# A STUDY OF HOW MATHEMATICS TEACHERS IN SECONDARY SCHOOLS IN HONG KONG CATER FOR STUDENTS' INDIVIDUAL DIFFERENCES

**LUN-CHUEN TSENG**

**A Thesis Submitted for the Degree of Philosophy of Doctor in the School of Education and Life-Long Learning, University of East Anglia**
**August 2012**



Signed__________________________

Date____________________________

# ABSTRACT

The purpose of this study is to investigate how teachers cater for students' individual differences in the context of a reform-based Mathematics curriculum, using the topic 'Similar triangles'. A group of six Hong Kong secondary schools in different locations, and with different banding and setting policies, took part in the study. The students were in the age-group 12 to 13 years.

A naturalistic research design, without any interference from the researcher, was chosen to examine teacher behaviour. The emphasis was on observing, describing, interpreting and exploring events in the complex setting of the classroom, via a case study approach. Data were collected from the six teachers through interviews, questionnaires, and video and audio recording of five to six lessons for each teacher. There was also one focus group interview with students from each teacher's classes.

This research reports on how the methods suggested in the Curriculum Guide for catering for individual differences were implemented in the classroom. In general, the teachers involved: (1) attempted to check students' prior knowledge, but only a small number of students was involved; (2) asked questions at different levels, but did not know about the students' learning progress; (3) chose content which was most likely to follow the textbook; (4) were unable to vary the focus to help students to learn; and (5) could not identify what was hindering students in working out problems during seatwork.

This study indicates that teachers are using their own methods to try to solve the problem of catering for student diversity, but the approaches they employ are not of a high enough quality to help students. Also, the ways in which teachers catered for individual differences in students varied considerably. This was found to depend on: the learning atmosphere; the opportunities created for student responses; variations in the scaffolding used; and the level of students' motivation for learning. It is strongly recommended that teachers open their minds to contacts outside the classroom to refresh their teaching repertoire, and try to use some new methods which are related to the theories discussed in this research. Also, it is suggested that policy makers could build on the teachers' experiences to enhance their ability to handle student diversity.

## Acknowledgements

First, I would like to extend my deepest gratitude to Dr. Roy Barton for supporting me in all my educational and professional endeavours since I started my doctoral studies at the University of East Anglia. I thank him for allowing me to try out my ideas on research and for guiding me in a most diligent and thorough way. His insightful comments and input throughout this project have been invaluable.

The professional team at the University of East Anglia has guided and mentored me, and helped me to grow and develop intellectually as a researcher and academic.

I am indebted also to the following senior colleagues: Professor Ronnie Carr, Professor Yvonne Fung, Dr. Brenda Tang Yim Man and Dr. Earnest Tse Kwok Keung. My admission to the Open University of Hong Kong as a lecturer and then the Education Bureau as a Curriculum Officer would not have been possible without their support.

I am grateful beyond words to the six teachers whose names remain confidential. It was critical to have their agreement to be involved in the study and videotape their lessons. I was constantly surprised by their level of enthusiasm and support for my research. This project would not have been possible without their help. I would also like to thank the school principals and students who participated in this research.

Also, obviously, I thank my husband and my lovely son – I don’t think I need to say why.

# CONTENTS

# CHAPTER 1
# INTRODUCTION AND BACKGROUND TO THE THESIS

## 1.1 Scope of the chapter

This chapter first introduces the researcher's background and then raises the issue of individual differences and the purposes of catering for them. Next, the rationale for this research project, the research questions and the significance of the study are discussed. Finally, the structure of the thesis is outlined briefly.

## 1.2 Introduction

### 1.2.1 My background

As a Mathematics teacher in a Chinese secondary school for about ten years, I struggled with ways of helping students of different ability levels to learn. Since I sympathized with the low-ability students in my classes, I hoped to design a special teaching plan for them to enhance their learning. However, despite my efforts to deal with their difficulties, the results were not good enough. At first, I believed that the more academic knowledge I learned, the more I could help these students – so I decided to apply for a Master of Education programme, hoping to discover up-to-date methods for handling the problem of the learning gap between students of different abilities. Fortunately, I was accepted by the Chinese University of Hong Kong and had an opportunity to learn about many different fields of knowledge, but I was unable to find the teaching approach I was searching for. After studying for a year, I discovered that there were specialists in a number of countries who were working on this issue, using a diverse range of approaches. I therefore felt that the best way for me to get in touch with current ideas on how to teach such students might be by joining a research team.

