolidation & application, and summarisation.

In the phase of exploration, a larger proportion of all the questions were used in IRF (multiple) conversations to discuss the concepts and properties. And the conversations tended to be longer than those in the following lessons in the phases of strategies, consolidation and application, and summarisation. The ratio of follow-up questions to initiation question was highest in lesson three which corresponded to the phase of exploration.

Also, in the phases of strategies, consolidation and summarisation, the teacher asked a larger number of questions to satisfy the need to use student ideas to consolidate the sophisticated knowledge. But he used a smaller proportion of IRF to save time for more guidance and summarisations, which were necessary for students to make sense of sophisticated mathematics knowledge. This represents a clear change in teacher questioning style in the later lessons.

In teacher CHN2’s lesson sequence, teacher questioning strategies were influenced substantially by the teacher’s balancing endeavour between allowing students to fully express their ideas in unstructured discussion and the need to strategically make use of students’ ideas to facilitate the construction of sophisticated mathematics knowledge.

7.1.4 Teacher AUS1

This section will outline teacher AUS1’s instructional objectives and tasks in the lesson sequence, and then the potential tensions and challenges that he might need to cope with. On the basis of these above two aspects (objectives and challenges), a discussion will be made to interpret the variations evident in teacher AUS1’s questioning practices.

7.1.4.1 Instructional objectives and tasks

The unit topic taught by the teacher AUS1 was trigonometry, mainly including trigonometric ratios and the applications of these ratios in contexts involving angles of elevation and depression. Outdoor measurement activities were organised in the last lesson of the unit. When talking about the unit objectives in the pre-topic interview, the teacher said,
... an understanding that ratios of side lengths of a triangle can be used to solve other pieces of information about a triangle and triangles frequently occur in problems, and how to approach finding unknowns in triangles using the trigonometric ratios.

If students don't get identifying the three sides of the triangle, then they can't do the rest of it essentially um and I did have one girl last year that never really got beyond that, ah, and that was it, but that would be an outlier I think.

The teacher AUS1 focused a lot on the basic knowledge and skills about trigonometric ratios. In the lesson sequence, there were some procedure-bound lessons, such as the foundation lesson and the strategies lessons in which the teacher focused a lot on showing the correct procedures of identifying sides and finding side length and angle size. But he also made great efforts to design various activities in which students could be engaged, and new mathematics knowledge could be developed and consolidated. For example, in lesson 2, students were asked to measure side ratios of three right-angled triangles which shared one acute angle in common. In lesson 7, students went out of the classroom and used the inclinometers to measure the height of the objects in the school campus. In the pre-topic interview, the teacher talked about the outdoor measurement activity,

...we go outside the school, so a bit of a walk around and then the students just in pairs or small groups ah I leave it up to them pretty much ah with their friends essentially to go and find the height of objects within the school by measuring the distance from the objects and using the inclinometer to measure the angle of elevation to the top. Well, the inclinometer is interesting, and it’s fun for the kids to do.

Mathematical tasks in the first four lessons involved mainly basic procedures and skills about trigonometric ratios and some simple applications related to triangles. In the phase of strategies, the mathematical tasks simply required students to practise the procedures of directly using trigonometric ratios to find unknown side lengths or angle sizes in right angled triangles. It was not until the last two lessons that any real-life context was involved. The second last lesson included several real-life problems involving angles of elevation and depression. There was one
comprehensive mathematical task in the last lesson and through the outdoor activity students needed to construct the connections between mathematics and real-life contexts. Overall, the mathematics tasks grew increasingly sophisticated, but the cognitive load did not increase to a great extent over the last two lessons (see Figure 4.3 in Chapter 4). Note that this is different from the cases of the two Chinese teachers we saw earlier.

These instructional objectives and tasks will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

### 7.1.4.2 Tensions and challenges

Very few challenges were mentioned by the teacher AUS1, who confidently designed and implemented classroom instruction in his class. When answering the question “Now what do you think the challenges are for you in teaching this subject as a teacher?” in the pre-topic interview, the teacher AUS1 said,

*Ah, I don't know, there aren't really any. I mean it's yeah I wouldn't say there aren't really any challenges.*

Similar opinions could also be found in his responses to the question “What were the key decisions you made during the teaching of this unit?” in the post-topic interview. Teacher AUS1 had said in reply,

*Well I don't know how much there was to decide really um, as for what is I mean it's not a huge unit of work really it's just teaching the three basic trig ratios and where they come from and how to apply them ah and that's not a huge scope really and ah so ah the students here pick up things pretty quickly so we went through it pretty fast and yeah I don't if there were any huge decisions that the whole thing leant on.*

When talking about the influences of exams on teaching and planning, teacher AUS1 said,

*Ah well, we have the semesterly exams are common exams um so that they're common assessment tasks across the whole year nine cohort. Ah so for that to work the year nines need to have done the same topics in semester one and then do the same topics in semester two, ah and so in that regard it affects what order*
we teach the topics in and we all need to do the same thing. But that's about it really.

For the NAPLAN test, might spend one or two lessons on it looking at some past papers. Just so that they've got a familiar with the kinds of question they're asked and the format how they need to answer it.

Teacher AUS1 mentioned that they didn’t have high-stakes examinations in the academic year of 9th grade. There were some school examinations which only affected the order of teaching various mathematics topics. The NAPLAN (National Assessment Program-Literacy and Numeracy) test is a nation-wide exam for all the Australian students in Years 3, 5, 7, 9. The Numeracy component in the NAPLAN test assesses the mathematics skills that are essential for students to progress in school life (NAPLAN, 2017). The assessment includes two types of items: multiple choice and constructed response. According to teacher AUS1’s responses, the NAPLAN test did not cause substantial pressure to his classroom teaching except dedicating two separate lessons to get students familiar with the test.

In the post-topic interview, when answering the question “How to cater to the students’ differences? ” teacher AUS1 said,

... certainly when I'm when the students are working, um typically I'll go around and speak with students about what they are doing like the work, questions anything that is not clear enough or doesn't seem to have been done correctly or just work on little things like the neatness of their diagrams ah and it's also an opportunity for students who need extra support to get extra support and ah usually ah there’s students in ah that class ah that need a bit of extra support so um students like Amy, Bella, Cathy, and Delia [pseudonyms] um need quite a bit of extra help. So I try to spend extra time.

During teacher AUS1’s classroom instruction, the teacher usually assigned seatwork to students before or after the whole classroom instruction. In the last lesson, the teacher had a very short period of whole class instruction, and then students went outside for measurement activities on the school campus, followed by calculation work in the classroom. The calculation work was done as individual seatwork, during which the teacher had a private talk with several different
students. The teacher AUS1 had enough time for a private talk with individual students when students were doing seatwork. Differences in students’ mathematics learning and understanding could be taken into consideration when the teacher provided this form of individual support to students during classroom instruction.

In summary, in teacher AUS1’s classroom instruction, few tensions and challenges were perceived or predicted in the teacher interview. He believed that he could plan and implement his teaching in a consistent way during the lesson sequence.

These tensions and challenges will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

7.1.4.3 Variations in questioning strategies

However, as in all other classrooms, teacher AUS1 did encounter various tensions and challenges, including unpredicted ones which would have just happened. It may be that the unpredictable student responses, or difficulties, are simply an assumed part of normal instruction for teacher AUS1 and so were not perceived by him as particularly challenging. In other words, then, questioning strategies in this teacher’s classroom instruction were still principally guided by the instructional objectives and tasks in each lesson and the variation introduced by different student responses could be seen (and was seen by the teacher) as a natural variation expected and accommodated with the teaching of every lesson.

On average, the teacher AUS1 asked a relatively small number of questions in all the lessons of the lesson sequence. But this average conceals the fact that the number of all questions asked by AUS1 teacher was very high in the introduction lesson and very low in the last lesson of the consolidation and application phase.

For the Introduction lesson, the teacher designed an activity for students to explore the trigonometric ratios before the whole class instruction. During and after the process of the activity, the teacher asked the students a lot of questions eliciting students’ thinking and reflection on the results that they obtained in the activity. Due to the exploratory nature of the activity, the teacher asked more questions in this lesson to elicit and facilitate students’ thinking than other lessons. Nearly sixty percent of these questions were used in the IRF (multiple)
sequences, in which every initiation question was followed by three follow-up questions. These statistics were also much higher than those in the other lessons.

For the last lesson of the *Consolidation and Application* phase, the whole class spent most of the time on the campus for measurement activities. For this reason, the teacher could not easily follow and check each group’s measurement work. After the measurement activity, the students went back to the classroom and focused on the calculation process. Although the teacher AUS1 asked questions of most of the student groups when they were working on the calculation process, the total number of questions were smaller compared with the other lessons. Nevertheless, it could be found that more than sixty percent of those questions asked in this activity-based lesson were used in the IRF (multiple) sequences, and this number was the highest among all the lessons in the lesson sequence. The students had experienced some similar real-life contexts in lesson 5, the first lesson of the consolidation and application phase. However, in lesson 7, students needed to collect the measurement themselves and then make use of the collected information to find the height of some building in the campus. Students were provided with a worksheet specifying the information that is needed to be collected, but there were no teacher demonstrations of how to do this. There was no clear teacher guidance about how to make use of the information to find the height they wanted. All the decisions had to be made by the students, which was quite different from the tasks or activities in the other lessons. Therefore, when the teacher asked questions to the students, he would then need to use extended conversations to elicit various students’ thinking. In the IRF (multiple) sequences, for every initiation question, the teacher usually asked two follow-up questions.