During my master's degree programme on Education, I attended a course on the topic of motivation, in which the professor introduced the TIMSS international study and mentioned that one of the study teams had formed a separate research laboratory and would like to employ an experienced secondary Mathematics teacher as a country associate. I was excited by this prospect and applied for the post at once, regardless of any difficulties it might cause for my studies. When I had completed all the compulsory courses in the remaining semesters, I started my master's project and simultaneously worked as a team member on the overseas project under supervision by email.

My master's project was completed in June 2000 with the help of LessonLab, Inc. The research question was: 'Are there any differences in the teaching methods and styles found among the different bands of school?' (See Chapter 2, section 2.2.1 for a discussion of the term 'banding'.) After finishing the project, I discovered that the teachers in the schools with different banding were using their own methods to deal with student diversity, an issue on which my project did not focus. In the current research, I hope to discover more about the special features of the methods teachers employ in catering for students' individual differences in ability in a range of schools.

### 1.2.2 Introduction to individual differences

Before studying how Hong Kong teachers handle students' individual differences, it is necessary to be clear about what the term means. There has been considerable research in educational psychology devoted to this area, e.g. differences in terms of multiple intelligences (Gardner, 1993) and brain-based learning (Caine and Caine, 1997). Also, as regards philosophy, the Wikipedia website starts with a statement from Plato:

> No two persons are born exactly alike; but each differs from the other in natural endowments, one being suited for one occupation and the other for another.

In this study, the phrase 'individual differences' is used to refer to variations in students' academic performance based on differences in aptitude, interest, personality and other characteristics – a usage which aligns with the findings of Tang and Lau's (2001) project on the issue. During the interviews for their project, the conception of variation in performance levels was the most common statement made; and seven out of the fourteen primary school teachers involved also embedded this conception in their main coping strategy. This inclusive perspective recognizes that individual differences have multiple sources and occur within a social context, and it takes into account the many domains in which students vary. In the present study, in which the focus is on individual differences related to achievement in mathematics, catering for individual differences is defined as 'tailoring teaching so that pupils of different abilities have the opportunity to learn at their own developmental level and at their own pace' (Carless, 1999, p. 16).

The ability to take account of student diversity is generally considered to be one of the attributes of effective teachers (e.g. Kyriacou, 1997). Research in Hong Kong (at least that published in English) related to individual learner differences has tended to focus mainly on helping students with learning difficulties (Hui and Yung, 1992; Chan, 1998). Also, in the area of language teaching strategies, Carless (2001) based his doctoral research on the implementation of the Target Oriented Curriculum (TOC), using predominantly qualitative case study data to examine the perceptions and classroom teaching of three primary school English teachers with respect to the notion of individual learner differences. The main focus of the thesis was to provide perspectives for English teachers on catering for individual learner differences; raise awareness of a variety of different classroom strategies that could be used for this purpose; and examine the implications for teaching and learning English as a second language. However, to date, there is no specific study of how teachers cater for individual differences during Mathematics lessons.

### 1.2.3 The purposes of catering for individual differences

Given that teachers are attempting to scaffold their students' learning with appropriate interventions and support, it is imperative that teachers have access to, and understanding of, the ways in which children's learning processes can vary. The more information they have on how children's mathematical development can differ, the more likely it will be that students' needs can be met in the classroom. If there are qualitative differences in the ways that children develop an understanding of mathematical concepts, then there will be differences in the kinds of support they require in order to maximize their mathematical development. If students with differing needs are taught Mathematics as a homogeneous group, some will necessarily be disadvantaged, as they will not be receiving the kind of teaching they need to learn as efficiently as possible.

Advances in technology are constantly allowing greater and greater personalization of learning. Research on identifying the variables that help to describe the different ways in which children learn will be important for the development of personalized learning systems.