For the other lessons in the lesson sequence, the teacher usually introduced the lesson topics and then made demonstrations with worked examples, followed by student seatwork exercises. The total number of questions asked in each of these lessons was quite similar. Although the lesson topics were different among these lessons, instructional objectives and tasks were mainly related to procedure, especially for the strategies lessons and the first lesson in the consolidation and application phase. In these three lessons, the majority of the questions were used in Q&A question pairs and the IRF (single) sequences. Exploratory activity with minimum teacher guidance provides conditions conducive to more IRF (multiple) sequences.
7.1.5 Teacher AUS2

This section will outline teacher AUS2’s instructional objectives and tasks in the lesson sequence, and then the potential tensions and challenges that she needed to cope with. On the basis of these above two aspects (objectives and challenges), a discussion will be made to interpret the variations evident in teacher AUS2’s questioning practices.

7.1.5.1 Instructional objectives and tasks

The unit topic for the teacher AUS2 was Pythagoras Theorem and trigonometry. It was a unit with a mixture of revision with the extension of the previous knowledge and the introduction of new knowledge. In the pre-topic interview, teacher AUS2 mentioned that

*It will be a little bit revision, but a bit of extension, um into not just using the ratios, but also putting Pythagoras and trigonometry together in the unit circle. Um, that's my aim, I've again, these kids sometimes struggle with spatial reasoning, so I could adapt it as we go because they may struggle with that. Um, but that's the intent of the unit. Um, yeah, I think that's yeah, um, is that everything you need to know about the unit?*

The instructional objectives were introducing the trigonometric ratios and constructing connections among Pythagoras, similar triangles and basic trigonometric knowledge. As the response to the question about unit objectives, the teacher said,

*... What I, what I really like the kids to get a really good understanding of; how Pythagoras and trigonometry are linked through the unit circle. I really like them to understand the effects that changing the angle inside a triangle has on the sides around it, I think. Particularly when I started teaching trigonometry, when I first, very first started teaching, I just focus on the algorithm rather than the understanding, and I really like the kids to actually have, to be able to picture in their head what happens to a triangle as you change the angle, why is it that a shadow has different height in certain parts of the day, what is it about the angle that makes it happen. I'd like them to be confident with the algorithms, though; I still like them to have a facility with sine and inverse sine, in all three*
cases. Um, I'd like them also to, I've introduced them to surds already. I'd like them through using unit circle to be a bit more comfortable with using surds in certain applications. I'd also, I guess then the last one is to be able to apply in actual real life situations, particularly in three-dimensional situations with Pythagoras because that's something that I found they didn't do very well last year, so I've spent quite a bit time on geometry this year, so I am hoping that putting those two together will result in them being more spatially aware.”

These instructional objectives and tasks will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

7.1.5.2 Tensions and challenges

To the pre-topic interview question “What do you think are the challenges for the teacher in teaching this topic well?” teacher AUS2 said,

And, I think, also making sure that they've got enough, they've had enough opportunity to see the unit cycle, to construct unit cycles, to make, you know, be a unit cycle, to find, all these different ways of representing it. So that, by the end of it, they've all got their own way of, you know, whether it's we got a piece of string and we make a unit cycle or they have lots of practice drawing it, or we have a digital manipulative that we do it through investigation as long as they've got enough different ways of making sure that they can hit the understanding of how unit circle works. And how this circle is linked to a triangle. Why would we use Pythagoras to draw a cycle when Pythagoras is got to do with triangles, why, why they are the same thing. So, that would be. Just making sure that I make those links clear in a few different ways would be challenging.

Here in teacher AUS2’s classroom instruction, the challenging part was how to help students construct multiple representations within the trigonometry. The teacher focused on students’ deep understanding of mathematical knowledge and the connections, instead of the superficial and isolated knowledge of facts and procedure. But it was really challenging for her to achieve this within a limited period.
Besides, the integration of one-to-one laptop use in mathematics was also a new attempt in her classroom. Thus, the teacher had to make some efforts to adapt herself to the integration of new technology with mathematics instruction. Regarding the use of new technology, she said that,

_We also just started with the one to one notebook technology. So I need to make decisions about how I would use that, how I would get the kids to interact with that, and that is still something that I like to play with a little more in the unit because there is such a visual aspect to this, so hopefully, I'll, you know, be able to make some clear decisions on that as the unit progresses._

Due to each student’s use of a laptop in mathematics learning, the teacher changed her normal way of teaching mathematics. In the interview she said,

_... they need opportunities to feel confident, they need more opportunities to feel successful, more than the other classes that I've taught. So I'd like to break things up into little bits so that they get in the role and feel successful. So instead of having big investigations, which is my preferred way of doing things, letting them play with that, they get really frustrated with that, they get really angry, five minutes in, if they can't figure it out or they don't know what to do..._

_...So I tend to break up things into little chunks rather than having a big investigation, having the investigation made in little parts, letting them doing ten minutes, and then saying ok, this is where we should be, doing another ten minutes, ok, let's have a chat, this is where we should be, rather than saying here is two periods, see how you go._

According to the above responses, the teacher used to have big investigations as part of her classroom instruction but changed that into multiple small sections so that students could get immediate feedback before they got frustrated or distracted.

In relation to the influence of examinations on teaching and planning, the teacher said,

_... VCAA has put out an assessment program, and it got a few aspects to it, but there is an adaptive assessment package, so I'll give the kids, for instance, a year_
nine test, and it will give them five questions, and if they get three out of five wrong, it will, right, sorry, it will go up a level, if they got three out five wrong, they would go down a level, and it will keep doing that until it sorts out where roughly the child is for that area, so we do a number test, a space test, so that we can track over time how they are going in each of the dimensions, so we are trying to do that every six months just we can see how they are going.

... particularly based on their pre-test. I knew when we did similarity and congruence at the start of the year, they really really struggle with it, so I had their assessment from that unit test from the start of the year to base that, that’s why I spend a little bit of time going over it, and I know teachers may not traditionally spend too much time going over it, but it is, it is a key idea, in the appropriate, I felt the appropriate understanding of trigonometry, so I did want to spend more time on it. And so based on their assessment from the start of the year which is why I did it for the purpose of trigonometry, I found that really needs more time so I re-introduced it as well. So I did not do some specific pre-testing, but I used some, some results from their previous assessments in other areas to bring into this.

... NAPLAN would be a hell of a lot more important in my teaching if you got the results straight away. And one of the drawbacks, I think NAPLAN could actually be quite a useful thing if you got the diagnostic information straight back. ... we do give the kids a preparation before NAPLAN, more because we were finding, and I am sure almost every school protects our kids, but just really put off by the, particularly the literacy aspect of NAPLAN, and how you tackle problem-solving in a test situation. ... So regarding the tests of literacy and problem-solving aspects, we do spend quite a bit of time in seven and eight going through it. In my personal teaching, it would be I am trying to take from this, how do I perform under pressure, how do I show my understanding in situations that I am not really confident in, and so in terms of the actually teaching, what I am trying to focus on, but relate to NAPLAN, that’s it. If we could have the diagnostic information a lot earlier, I would use that a lot, by the time, we get the NAPLAN
in about six weeks. By the time that happens, I'll actually cover a lot in what was in NAPLAN, so then the information that was good from the teaching perspective as what could be, but from a coordinator perspective, I would use it quite differently.

Here teacher AUS2 viewed the examinations (including both school tests and national examinations) more like a collection of diagnostic information rather than simply an evaluation of students’ performance. Although the teacher mentioned she would provide the students with some lessons for examination preparations, she was not ‘teaching to the test’, but just for some techniques allowing students to get used to the examination style. In teacher AUS2’s classroom instruction, there were almost no tensions and challenges resulting from examinations, which means the teacher might have experienced less pressure from examinations when planning and using questioning strategies in classroom teaching.

In the post-topic interview, when answering the question “How to cater to the students’ differences? ” teacher AUS1 said,

... in terms of catering for individual differences, I probably haven't done that in the unit so far to a great extent. I have one or two cases, I think, knowing the kids well enough I know that they will be fairly confident with this material. It's when we extend a little bit further that I think I'll find the need to differentiate for individual needs a little bit more. And I think technology would be the easiest way to do that, to give them slightly modified tasks based on the same idea.

The teacher believed there were few individual differences to cope with unless teaching some extended more challenging content. Since the teacher had not planned to do too much extension teaching, almost no individual differences were taken into account when preparing her teaching.

In summary, during teacher AUS2’s classroom instruction, the main tensions and challenges were how to help students construct deep mathematics understanding in trigonometry and how to integrate the use of one-to-one laptop into mathematics teaching. Instead of the usual way of teaching which included big investigations, teacher AUS2 designed multiple small tasks to keep students engaged in mathematics learning.
These tensions and challenges will be revisited in the third part of this section to interpret teacher questioning practices across the consecutive lessons.

7.1.5.3 Variations in questioning strategies

How then did the instructional objectives and the challenges discussed in the above sections affect teacher AUS2’s use of questioning strategies in her lessons?

In the Foundation phase, the laptops were not very frequently used by the students in the first two lessons where the revision and extension of Pythagoras Theorem were covered. By contrast, in the last lesson of the foundation phase, activities were designed to be finished by students with laptops to revise the knowledge of congruence and similarity.

In the first two lessons of the Foundation phase, the teacher asked a lot of questions to check whether students still remember what they had learnt previously. For some common mistakes, the teacher guided the students to reconsider them by asking questions. Thus, a higher frequency of question posing was observed in these two early lessons, compared with the other lessons.

In the last lesson of the Foundation phase, some online activities were investigative and open-ended in nature and students were given a lot of time to work on the activities independently with their laptops. The teacher only asked questions to talk with students when students had some problems. The frequency of asking questions in this lesson was much lower than the first two lessons. But the IRF (multiple) sequences in this lesson lasted longer than those in the other lessons. For every initiation question, it was followed by more than 2.13 follow-up questions and this number was the highest throughout the lesson sequence. This phenomenon will be unpacked below.

In the Introduction lesson, the objective was to introduce the background and basic information about the trigonometric ratios. Student had few opportunities to use laptops in this lesson. A lot of time was spent on telling the students the history of trigonometry’s origin and development. Therefore, questions were less frequently asked in this lesson, compared with the other lessons.

In the Exploration lesson, activities were designed for students to complete using laptops. Instead of exploratory tasks, the activities in this lesson were more like calculation tasks in which
students were mainly required to calculate the values of trigonometric ratios in various right-angled triangles. It is worthwhile to mention that the activities in this lesson were quite different from those in the last lesson of the foundation phase, where the activities were online and immediate feedback could be provided as soon as students submitted their answers. To some extent, students could be engaged with those online activities even without teacher’s guidance. By contrast, the activities in the exploration lesson were given in an Excel worksheet and students were required to find the ratios and compare the values to summarise the trend of changes regarding sine ratios and cosine ratios. The teacher needed to ask questions more frequently to help students with errors and confusions they encountered during the activities so that students could not be easily frustrated or distracted. However, she also wanted to give students some more time to consider and explore the new knowledge, resulting in relatively less questions asked when compared to the first two lessons of the foundation phase.

In the Strategies lesson, laptops were not frequently used by the students and the teacher went through some worked examples via the whole class instruction. But different from the introduction lesson, teacher AUS2 talked about more mathematics knowledge and applications rather than historical facts as in the introduction lesson. Meanwhile, the teacher did not need to give students as much time for independent thought as had been the case in the exploration lessons. As a result, questions were asked more frequently by the teacher in the strategies lesson than in the introduction lesson and the exploration lesson.

However many questions were asked by the teacher in the lesson, the teacher tended to break down a comprehensive task into multiple small tasks, and thus fast-paced short conversations were observed more frequently in her classroom.

To guide and push students to have deeper thinking, the teacher asked a large number of questions (more than 100 in all the lessons of the teaching unit). But to avoid leaving students feeling frustrated and distracted, the teacher embedded a large proportion of all the questions in fast-paced short conversations. For all the lessons except lesson 2 in the phase of Foundation, regardless of how many questions were asked altogether, nearly half of the questions occurred in Q&A question pairs and IRF (single) sequences.
Likewise, the IRF (multiple) sequences in the teacher AUS2’s classroom tended to be relatively short. On average, in the IRF (multiple) sequences, there were fewer than 2 follow-up questions for every initiation question. This pattern of questioning is entirely consistent with the teacher’s stated adapted instructional practice, intended to accommodate the introduction of individual student laptops.

7.1.6 Summary

By looking at the instructional objectives, tasks and activities together with the possible tensions and challenges in classroom instruction, the variations regarding teacher questioning strategies were discussed in the above sections. These could help us understand better why each participating teacher’s use of questioning strategies varied across the lesson sequences. In other words, variations in teacher questioning strategies can be seen to reflect teachers’ responses to particular elements (constraints or influences) that were inevitably interwoven in mathematics instruction.

The use of IRF structure could help identify a further layer of teacher’s strategies in coping with the possible tensions and challenges. As pointed by Smith and Higgins (2006), the examination of questioning strategies in the IRF structure could help us better understand the intention behind questioning strategies. As discussed in the above sections, out of the total number of questions, the proportion of questions used in the IRF (multiple) sequences varied across the lesson sequences, and this appears to be a key indicator of teachers’ different ways of dealing with the possible tensions and challenges in their classroom instruction.

7.2 The consistencies in questioning strategies

As reported in Chapter 5, for each participating teacher, there were some consistencies regarding the use of questioning strategies across each lesson sequence. Here these consistencies are summarised as follows.

(1) The proportion of initiation questions in IRF (multiple) sequences out of all questions in each lesson stayed stable at about 20% for all four teachers.

(2) The ratio of follow-up questions to initiation questions in the IRF (multiple) sequences (the ratio was the number of follow-up questions divided by the number of initiation questions in
the IRF (multiple) sequences) stayed relatively stable at 2 over the consecutive lessons. That is, for each initiation question in the IRF (multiple) sequences, about 2 follow-up questions were posed.

(3) The use of subcategories for follow-up questions over the lesson sequence keep consistent over the lesson sequence:

- Teacher CHN1: Clarification, Supplement, and Cueing questions;
- Teacher CHN2: Agreement request, Clarification, Elaboration, Cueing, Justification and Refocusing questions;
- Teacher AUS1: Clarification, Supplement, Cueing and Repeat/rephrase questions;
- Teacher AUS2: Clarification, Cueing and Repeat/rephrase, Supplement, Refocusing and Agreement request questions.

It could be argued, to some extent, that habitual strategies emerged in each participating teacher’s questioning practices over the lessons in the teaching unit. These habitual strategies could be interpreted by considering the theory of habitus (Belland, 2009; Bourdieu, 1979; Zevenbergen, 2006) and the values in teaching (Baba, Iwasaki, Ueda & Date, 2012; Bishop, 2008; Seah, 2008). In the following discussion, I will explore the relative merits of applying each of these two theoretical lenses.

In this study, for all four participating teachers, regardless of the differences in their cultural background, some aspects of the questioning practices (i.e., the proportion of initiation questions in IRF (multiple) sequences out of all questions, and the use of subcategories for follow-up questions) were observed consistently. Given the existence of those observed variations discussed in the last section, the emerging consistencies across the lesson sequences obviously can be interpreted as mirroring each teacher’s habitus in using questioning strategies. All the participating teachers in this study are considered to be competent teachers by local criteria and each of them had many years of teaching experiences at the time when data were collected. During their past experiences of using questioning strategies, some habitual actions were developed over time by these mathematics teachers.
The observed consistencies also reflected the implicit values held by the participating teachers. Given the apparent internal coherence of each teacher’s rationale regarding what constitute a challenge and how it might be addressed, it can be argued that, in the past years of teaching practices, the participating teachers had internalised, consciously or unconsciously, what they valued with regards to thinking about and using questioning strategies in classroom practices. These valuing could be about the influences of various questioning strategies on students’ construction of mathematical knowledge, or about the balance between students’ expression of mathematical thinking and the accomplishment of lesson objectives, for example. By looking at the initiation questions and follow-up questions asked by the teachers in one whole unit of consecutive lessons, the consistencies regarding teacher questioning strategies and the values that were driving these could be made visible.

7.3 Culturally-informed employment of IRF (multiple) sequences

As reported in Chapter 6, some cultural specialities were identified in the purposes of IRF (multiple) sequences used by the participating teachers. For the two Chinese mathematics teachers, the usages of three different types of IRF (multiple) sequence varied across the consecutive lessons, but overall each teacher displayed a characteristic proportion of each type of IRF (multiple) sequences across the whole unit of consecutive lessons. Looking at each isolated lessons within the teaching sequence, the two Chinese teachers had different inclinations regarding the purposes of using IRF (multiple) sequences, but from the perspective of the whole teaching unit, the three types of IRF (multiple) sequences (i.e., Leading, Facilitating/probing, and Orchestrating) were distributed within the teaching sequence consistent with the teacher’s characteristic proportions. By contrast, for the two Australian mathematics teachers, the systematic arrangement of distributing the three types of IRF (multiple) sequences could be found in each lesson within the teaching sequence.

This cultural speciality could be attributed to teachers’ different ways of planning and preparing mathematics instruction in mainland China and Australia.

In mainland China there is a tradition of collective lesson planning meeting weekly in which mathematics teachers at the same grade level collaboratively prepare and design the lessons to be taught (Fan, Miao & Mok, 2015; Li, Qi & Wang, 2012; Lim, 2007). Compared with teachers in
western cultural settings like the US, Chinese teachers’ mathematics lesson planning focused more on the connections among lessons within one whole unit (An, 2008). The existence of the weekly collective lesson planning allows mathematics teachers in China to not only think and design just one mathematics lesson, but a sequence of lessons in the following days before the next weekly lesson planning meeting. Therefore, in the minds of Chinese mathematics teachers, one mathematics lesson is not isolated but always connected to other lessons. In particular, when planning for the instruction of a unit of several lessons, the Chinese mathematics teachers usually design these lessons as a whole before breaking the whole unit to several connected lessons.

Besides, instructional coherence within one single lesson and across lessons in Chinese mathematics teaching have been reported and discussed extensively by many researchers (Cai, Ding & Wang, 2014; Chen & Li, 2010; Mok, 2012; Wang, Cai & Hwang, 2015). Chen and Li (2010) examined a sequence of consecutive lessons taught by a Chinese mathematics teacher and found that the teacher designed the four lessons strategically and coherently around one mathematics topic and each lesson within the teaching sequence separately focused on one particular aspect of the mathematics topic. Wang, Cai and Hwang (2015) pointed out that the accomplishment of instructional coherence in Chinese mathematics classrooms requires both strategic lesson planning and strategic instruction, the latter of which might involve teachers’ spontaneous decision making and flexible adjustment of the lesson plans. To help students to interpret the content connections and thematic coherence, the teachers also need to use a variety of discourse management strategies, each of which serves different purposes supporting the instructional coherence. Therefore, in the sequence of consecutive lessons, Chinese mathematics teachers’ instruction might lay particular emphasis on different discourse strategies in different lessons.

By contrast, for Australian teachers, lesson planning and preparations are normally completed by teachers on their own with less collaboration among teachers. Meanwhile, compared with Chinese mathematics teacher who always prioritise the coherence of content high above all the other issues in classroom instruction (Bryan et al, 2007; Cai, Ding & Wang, 2014; Chen & Li, 2010), the Australian mathematics teachers valued the organisation of activities and teacher-student interactions much more highly than other objectives. Some researchers (Bryan et al, 2007) found that the Australian teachers did not pay specific attention to content coherence as
a criterion of an effective lesson, but only stated that an effective lesson should have clear objectives in this regard. As reported by Bryan et al (2007), Australian teachers considered the knowledge of students and the understanding of students’ demands as the key to being an effective teacher, which thereby resulted in less structured but flexible mathematics instruction aimed at accommodating students’ needs. Therefore, in Australian mathematics lessons, a large amount of time was observed to be spent on teacher-student interaction (Hiebert et al, 2003). In addition, it was also found that Australian mathematics teachers value the cultivation of students’ interest through some activities or questions since they believed that students’ engagement could be extended once they felt interested in the lesson at the very beginning (Bryan et al, 2007). Sometimes the chosen activities and questions used to stimulate students’ interest did not even have to be connected with the particular topic of the lesson.