The investigation reported in this thesis will go some way towards increasing our knowledge of how teachers vary their teaching methods to help students develop mathematical concepts – which will enhance our understanding of how the teaching of similar triangles ought to be modelled. At some stage in the future, it is envisaged that increasing the individuality of learning will allow for children's personal needs in mathematics learning to be addressed. This investigation will help to define some of the variables across which children can differ in their learning of the subject so that their individual needs can be identified clearly.

One intended end-result of mathematics education research is to find ways in which classroom teaching can be designed to ensure that all students are given the appropriate types of support. If children have different learning styles or levels of strategy variability, then it is likely that different kinds of support will be required to allow each child to reach his/her highest potential level of achievement in mathematics. The more we can find out about the way levels of strategy variability are distributed across children, the more able we will be to match the delivery of teaching to their needs.

## 1.3 Rationale for the research

The Third International Mathematics and Science Study (TIMSS) found that students in primary schools in Singapore, Korea, Japan and Hong Kong were outperforming their Western counterparts, and that they occupied the first four positions in mathematics achievement (Beaton et al., 1996; Mullis et al., 1997). However, it was found that the learning environment in Hong Kong involved large class sizes, an examination-oriented curriculum and teacher-centred teaching methods – factors which contrasted with what is considered to be conducive to learning by Western researchers (Morris, 1985; Biggs, 1994; Leung, 1995, 2001; Morris et al., 1996; Wong, 1998, 2000). This paradox has attracted many researchers to explore the reasons for East Asian students' superior performance in mathematics from various perspectives (Stevenson and Stigler, 1992; Stevenson, Chen and Lee, 1993; Watkins and Biggs, 1996; Schmidt et al., 1997, 1999). In recent years, there has been considerable research on teaching in Mathematics classrooms in different cultures (Leung, 1992; Stevenson and Stigler, 1992; Stigler and Hiebert, 1999). However, most studies have just focused on the structure of lessons and classroom interaction using a quantitative approach (Stevenson and Stigler, 1992; Leung, 1995; Stevenson, 1995). The qualitative features of the process of teaching – such as how teachers deal with specific topics and the related concepts in a Mathematics class – have not been addressed. The current researcher considers that a qualitative study on how teachers handle specific mathematical concepts will help us to understand what actually happens in a Mathematics classroom. Such a study may also shed new light on how Hong Kong teachers cater for students' individual differences when teaching the subject.

According to the TIMSS-R study, Hong Kong classrooms have the highest ratio of words spoken by the teacher to those spoken by their students. As the Study Report pointed out, ‘Hong Kong SAR eighth-grade mathematics teachers spoke significantly more words relative to their students (16:1) than did teachers in Australia (9:1), the Czech Republic (9:1), and the United States (8:1)’ (Hiebert et al., 2003, p. 109). The report also noted that ‘Hong Kong Special Administrative Region lessons contained a larger percentage of problem statements classified as using procedures (84%) than all the other countries’ (Hiebert et al., 2003, p. 98).

The qualitative analyses of the data in the above study were performed by an expert panel comprising mathematicians and mathematics educators. Panel members reviewed detailed descriptions of a random sub-sample of the videotaped lessons ‘country-blind’ and made qualitative judgements about them. The panel also assessed the quality of the mathematics in the lessons along four dimensions: *coherence*, *presentation*, *engagement* and *overall quality*. It was found the content covered in the Hong Kong (and Czech Republic) classrooms was relatively more advanced: the mathematics content of 20% of the lessons was judged to be advanced, while the content in none of the lessons was judged to be elementary. Also, the mathematical problems Hong Kong students worked on in their classrooms were mainly unrelated to real life, and the problem statements suggested that they were typically solved by applying a procedure or set of procedures rather than calling for mathematical concepts or constructing relationships among mathematical ideas and facts. Furthermore, students were expected to follow prescribed methods in solving these problems instead of being given a choice of solution methods.