In this study, the two Chinese mathematics teachers’ use of three types of IRF (multiple) sequences (i.e., Leading, Facilitating/probing, and Orchestrating) showed distinct features in different lessons within their teaching sequences. To some extent, this reflects each teacher’s unique design and implementation of mathematics lessons in a sequence of instruction for one mathematics topic. Both teachers placed substantial emphasis on the lesson content. The teaching sequence was considered as a whole unit by the two Chinese mathematics teachers and within the sequence, each lesson was designed to address one particular aspect of the unit topic. To accomplish the instructional coherence among these consecutive lessons, IRF (multiple) sequences were used as a tool in different ways in different lessons.

In contrast, for each of the two Australian teachers, the three types of IRF (multiple) sequences were used in almost the same way across the lessons in the teaching sequence. To some extent, this result mirrors the two teachers’ consistent strategies in designing and teaching mathematics lessons over the sequence. The two Australian teachers placed high emphasis on both students’ demands and lesson content. Due to the differences in lesson topics, the number of all questions used in each individual lesson changed from one lesson to another. However, the use of IRF (multiple) sequences remained stable and the opportunities for students to express their thinking were provided in a consistent manner across all the lessons. Instead of pursuing the balanced use of IRF (multiple) sequences within the whole sequence, where some particular type
of IRF (multiple) sequences might be preferred in some lessons, the two Australian teachers tended to maintain a balanced use of IRF (multiple) sequence within each lesson.

### 7.4 Summary

In this current study, video records of a consecutive sequence of lessons taught by four participating mathematics teachers were collected. The questioning practices across the consecutive lessons were identified and categorised by using a coding system featured with the distinction of initiation questions and follow-up questions. Meanwhile, for each teacher a further analysis was conducted of the observed employment of IRF questioning sequences across consecutive lessons.

Analysis of the data collected suggests that across the professional practice of the four teachers, two each in mainland China and in Australia, similarities and differences in the ways in which teachers employ questioning strategies were observed. The differences regarding questioning strategies across the consecutive lessons include: (1) the number/frequency of questions asked in each lesson; (2) the proportions of questions in IRF (multiple) sequences and the proportions of the questions in Q&A question pairs and IRF (single) sequences; (3) the use of question types for initiation questions. And the similarities are as follows: (1) the proportion of initiation questions in IRF (multiple) sequences out of all questions in each lesson; (2) the use of subcategories for follow-up questions in each lesson.

What appears to emerge is the proposition that regardless of the cultural location of the classroom, teachers’ questioning strategy choice is rationally made based on such considerations as the nature of instructional tasks and the nature of the challenges facing the teachers at the time. As we saw in Sections 7.1 and 7.2, those instructional tasks within a unit of consecutive lessons include introduction of unit topics, demonstration or exploration of problem solving strategies, the consolidation of concepts and strategies, and the review/summary of the whole unit, and so on. The tensions and challenges might involve time limit and overemphasis on procedure fluency caused by high-stakes examinations, the demands of catering to students’ individual differences, coherent delivery and explanation of sophisticated mathematics, introduction of new technology and so on.
Similarly, as we saw in the case of the use of the three kinds of IRF (multiple) sequences, the nature of teacher lesson planning – collaborative institutionalised in the case of mainland China, and individually undertaken in the case of Australia – affects how teachers make use of questions in class. Yet, these local educational considerations are culturally-based, even though the teacher questioning strategies that are chosen and expressed may reflect rational professional decisions.
CHAPTER 8 CONCLUSIONS AND IMPLICATIONS

In Chapters 4, 5, 6 and 7, the results were presented and the findings were discussed in detail. This chapter presents the study’s conclusions, implications, limitations and some directions for future research, practice and policy-making. In this chapter, the research questions will be revisited in Section 8.1, in the light of the findings of the study. Then the origins and influences on the teacher questioning practices are discussed in Section 8.2, followed by the implications for mathematics education research and teacher professional development design in Section 8.3. The limitations of this study will be clarified in Section 8.4 and the directions for the future research will be presented in Section 8.5. This chapter ends with Section 8.6 which summarises the whole thesis.

8.1 Revisiting the research questions

As was stated in Chapter 2, this study was designed to answer the following research questions: (1) what kinds of initiation questions were asked by the participating teachers in two Australian and two mainland Chinese secondary mathematics classrooms; (2) what kinds of follow-up questions did the participating teachers employ to build on students’ initial responses in two Australian and two mainland Chinese secondary mathematics classrooms; (3) what variations or consistencies in teacher questioning practices were evident across the consecutive lessons in two Australian and two mainland Chinese secondary mathematics classrooms; (4) what similarities and differences were evident between the questioning practices identified in the four secondary mathematics classrooms. In the following paragraphs, the answers to these research questions will be summarised and their implications identified.

Research Question 1: What kinds of initiation questions were asked by the participating teachers in two Australian and two mainland Chinese secondary mathematics classrooms?

Altogether, 14 types of initiation questions were identified in the four participating teachers’ classroom instruction. As was depicted in Chapter 3, these 14 types of initiation questions were Comparison, Conjecture, Evaluation, Explanation, Information extraction, Generation, Link/application, Progress monitoring, Reflection, Result/product, Review, Strategy/procedure, Understanding check, and Variation.
These initiation questions were used by the participating teachers to start classroom interactions with either the whole class, a group of students or an individual student. For the four participating teachers, their questioning practices are quite similar in the employment of initiation question types. Out of the 14 initiation question types, 11 question types were observed in all four participating teachers’ classrooms. It is reasonable to argue that the initiation question types identified across the unit of consecutive lessons could represent a comprehensive set of possible initiation question types that could be used by any one teacher.

It is worth mentioning that teacher AUS2 used all these 14 types of initiation questions in her teaching of six lessons. But for the other three teachers, not every type of initiation question was used in their documented teaching sequences. In particular, it seems that questions requiring students to conjecture were extremely rare in the classrooms studied, being only used by teacher AUS2. Yet contemporary curricula are giving increasing emphasis to developing student capacity to conjecture and/or formulate hypotheses. The teachers studied may not see student conjecturing as important mathematical activity or they may lack the expertise to frame questions requiring conjecture. In either case, the contemporary curriculum requires an increase in the frequency of occurrence of this type of initiating question.

In this study, the question types that were observed during teacher-student interactions were divided into three categories, namely Q&A question pairs, IRF (single) sequences, and IRF (multiple) sequences. Although there was a range of different types of initiation questions observed in each teacher’s classroom, the group of initiation question types used in Q&A question pairs and IRF (single) sequences was usually different from that in IRF (multiple) sequences. There does not appear to be any pattern in the initiating questions used to trigger multiple IRF sequences. It appears, therefore, that the distinctive character of multiple IRF sequences does not lie in any particular characteristic of the initiating questions used. This poses the important question: What is it that distinguishes the situations leading to multiple IRF sequences from the other more limited forms of classroom interaction? The answer to this question requires consideration of the other analyses reported in this thesis.

**Research Question 2:** What kinds of follow-up questions did the participating teachers employ to build on students’ initial responses in two Australian and two mainland Chinese secondary mathematics classrooms?
10 types of follow-up questions had been identified in the classroom teaching of the four participating teachers in this study. These 10 types of follow-up questions were Agreement request, Clarification, Cueing, Elaboration, Extension, Justification, Refocusing, Reformulation request, Repeat/rephrase, and Supplement. Unlike the initiation questions, which were not all used by all teachers, the types of follow-up questions were employed by all four teachers (with only the one exception of the Extension question, which was not used by teacher AUS1 in any lesson). What does this tell us? It may be that the difference between one teacher and another lay in the frequency of use of particular follow-up question types. The following discussion about Research Question 3 will explore this possibility.

**Research Question 3:** What variations or consistencies in teacher questioning practices were evident across the consecutive lessons in two Australian and two mainland Chinese secondary mathematics classrooms?

In the following paragraphs, the observed variations and consistencies of teacher questioning strategies across the teaching sequence are summarised.

**The observed variations**

In general, the total number/frequency of questions varied across the consecutive lessons for each of the participating teachers. The proportion of questions used in IRF (multiple) sequences and the proportion of questions used in Q&A question pairs and IRF (single) sequences were observed to vary over the consecutive lessons. Within a teacher’s teaching lesson sequence, these two proportions changed from one lesson to another, and this was dependent on the location of the lesson in the lesson sequence. More questions in a lesson did not mean a proportionate increase in the occurrence of multiple IRF sequences. When the teacher used a larger number of questions in classroom instruction, proportionally more questions were used in Q&A question pairs and IRF (single) sequences rather than in IRF (multiple) sequences. This means a large variation could exist in one teacher’s use of question types in mathematics classrooms and this variation could be better observed in a sequence of lessons rather than one single lesson.

**The observed consistencies**

Despite the fact that the total number of questions changed from one lesson to another, each participating teacher was inclined to use a consistent proportion of these questions to initiate IRF
(multiple) sequences. For each initiation question in the IRF (multiple) sequences, each participating teacher tended to ask about two follow-up questions.

By looking at the question types constituting the follow-up questions, a relative consistency was observed. Over the consecutive lessons in the teaching sequence, when the teacher asked initiation questions to start the IRF (multiple) sequences, a regular group of question types that is characteristic of each teacher was used to build upon the students’ responses. Specifically, this regular group of questions included Clarification, Supplement, and Cueing questions for teacher CHN1, Agreement request, Clarification, Elaboration, Cueing, Justification and Refocusing questions for teacher CHN2, Clarification, Supplement, Cueing and Repeat/rephrase questions for teacher AUS1, Clarification, Cueing and Repeat/rephrase, Supplement, Refocusing and Agreement request questions for teacher AUS2. This suggests that, while all teachers employed the full range of initiation questions, each teacher employed a different combination of follow-up question types.

**Research Question 4**: What similarities and differences were evident between the questioning practices identified in the four secondary mathematics classrooms?

Although the four participating teachers are from two distinct cultural backgrounds, namely Australia and China, these teachers shared a lot in common regarding the use of questioning strategies over a sequence of consecutive lessons. A key element in the design of this study is the use of teachers from contrasting cultures. It was intended that this major difference in educational context would maximise the possible variation in questioning practices among the studied teachers. Remarkably, as can be seen from the discussion of Research Question 3, between teacher differences were more evident than between culture differences. Particular variations and consistencies are noteworthy.

**Variations**

- For all the participating teachers, both the total number and the average frequency of questions asked in each lesson varied across the teaching sequence;

- For all participating teachers, the proportions of the questions used in IRF (multiple) sequences in Q&A pairs and in IRF (single) sequences varied across the teaching sequence;
• For all participating teachers, the question types for initiation questions varied from one lesson to another over the teaching sequence;

Consistencies

• For all participating teachers, the proportion of initiation questions used in IRF (multiple) sequences stayed consistent over the consecutive lessons;

• For all participating teachers, the ratio of follow-up questions to initiation questions in the IRF (multiple) sequences (the ratio was the number of follow-up questions divided by the number of initiation questions in the IRF (multiple) sequences) stayed relatively stable at 2 over the consecutive lessons. That is, for each initiation question in the IRF (multiple) sequences, about 2 follow-up questions were posed.

• For all participating teachers, the question types for follow-up questions stayed consistent over the consecutive lessons. Remarkably, the follow-up question types were the same for each teacher separately over the lesson sequence.

Stigler and Hiebert (1998) claimed that teaching practices should be regarded as cultural activities. Questioning practices in the two Chinese classroom instruction should be very different from those in their Australian counterparts. However, the findings in this study suggest that teachers’ questioning practices shared a lot in common despite the cultural differences in the teachers. While the aspects of teachers’ questioning strategy choices might be culturally neutral, the contexts within which they take place might belong to aspects at the societal or institutional levels, and which might be influenced by the respective cultures. If we had randomly selected one single lesson from each teacher, the four participating teachers’ questioning practices might have appeared to be very different. But when looking at a sequence of consecutive lessons, the stable features in each teacher’s questioning practices are made visible and explicit.

Teachers’ strategic utilisation of IRF (multiple) sequences is important and worthy of closer examination because only in the questioning sequences can the teachers possibly use specific types of questions intentionally to “guide students through the thinking necessary to generate deep understanding of the content and its implications” (Marzano & Simms, 2012, p.10). There is actually no need either to vilify those questions asking students to review prior knowledge or
to glorify the so called “high-order” questions, since each specific question has a place in the questioning sequence and can make a difference in promote students’ thinking.

By examining the combinations of initiation questions and follow-up questions in the IRF (multiple) sequences, some distinct features were also identified in each cultural setting. This study found that each of the two Chinese participating teachers used the IRF (multiple) sequences differently in each lesson of the lesson sequence. As interviews with the Chinese teachers have shown, the two Chinese participating teachers designed the teaching and questioning strategies by taking the whole teaching sequence into consideration. The whole sequence’s instructional goals were divided into separate but coherent components in the consecutive lessons. The two Chinese teachers’ different use of IRF (multiple) sequence can be seen as a response to the changing pedagogical goals of the lessons as the instruction proceeds in a teaching unit.

Unlike the two Chinese teachers who valued the completion of lesson goals above any other factors, both Australian teachers placed greatest emphasis equally on students’ demands and lesson contents. The use of IRF (multiple) sequences appeared to be consistent in each lesson of the teaching unit to cater to students’ demands and to accomplish lesson goals.

The purpose of this study was not to determine which is the better way of asking questions in mathematics classrooms. Instead, it attempts to unpack and understand teacher questioning practices through a comprehensive coding framework developed in the four participating teachers’ classes. The similarities and differences regarding teacher questioning practices in this study reflect that Chinese teachers and Australian teachers employed questioning strategies in similar forms but with distinct functions. It is impossible for only two teachers to represent their colleagues in the whole nation, and this was not the intention, but the extreme differences in cultural settings uncovered some aspects about the forms and functions of teacher questioning practices in mathematics classrooms.

8.2 Origins and influences on the teacher questioning practices

In this study, teacher questioning practices were found to be shaped and influenced by various factors. In this section, these factors are synthesised to provide a coherent description of
the dynamic nature of teacher questioning as performed in the participating teachers’ mathematics classroom.

**8.2.1 Teacher questioning as a strategy in response to changing instructional goals**

Teacher questioning can be seen as the implementation of the teacher’s pedagogical strategies to cope with adjustments to the teacher’s instructional goals in order to accommodate changing circumstances as the instruction proceeds in a teaching unit.

As observed in all four participating teachers’ lesson sequences, mathematical tasks grew increasingly sophisticated and comprehensive across the lesson sequence. This usually required students to synthesize mathematics knowledge and strategies to a larger extent in the later lessons than in the early lessons in a teaching unit. As a result, the teachers’ questioning strategies tended to adjust to reflect the increases in cognitive load required in mathematics tasks across the teaching unit. For example, in teacher CHN1’s class, she had to use more time in lecturing and demonstration in later lessons than in the early lessons of the teaching unit in order to deliver the increasingly sophisticated mathematics knowledge and tasks in the time available. Accordingly, the number of questions she asked displayed a decreasing trend over the lesson sequence. However, she did not entirely compromise her provision of the opportunities via teacher questions for students to express their mathematical thinking. She strategically asked fewer questions as the lesson sequence proceeded, but consistently ensured using a regular proportion of these questions for extended conversations and built upon students’ responses with follow-up questions, thereby maximizing students’ chances to express their mathematical thinking.

For teacher AUS2, it grew increasingly challenging to promote students’ deep understanding of mathematics knowledge and eternal connections as teaching proceeded in the lesson sequence. This led to a characteristic of her individual questioning strategies. However many questions were asked by the teacher in the lesson, the teacher tended to break down a comprehensive task into multiple small tasks, and thus fast-paced short conversations were observed more frequently in her classroom.
8.2.2 Teacher questioning as a resolution of tensions in class

Teacher questioning can be seen as the teacher’s resolution of the dilemmas or tensions arising in the mathematics classrooms. These dilemmas or tensions can be attributed to high-stakes examinations, introduction of non-conventional teaching model or the introduction of new technological tools. For example, teacher CHN1 stated explicitly that there existed a conflict in her classroom between teaching for understanding and teaching for examination preparation and that she could not ensure both teaching purposes could be achieved together in her classroom. As a resolution of the tension, she made efforts to strike a balance between asking questions and lecturing.

The high-stakes examination was mentioned by teacher CHN2 as an important purpose for mathematics teaching. Teacher CHN2 also acknowledged the constraints of lesson time on mathematics teaching. But he made no attempt to strike a balance between asking questions and lecturing, but instead made maximum efforts to promote students’ expression and communication in an efficient way as a strategy to better prepare students for high-stakes examinations. On one hand, he did not think teaching for high-stakes examinations and teaching for understanding are conflicting but rather that they could be mutually reinforcing. So he did not reduce the number of questions over the lesson sequence as was seen in teacher CHN1’s classroom. On the other hand, how to sustain the efficiency of classroom communication and discussion was a dilemma in his classroom. So in his questioning strategies, it is easy to observe his efforts to find a balance between allowing students to fully express their mathematics ideas and strategically (and efficiently) make use of the same ideas to facilitate the construction of sophisticated mathematics knowledge.

In teacher AUS2’s class, the main tensions and challenges were how to help students construct deep mathematics understanding in trigonometry and how to integrate the use of one-to-one laptops into mathematics teaching. Instead of the usual way of teaching which included big investigations, teacher AUS2 designed multiple small tasks to keep students engaged in mathematics learning. To guide and push students to have deeper thinking, the teacher asked a large number of questions (more than 100 in all the lessons of the teaching unit). But to avoid leaving students feeling frustrated and distracted, the teacher embedded a large proportion of all the questions in fast-paced short conversations. For all the lessons except lesson 2 in the phase of
foundation, regardless of how many questions were asked altogether, nearly half of the questions occurred in Q&A question pairs and IRF (single) sequences.

Likewise, the IRF (multiple) sequences in the teacher AUS2’s classroom tended to be relatively short. On average, in the IRF (multiple) sequences, there were fewer than 2 follow-up questions for every initiation question. This pattern of questioning is entirely consistent with the teacher’s stated adapted instructional practice, intended to accommodate the introduction of individual student laptops.

In addition, out of the total number of questions, the proportion of questions used in the IRF (multiple) sequences varied across the lesson sequences, and this appears to be a key indicator of teachers’ different ways of dealing with the various tensions and challenges in their classroom instruction.

**8.2.3 Teacher questioning as a habitual and valuing act**

In this study, for all four participating teachers, regardless of the differences in their cultural background, some aspects of the questioning practices (i.e., the proportion of initiation questions in IRF (multiple) sequences out of all questions, and the use of subcategories for follow-up questions) were observed consistently. Given the existence of those observed variations discussed in the last section, the emerging consistencies across the lesson sequences can be interpreted as mirroring each teacher’s habitus in using questioning strategies. All the participating teachers in this study were considered to be competent teachers by local criteria and each of them had many years of teaching experiences at the time when data were collected. During their past experience of using questioning strategies, some habitual actions were developed over time by these mathematics teachers.