According to Teppo (1998), the process of classroom teaching is more complicated than expected, and its complexity and messiness needs to be investigated from various perspectives and frameworks of inquiry. In order to study closely how teachers cater for students’ individual differences while teaching, I decided to employ the following two strategies to sharpen the focus of this research. First, a specific topic, *Similar triangles*, was selected, and all the lessons studied dealt with this issue. (The reasons for choosing this topic are discussed in Chapter 2, section 2.5.2.) Second, the variation theory of teaching and learning (Marton and Booth, 1997; Bowden and Marton, 1998) was used as a tool for examining the process of classroom teaching. According to this theory, discernment is a fundamental constituent of learning and students can never discern anything without experiencing a certain pattern of variation. By selecting and analysing several Secondary 1 Mathematics lessons on ‘Similar triangles’ in different schools in Hong Kong, the researcher attempted to explore some features of Mathematics classrooms in depth from the selected theoretical perspective.

## 1.4 Research questions

The research questions for this thesis are as follows:

*Main research question*: How do Mathematics teachers in secondary schools in Hong Kong cater for students’ individual differences?

For comparison, the research will consider the teaching of a specific mathematics topic in different schools.

The *sub-questions* to be explored are:

1 What are the teachers’ attitudes towards Mathematics teaching in general?

2 What is their understanding of the recommendations in the Mathematics Curriculum Guide on catering for individual differences, and to what extent do they understand the principles behind this guidance?

3 How do these teachers approach their teaching in the classroom, specifically related to catering for individual differences both within a class and between classes, and what is their rationale for doing so?

4 What is the relationship between the recommendations in the Curriculum Guide on catering for individual differences and teachers’ actual practice, both within a class and between classes?

5 What are the implications for teachers, advisors and policy makers?

## 1.5 Significance of the research

The present study is significant in various respects. First, although researchers have been interested in the reasons for Hong Kong students’ outstanding performance in mathematics, how Hong Kong teachers help students to learn the subject in the classroom has not been studied deeply. As Stigler and Hiebert (1999) argue, teaching is a cultural activity. The current study will contribute not only to increased understanding of local Mathematics classroom teaching, but also shed light on how the teachers cater for student diversity during their teaching.

Second, the general variations in teaching are investigated in looking at different aspects of classroom teaching. The areas include how teachers diagnose students' needs and differences, and how they vary the level of difficulty and the content covered, as well as their questioning techniques and their approach when introducing concepts. This kind of investigation has never been carried out before in classroom research in Hong Kong. The present thesis will be the first attempt to study the local Mathematics classroom from this perspective on such a scale, and will help to provide insights into how Mathematics is taught in Hong Kong schools.

Finally, as Hong Kong has recently launched a series of reforms in mathematics education, a good understanding of teachers' practices in Mathematics classrooms will be a useful reference for the implementations of these reforms.

## 1.6 Structure of the thesis

This thesis consists of nine chapters. This first chapter has provided the background to the study. Chapter 2 reviews curriculum innovation and the context for implementing educational innovations in catering for individual differences. In Chapter 3, the relevant literature is reviewed and discussed, and this is followed in Chapter 4 by an explanation of the methodology adopted for conducting this study. Chapter 5 introduces the background to the case study schools and teachers; Chapter 6 presents an in-depth cross-analysis of all six cases; and Chapter 7 addresses the first four research sub-questions. Next, in Chapter 8, the findings are interpreted from a cultural perspective and the implications of the study are discussed (research sub-question 5). Finally, Chapter 9 includes perspectives on the research questions, and considers the limitations of the study and possible areas for future research.

# CHAPTER 2

# THE CONTEXTUAL BACKGROUND FOR THE CURRICULUM GUIDE

## 2.1 Scope of the chapter

This chapter starts by describing the allocation procedures for primary school students moving into secondary school, and this is followed by an outline of the different tracking or ability grouping systems adopted in secondary schools to cater for students' individual differences. Before discussing the issue of handling student diversity in curriculum innovation, the historical background and the perspective of the Education Department are considered. The chapter then focuses on examining both the Mathematics Syllabus and Mathematics Curriculum Guide.