The observed consistencies also reflected the implicit values held by the participating teachers. Although teaching and learning of mathematics had traditionally been viewed as a “value-free” subject (Bishop, 2008), values have more recently been regarded as being involved in teachers’ efforts of “making school mathematics more relevant to the demands of everyday living” (Seah, 2008, p. 239). In other words, what teachers valued with regards to the subject is implicit in their practice.
In this study, the two Chinese mathematics teachers’ use of three types of IRF (multiple) sequences (i.e., Leading, Facilitating/probing, and Orchestrating) showed distinct features in different lessons within their teaching sequences. To some extent, this reflects each teacher’s unique design and implementation of mathematics lessons in a sequence of instruction for one mathematics topic. Both of the two teachers placed substantial emphasis on the lesson content. The teaching sequence was considered as a whole unit by the two Chinese mathematics teachers and within the sequence, each lesson was designed to address one particular aspect of the unit topic. To accomplish the instructional coherence among these consecutive lessons, IRF (multiple) sequences were used as a tool in different ways for different lessons.

In contrast, for the each of the two Australian teachers, the three types of IRF (multiple) sequences were used in almost the same way across the lessons in the teaching sequence. To some extent, this result mirrors the two teachers’ consistent strategies in designing and teaching mathematics lessons over the sequence. The two Australian teachers placed high emphasis on both students’ demands and lesson content. Due to the differences in lesson topics, the number of all questions used in each individual lesson changed from one lesson to another. However, the use of IRF (multiple) sequences remained stable and the opportunities for students to express their thinking were provided in a consistent manner across all the lessons. Instead of pursuing the balanced use of IRF (multiple) sequences within the whole sequence, where some particular type of IRF (multiple) sequences might be preferred in some lessons, the two Australian teachers tended to maintain a balanced use of IRF (multiple) sequence within each lesson.

8.3 Implications

This study was designed to advance the understanding of teacher questioning practices in mathematics classrooms by investigating two Australian and two Chinese mathematics teachers’ questioning strategies over a sequence of consecutive lessons. Implications for research and for classroom teaching arising from the findings will be reported in the sections to follow.

8.3.1 Implications for mathematics education research

8.3.1.1 The significance of examining teaching strategies over a sequence of lessons

Expert teachers are capable of using various strategies in a flexible way to accommodate different demands as these emerge in the process of classroom teaching. This type of flexibility
in using teaching strategies might not be observed without examining teaching practices over a sequence of consecutive lessons.

It is reasonable to claim that the more lessons that are examined, the richer the information that could be uncovered about one teacher’s teaching strategies. But there are practical limits on how many lessons taught by a teacher can be recorded and studied, due to the excessive resources required to collect the video recordings and then conduct the video analysis. A unit of consecutive lessons represents an effective and feasible balance between the necessity of examining an appropriate number of lessons to obtain richer information about teacher’s strategies and the overload of data collection and analysis. One mathematics topic’s introduction, development and application could be covered in a unit of consecutive lessons and thereby provide a more comprehensive record of one teacher’s strategies in different stages of the instructional process.

8.3.1.2 The power of the IRF framework in studying classroom interactions.

In this study, the IRF framework was used in analysing teacher-student interactions in mathematics classrooms. Instead of simply aggregating the totals of question types employed, all question types were examined within the context of questioning sequences. According to the context where the questions were used, two major categories were developed: initiation questions and follow-up questions. This distinction between initiation questions and follow-up questions is significant since it could help to better understand the purposes of teacher questioning by examining the context in which the question is asked. When a teacher asks two questions with the same wording but in different contexts, the purposes of the two questions might be completely different. Thus the lack of the above distinction might result in the incapability of identifying a comprehensive set of features regarding teacher questioning strategies.

The results obtained in this study reflected the consistency in the participating teachers’ use of follow-up questions across the sequence of consecutive lessons, in contrast with the degree of variation evident in the use of initiation questions. These consistencies would be undetectable or would have gone unnoticed if the initiation questions and follow-up questions were not categorised separately using two sets of coding systems. IRF sequences have become identified
with low-quality classroom interaction (e.g., Drageset, 2014; Franke, Kazemi & Battey, 2007; Kyriacou & Issitt, 2007), but IRF sequences as an instructional move can be implemented effectively or deleteriously, depending in the situation and the skill of the teacher. The results of this study support the adoption of the IRF framework as a generic platform to better investigate and interpret teacher-student interactions. In the four participating teachers’ mathematics classrooms, the IRF sequences could have different functions depending on the way in which the questions were used by the participating teachers. In some of these IRF sequences, the students indeed had constrained opportunities to express their mathematical thinking. But in some other IRF sequences, students were given substantial chances for mathematics communication and discussions.

The use of the IRF framework made explicit how the teacher questions were distributed in mathematics classrooms. In this study, all the questions were classified as used in three distinct situations: Question and answer pairs, IRF (single) sequences, and IRF (multiple) sequences. The identification of these three situations helps us to see more clearly, for example, the proportion of questions used in IRF (single) sequences, as well as the question types employed. Undoubtedly these characteristics will contribute to a better understanding of teacher questioning strategies in mathematics classrooms.

In addition, this study shows that the nature of teacher-student interactions can be revealed and examined more clearly by using the IRF framework. In this study, apart from the identification of Question and answer pairs, IRF (single) sequences, and IRF (multiple) sequences, there was a further analysis of the IRF (multiple) sequences, which categorised each extended interaction as either leading sequences, facilitating/probing sequences, or orchestrating sequences. By using the IRF framework, extended questioning sequences could be examined in further details in depth.

8.3.1.3. The complexity of teaching practices

This study provides further evidence to support the observation that teacher questioning practices in classroom instruction are very complicated, which also reflected the complexity of teaching practice as a whole.
Research in teacher questioning should take these associated factors into consideration so as to understand the mechanism behind teacher actions in questioning practices. Meanwhile, the research into effective questioning should also move beyond the focus only on the questioning behaviour per se, but also focus on the connection between questioning practices and other instructional factors.

8.3.2 Implications for classroom mathematics teaching

The findings of this study make it clear that some important characteristics regarding an expert teacher’s questioning strategies could not be observed or identified simply by looking at isolated lessons. Therefore, the selection of isolated lessons might result in the novice teachers’ inability to achieve a full understanding of the expert teacher’s strategies. Since the use of questioning strategies in one lesson of the teaching sequence could be very different from those in another lesson, novice teachers’ observation and learning based on one isolated exemplary lesson might cause a misleading impression that the observed questioning strategies would be used by the expert teacher in all the other lessons. Once this kind of stereotypical characterisation is constructed in the novice teachers’ minds, not only will it give these novice teachers a misleading understanding of the use of questioning strategies, it will also cause longer side effects by hindering the novice teachers’ understanding of the situated nature of teaching practice. This will further impede their development of the pedagogical content knowledge required to stimulate and utilise students’ existing knowledge.

Therefore, this study proposes that teacher professional development program designers ensure that novice teachers are given an opportunity to observe the teaching of a sequence of lessons and thereby raising the awareness that (expert) teachers’ teaching strategies are strategically employed.

8.4 Limitations

There are some limitations in this study, in the context of which the results and implication of this research should be read.

Despite the fact that all these four teachers were considered to be competent teachers by the local criteria, these teachers could not be taken as representative of all the mathematics teachers in either China or Australia. In addition, the teaching topics in the four participating teachers’
instruction were limited to trigonometry and quadratic functions. Since the instructional topics and tasks could influence the ways of using questioning strategies, it cannot be concluded that the participating teachers’ questioning strategies observed in the collected videos would be exactly the same in the teaching of other mathematics topics.

However, the value of case studies should be interpreted by moving beyond the issue of generalisability, as was argued by Bassey (1981) below:

An important criterion for judging the merit of a case-study is the extent to which the details are sufficient and appropriate for a teacher working in a similar situation to relate his decision making to that described in the case-study. The relatability of a case-study is more important than its generalisability. (p. 85)

In this study, the detailed and in-depth analysis of the four participating teachers’ questioning practices provides sufficient and valuable information about the characteristics of these teachers’ use of questioning strategies for the recognition of both the range and variety of question types employed by the teachers and also for the identification of patterns of use with respect to both question types and question sequences. Thus, this study has significant relatability to mathematics teachers’ use and reflection of questioning strategies. In this regard, this study has the capacity to make a significant contribution to the community of mathematics education research and practice.

8.5 Directions for future research

Based on the results and discussions in this study, there are some suggested directions for future research into teacher questioning strategies.

8.5.1 Competent and novice teachers

The participating teachers in this study were all competent teachers according to local criteria and all had teaching experiences of more than 5 years. Their questioning practices could be attributed, to some extent, to their teaching experiences, through which deeper and more comprehensive understanding could be developed about mathematics teaching and learning. And most importantly, through years of classroom teaching, the teachers developed capacities for flexible planning and the implementation of mathematics instruction. These capacities could not
be developed without a process of the accumulation of teaching practices, accompanied by reflection over time, and thus novice teachers are very likely to be less equipped with these questioning capacities, compared with their more experienced counterparts. Therefore, the novice teachers’ use of questioning strategies across the sequence of consecutive lessons might have some characteristics rather different from those of competent teachers. It would be worthwhile to examine the differences and similarities between competent and novice teachers’ use of questioning strategies across a unit of consecutive lessons.

8.5.2 Primary and secondary teachers

The participating mathematics teachers in this study are all from junior secondary level. With the development of students’ cognitive and social skills and capabilities, the ways of mathematics teaching and learning at the junior secondary levels are usually different from that at primary levels. Meanwhile, the mathematics topics covered in junior secondary schools are more sophisticated than those in primary schools. It would be interesting to examine the characteristics of questioning strategies across consecutive lessons in primary mathematics classrooms and compare these characteristics with those in junior secondary mathematics classrooms. Likewise, the comparison could also involve teachers’ questioning practices in senior secondary mathematics classrooms. These comparisons of questioning strategies across a sequence of consecutive lessons in various learning stages could help the researchers and practitioners better understand the evolution of the connection between teaching and learning mathematics as we move from classrooms at the primary level up to the senior secondary level.

As is shown in the analysis of questioning practices over the lesson sequence in this study, one teacher’s use of questioning strategies is a rather sophisticated phenomena in which a variety of factors (such as the location of a lesson within a teaching unit, the teacher’s pedagogical goals etc.) are interwoven. Such sophistication would not be observed or comprehended completely without a fine-grained examination of teacher questioning in the context of a sequence of consecutive lessons. In this study, the four experienced teachers’ questioning practices showed rather stable characteristics which could be explicitly observed in the instruction of the sequence of lessons. Besides, the connections between teacher questioning practices and other pedagogical factors could be better examined and analysed by looking at the sequence of consecutive lessons. This reminds us that one teacher’s teaching practices could never be defined nor comprehended
by his or her teaching in isolated lessons. Rather, a sequence of consecutive lessons ought to be taken into consideration to better understand the sophisticated teaching practices in mathematics classrooms.

8.6 Closure

As is shown in the analysis of questioning practices over the lesson sequences in this study, a teacher’s use of questioning strategies is a rather sophisticated phenomenon in which a variety of factors are interwoven. These factors include the location of a lesson within a teaching unit, emergent dilemmas or tensions in the classroom, the balancing decisions made by the teacher, the teacher’s habitus resulting from past teaching experiences. Such sophistication cannot be observed or comprehended completely without a fine-grained examination of teacher questioning in the context of a sequence of consecutive lessons. In this study, the four experienced teachers’ questioning practices showed several stable characteristics which could be explicitly observed in the instruction of the sequence of lessons. This study has demonstrated that the connections between teacher questioning practices and other pedagogical factors can be better examined and analysed by looking at the sequence of consecutive lessons than by any aggregation of unconnected individual lessons. This reminds us that a teacher’s teaching practices can never be defined nor comprehended by his or her teaching in isolated lessons. Rather, a sequence of consecutive lessons ought to be taken into consideration to better understand the sophisticated teaching practices in mathematics classrooms. It is only as a result of the analysis of lesson sequences that this study is able to report:

1. The ways that each participating teacher changed their questioning practices as the instruction proceeded in the lesson sequence in two contrasting cultural settings and thereby report a large variety of possible ways of using questions in mathematics classrooms;

2. The participating teacher’s consistent ways of asking questions that was evident in each lesson of the teaching sequence in two contrasting cultural settings and thereby the proportionally consistent use of initiation questions in IRF (multiple) sequences for all four participating teachers in spite of their contrasting cultural backgrounds.
3. The culturally-specific characteristics of the Chinese and Australian teachers’ employment of three kinds of IRF (multiple) sequences (Leading, Facilitating/probing, and Orchestrating) in each lesson of the whole teaching unit.

4. The significant factors that exerted great influence on the participating teachers’ questioning practices and determined the teachers’ strategic adjustment in employing questioning over the lesson sequences in mathematics classrooms. These factors included the progressive adjustment of pedagogical goals as the instruction proceeded in the lesson sequence, the tensions or dilemmas existing in mathematics instruction, teachers’ habitus developed in the past years of teaching experiences, and teachers’ values in terms of mathematics teaching and learning.
REFERENCES


Van der Meij, H. (1990). Question asking: To know that you do not know is not enough. *Journal of Educational Psychology, 82*(3), 505-512


# APPENDICES

## APPENDIX 1 ALIGNMENT PROJECT DATA CHECK LIST

<table>
<thead>
<tr>
<th>Data types</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System</strong></td>
<td></td>
</tr>
<tr>
<td>Official curriculum documents</td>
<td></td>
</tr>
<tr>
<td>State or national assessment materials</td>
<td></td>
</tr>
<tr>
<td>Interviews with key stakeholders</td>
<td></td>
</tr>
<tr>
<td><strong>School</strong></td>
<td></td>
</tr>
<tr>
<td>School profile</td>
<td></td>
</tr>
<tr>
<td>Curriculum personnel interviews</td>
<td></td>
</tr>
<tr>
<td>School policy documents</td>
<td></td>
</tr>
<tr>
<td>Scope and Sequence documents</td>
<td></td>
</tr>
<tr>
<td>Teaching support documents</td>
<td></td>
</tr>
<tr>
<td>Student assessment work samples</td>
<td></td>
</tr>
<tr>
<td>Assessment schedule</td>
<td></td>
</tr>
<tr>
<td><strong>Classroom</strong></td>
<td></td>
</tr>
<tr>
<td>Classroom Videos</td>
<td></td>
</tr>
<tr>
<td>Lesson Tables</td>
<td></td>
</tr>
<tr>
<td>Class list and seating plan</td>
<td></td>
</tr>
<tr>
<td>Classroom instructional materials</td>
<td></td>
</tr>
<tr>
<td>Student written work</td>
<td></td>
</tr>
<tr>
<td><strong>Teacher</strong></td>
<td></td>
</tr>
<tr>
<td>Teacher interviews</td>
<td></td>
</tr>
<tr>
<td>Teacher questionnaires</td>
<td></td>
</tr>
<tr>
<td>Key resources or texts for instructional planning</td>
<td></td>
</tr>
<tr>
<td>Organisational documents</td>
<td></td>
</tr>
<tr>
<td>Student achievement results</td>
<td></td>
</tr>
<tr>
<td>Student reports</td>
<td></td>
</tr>
<tr>
<td>List of pseudonyms</td>
<td></td>
</tr>
<tr>
<td>Additional information</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2 TEACHER QUESTIONNAIRE

Valued Performances in Mathematics and Science Classrooms in Australia, China, and Finland
CLASSROOM CASE STUDY

TEACHER QUESTIONNAIRE

[To be completed after each lesson]

Your Name: ___________________________  Date: ____________

School’s Name: _________________________

Year Level: ____________________________

Name of Subject: ________________________
In this section we will ask you a few questions about the lesson you just delivered and the students in this classroom.

1. Please describe the subject matter content of today’s lesson.

2. What was the main thing you wanted students to learn from today’s lesson? Why do you think it is important for students to learn this? *Please write at least one sentence on each question*
3. To what extent did the students meet your learning goals? How do you know? *Please write at least one sentence on each question*

4. For this class of students, was the content of today’s lesson review, new, or somewhere in between?

   - [ ] all review
   - [ ] mostly review
   - [ ] half review/half new
   - [ ] mostly new
   - [ ] all new

5. How is the content of this lesson related to other lessons in this unit?
6. Types of instructional method I used for today’s lesson:
(select as many as are applicable)
☐ Whole Class instruction
☐ Whole class discussion
☐ Teacher demonstration
☐ Student demonstration/presentation
☐ Individual student work
☐ Small group work
☐ Hands-on activity
☐ Field study, out of class investigations
☐ Multimedia or ICT presentation
☐ Reading from books
☐ Taking notes
☐ Quiz or test
☐ Others, please specify:

7a. The teaching methods I used for today’s lesson were:

☐ very similar to the way I always teach
☐ similar to the way I always teach
☐ somewhat different from the way I always teach
☐ very different from the way I always teach

7b. What, if anything, was different from how you normally teach?
8a. Was there anything about today’s lesson that did not go according to plan or that you would have wanted to be different?

☐ no (skip to end) ☐ yes (go to 8b)

8b. Please describe what did not go according to plan.

THANK YOU!!!

*for your cooperation*
APPENDIX 3 TEACHER INTERVIEWS

Interview Protocols – Teacher pre-topic interview

Prompt One: Tell me something about the topic.

Prompt Two: How do you decide what to teach?

Prompt Three: Which resources, such as documents or websites, did you refer to in planning this topic? For each resource the teacher mentions, ask “Can you give me an example of how you used it when planning the lessons”?

Prompt Four: What are your main objectives in teaching this topic? What do you hope that your students will learn about this topic?

Prompt Five: How do you decide how to teach the topic? What activities have you chosen for the teaching of this topic? Why did you choose these particular activities?

Prompt Six: What do you think are the challenges for the students to learn about this topic? [Is there anything about this particular topic that makes it difficult for the students to learn?] [Can you give an example?]

Prompt Seven: What do you think are the challenges for the teacher in teaching this topic well?

Prompt Eight: How will the students be assessed?

Prompt Nine: Can you please describe which people have curriculum responsibilities at your school and explain how they fit into the school structure?

Teacher post-topic interview

[This interview was conducted with each teacher at the end of classroom videotaping.]

Questions Specific to the Filmed Unit

1. To what extent have you achieved your instructional goals for this unit?
2. How can you tell how well you have achieved your instructional goals for this unit?
3. What were the key decisions you made during the teaching of this unit?
4. How is the topic of this unit related to other topics in the curriculum?
5. To what extent did you need to cater for differences between the students? How did you cater for these differences? Did you think that you delivered the same curriculum to all students, or did students with different needs or abilities receive a different curriculum?

6. How are you assessing the content of this unit?

7. What types of assessment are the students expected to complete this year?

8. To what extent did assessment of any type influence the planning and the teaching of this unit? And how does it affect any other aspects of teaching besides this topic?

9. What other things (not mentioned so far) do you think are important for the teaching of this topic?

**General Questions for teaching students at the grade level:**

1. What are the key resources that you used in planning your lessons for this grade? Please list them and give me an example of how you used each of them.

2. Who do you talk to when planning your lessons?

3. How important are external exams (national or state assessment) in your teaching?
# APPENDIX 4 CATEGORIES IN THE FOUR PREVIOUS STUDIES


<table>
<thead>
<tr>
<th>QUESTION TYPE</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematical Questions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type 0: Agreement Questions</strong></td>
<td>“You will get one, but this one is three over two, correct?” (SG2_L02)</td>
</tr>
<tr>
<td>These questions often end with ‘isn’t it?’, ‘correct?’, ‘alright?’ or ‘right?’</td>
<td></td>
</tr>
<tr>
<td><strong>Type 1: Factual (short) Questions</strong></td>
<td>“What is the power of Y?” (SG2_L02)</td>
</tr>
<tr>
<td>These are basically lower-order questions which require knowledge of subject matter or the recall of facts and specifics. These questions usually begin with ‘what’ or ‘which’.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 2: Factual (long) Questions</strong></td>
<td>“How do you simplify this one?” (SG2_L02)</td>
</tr>
<tr>
<td>These include procedural questions that are questions that require the students to explain the workings or the steps leading to the answer (i.e. the processes or procedures). Also These questions often begin with ‘how’.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 3: Explanation/Justification Questions</strong></td>
<td>“Why you expand it?” (SG2_L10)</td>
</tr>
<tr>
<td>These questions require students to give reasons for given outcomes. They usually begin with ‘why’.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 4: Opinion/Evaluation/Judgment Questions</strong></td>
<td>“Is it advisable to expand it?” (SG2_L02)</td>
</tr>
<tr>
<td>These questions seek students’ own perceptions and views on concepts learnt and they are invited to voice their opinions through critical thinking.</td>
<td></td>
</tr>
<tr>
<td><strong>Type 5: Conjecture Questions</strong></td>
<td>“What happens if it is zero?” (SG2_L02)</td>
</tr>
<tr>
<td>These are higher-order questions which require students to synthesise and think critically. The questions often involve the word ‘if’ in it.</td>
<td></td>
</tr>
<tr>
<td><strong>Classification of Type U Questions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type R: Repeated Questions</strong></td>
<td>“What does M represent?” “What does M represent?” (SG3_L04)</td>
</tr>
<tr>
<td>These are questions that are repeated or rephrased because the students did not understand the question at the first instance.</td>
<td></td>
</tr>
<tr>
<td><strong>Type RSQ: Repeated Student Questions</strong></td>
<td>“Why ah?” (SG1_L02)</td>
</tr>
<tr>
<td>These are questions which are repeated or revoiced the student question for reassurance or for other students to hear it as well.</td>
<td></td>
</tr>
<tr>
<td><strong>Type RSA: Repeated Student Answers</strong></td>
<td>“A is the hypotenuse?” (SG3_L06).</td>
</tr>
<tr>
<td>These questions are in fact student answers and teacher repeated them for verification.</td>
<td></td>
</tr>
<tr>
<td><strong>Type NT: Not Teacher</strong></td>
<td>“So how much must he pay the company to clear the debt by the end of first year?” (SG1_L04).</td>
</tr>
<tr>
<td>These are questions are not technically the teacher’s own questions. These questions included questions from the textbook or worksheet and they were merely recited by the teachers.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question type</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gathering information, leading students through a method</td>
<td>Requires immediate answer; Rehearses known facts/procedures; Enables students to state facts/procedures</td>
<td>What is the value of x in this equation?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How would you plot that point?</td>
</tr>
<tr>
<td>2. Inserting terminology</td>
<td>Once ideas are under discussion, enables correct mathematical language to be used to talk about them</td>
<td>What is this called?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How would we write this correctly?</td>
</tr>
<tr>
<td>3. Exploring mathematical meanings and/or relationships</td>
<td>Points to underlying mathematical relationships and meanings. Makes links between mathematical ideas and representations</td>
<td>Where is this x on the diagram? What does probability mean?</td>
</tr>
<tr>
<td>4. Probing, getting students to explain their thinking</td>
<td>Asks student to articulate, elaborate or clarify ideas</td>
<td>How did you get 10?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can you explain your idea?</td>
</tr>
<tr>
<td>5. Generating Discussion</td>
<td>Solicits contributions from other members of class.</td>
<td>Is there another opinion about this?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What did you say, Justin?</td>
</tr>
<tr>
<td>6. Linking and applying</td>
<td>Points to relationships among mathematical ideas and mathematics and other areas of study/life</td>
<td>In what other situations could you apply this?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Where else have we used this?</td>
</tr>
<tr>
<td>7. Extending thinking</td>
<td>Extends the situation under discussion to other situations where similar ideas may be used</td>
<td>Would this work with other numbers?</td>
</tr>
<tr>
<td>8. Orienting and focusing</td>
<td>Helps students to focus on key elements or aspects of the situation in order to enable problem-solving</td>
<td>What is the problem asking you? What is important about this?</td>
</tr>
<tr>
<td>9. Establishing context</td>
<td>Talks about issues outside of math in order to enable links to be made with mathematics</td>
<td>What is the lottery? How old do you have to be to play the lottery?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question type</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recall</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall factual information</td>
<td>Recite previously learned or currently available facts</td>
<td>What number is in the one’s place?</td>
</tr>
<tr>
<td>Recall procedures</td>
<td>Prescribe previously learned rule</td>
<td>What should we do next?</td>
</tr>
<tr>
<td>Recall prior work</td>
<td>Recall a previously discussed topic</td>
<td>What did we do yesterday?</td>
</tr>
<tr>
<td><strong>Describe strategy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Describe strategy</td>
<td>Tell how you solved the problem</td>
<td>How did you find the answer?</td>
</tr>
<tr>
<td>Describe alternative strategy</td>
<td>Describe another way to solve the same problem</td>
<td>Did anyone do this problem a different way?</td>
</tr>
<tr>
<td><strong>Generate problem</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generate story</td>
<td>Create a story to match a number sentence</td>
<td>Who can tell a story about this number sentence?</td>
</tr>
<tr>
<td>Generate problem</td>
<td>Create a problem to fit given constrains</td>
<td>Can you make up a problem about the distances on this map?</td>
</tr>
<tr>
<td><strong>Examine underlying features</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td>Explain why a procedure is chosen or why it works</td>
<td>Why did you work the problem like that?</td>
</tr>
<tr>
<td>Analysis</td>
<td>Consider the nature of a problem or a solution strategy</td>
<td>How is this different than the one before?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Referential</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Focus</strong>: student articulation of their own ideas and understandings;</td>
<td>What do you see in this egg?</td>
</tr>
<tr>
<td></td>
<td>students’ individual and informal experiences; student thinking and</td>
<td>What other behaviors do you see that our crayfish engaged in?</td>
</tr>
<tr>
<td></td>
<td>reasoning</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Format</strong>: open-ended wh-questions with multiple possible answers; you-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>questions</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Function</strong>: to encourage students to express their own ideas, thoughts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and understandings; to prompt students to give their personal opinions on</td>
<td></td>
</tr>
<tr>
<td></td>
<td>issues or concepts under discussion</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Student response</strong>: one or more sentences with falling intonation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Display</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Focus</strong>: student recall of scientific terminology; student recall of</td>
<td>Do you remember what I told about some of these eggs?</td>
</tr>
<tr>
<td></td>
<td>shared classroom experiences; student knowledge of standard scientific</td>
<td>Do we really know what the crayfish is feeling?</td>
</tr>
<tr>
<td></td>
<td>concepts</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Format</strong>: Yes-or-no questions; or convergent wh-questions with one</td>
<td></td>
</tr>
<tr>
<td></td>
<td>possible “right” answer</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Function</strong>: to test students; to find out whether students know the right</td>
<td></td>
</tr>
<tr>
<td></td>
<td>answer; to remind students of work completed and canonical scientific</td>
<td></td>
</tr>
<tr>
<td></td>
<td>terminology introduced in previous lessons</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Student response</strong>: one-word answers with rising intonation</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Clarification</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Focus</strong>: students’ previous utterances</td>
<td>Make what smaller?</td>
</tr>
<tr>
<td></td>
<td><strong>Format</strong>: specified alternative questions; fill-in-the blank questions;</td>
<td>What grows ugly?</td>
</tr>
<tr>
<td></td>
<td>closed wh-questions</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Function</strong>: to express inability to understand or hear students’ intended</td>
<td></td>
</tr>
<tr>
<td></td>
<td>meanings; to request clarification, repetition or elaboration from students</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Student response</strong>: one-word answers with falling intonations</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Confirmation</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Focus</strong>: students’ previous utterances</td>
<td>It would be a good rain coat, wouldn’t it?</td>
</tr>
<tr>
<td></td>
<td><strong>Format</strong>: tag-questions; so-statements with rising intonations; yes-or-no</td>
<td>So it’s a continuous lost of motion from its initial force?</td>
</tr>
<tr>
<td></td>
<td>questions</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Function</strong>: to confirm understanding of students’ intended meanings; to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>offer candidate understandings; to reword students’ utterances in more</td>
<td></td>
</tr>
<tr>
<td></td>
<td>specialized ways</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Student response</strong>: one-word affirmative/negative answers (“yes,” “no”),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>reactive tokens (“umhm”), headshakes</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Comprehension</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Focus</strong>: teachers’ previous utterances</td>
<td>We are only on day 9, okay?</td>
</tr>
<tr>
<td></td>
<td><strong>Format</strong>: tag-questions; yes-or-no questions</td>
<td>Here are the things we are trying to keep the same, ok?</td>
</tr>
<tr>
<td></td>
<td><strong>Function</strong>: to check whether students heard and/or understood teachers’</td>
<td></td>
</tr>
<tr>
<td></td>
<td>previous utterances; to encourage students to express their listenership</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and/or understanding; to give students a chance to ask questions before</td>
<td></td>
</tr>
<tr>
<td></td>
<td>moving on to a different topic or activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Student response</strong>: reactive tokens (“okay”), headshakes</td>
<td></td>
</tr>
</tbody>
</table>
Author/s: Dong, Lianchun

Title: Teacher questioning practices across a sequence of consecutive mathematics lessons: a multiple-case study of junior secondary teachers in Australia and mainland China

Date: 2017

Persistent Link: http://hdl.handle.net/11343/191128

File Description: Teacher questioning practices across a sequence of consecutive mathematics lessons: a multiple-case study of junior secondary teachers in Australia and mainland China

Terms and Conditions: Terms and Conditions: Copyright in works deposited in Minerva Access is retained by the copyright owner. The work may not be altered without permission from the copyright owner. Readers may only download, print and save electronic copies of whole works for their own personal non-commercial use. Any use that exceeds these limits requires permission from the copyright owner. Attribution is essential when quoting or paraphrasing from these works.