## 2.2 The current situation in Hong Kong

### 2.2.1 The allocation method for students moving from Primary 6 to Secondary 1

In Hong Kong, students are allocated to schools with the banding which is assumed to be most suitable for them according to their attainment in Chinese, English and Mathematics. This mechanism is called the Primary School Places Central Allocation System (SSPA). All Primary 6 students need to take an aptitude test before they are allocated to a secondary school. At the time of the data collection, students were allocated to secondary schools by taking a placement test to separate them into five bands within districts, not territory-wide. This means that there is competition for school places within each district and, consequently, pupils might be placed in the lowest band in one school district but not if they lived in another district.

The allocation is also based on parents' selection from the secondary schools' name-list within the area in which they live and their connections with the schools – for example if they have a family member studying in the chosen school. Schools cannot accept only a single band of students, as there are many students within the school districts, and schools are assumed to accept students from the local school district. As a result, each class in schools has different bands of students. If the dominant ability level of a school's students were at a higher band, then this school would be coded as a 'high-band' school. Once this banding has been communicated to the public informally, the perception of the school's reputation is not easily changed.

In these kinds of classes, the individual differences between students are very considerable. Imagine that there are forty students in a class of a medium-band school, which includes:

2 band one (high ability) students;
10 band two students;
20 band three students; and
8 band four or band five (low ability) students.

Obviously, in such a situation, teachers are presented with the problem of how and what to teach in their lessons. Are different methods used in teaching in schools with a different banding? In the Education Commission (EC)'s review of the SSPA mechanism a few years ago, it was proposed that the number of bandings should be reduced from five to three, and that banding should be based entirely on students' internal results from 2005. Thus, from 2005 onwards, every secondary school has students spanning the three bandings. With the reduction of the allocation bands from five to three, the range of student ability within each class in all schools widened. As a result, the Education Department provided various kinds of support, including additional human resources, on-site support and assistance in curriculum tailoring to schools which admitted a large number of academically low achievers.

### 2.2.2 The learning context

Cheng (1997) outlined some of the main characteristics of the Hong Kong teaching and learning context. Traditionally, parents regard education as the main route to upward social mobility. Students are forced to study hard in both primary and secondary school; and there is a general emphasis on effort and diligence rather than ability, with failure in student achievement usually being ascribed to 'laziness' rather than lack of ability. Mathematics is a highly regarded subject and is viewed as the most important subject for indicating students' ability.

Biggs (1996a), who believed that the education systems in China, Japan, South Korea, Singapore, Taiwan and Hong Kong are influenced by Confucianism, examined the paradox that students in these countries had high achievement in what appeared to be poor conditions for studying – such as large class sizes, authoritarian teaching styles and an examination-driven approach. In the Confucian heritage culture (CHC), the teacher is highly respected as a figure of authority and wisdom (ibid.). Teachers in Hong Kong tend to impart knowledge to students who are expected to sit quietly and pay attention to what is being said.

Another factor which has an important effect on teaching in Hong Kong is the use of textbooks. For English teaching in Hong Kong, Ng (1994, p. 82) observed that 'many teachers, perhaps as a result of perceived or actual pressure from the school or from parents, try to "finish the textbook" with little regard to the ability of the students'. Also, Tong (1996) claims that adherence to the textbook is reinforced by the importance of texts in the Chinese culture. This is also the case in teaching Mathematics, where teachers wish to cover the textbook before sending students to sit examinations, since Hong Kong is well-known as an examination-oriented city (Fullilove, 1992). Students have to face different kinds of high-stakes examinations from kindergarten to secondary school. Indeed, Cheng and Wong (1996) view competition as the essence of schooling in Hong Kong and see it as a means of socialization to prepare students to deal with a tough future. The factors which may limit the extent to which teachers are able to cater for individual differences include large class sizes, the crowded curriculum and frequent examinations.

## 2.3 Catering for students' individual differences in secondary schools

### 2.3.1 Tracking or ability grouping within a level

Most Hong Kong secondary schools stream students based on the pre-S1 examination once they are assigned to a school. The tracking or ability grouping means that students of different ability are selected using the test results and then put into different classes. However, the percentage of each band of students in a class varies across school contexts.

*Mixed-ability* grouping refers to the practice of allocating students to classes across all subjects so that there is a range of different attainment levels in every class. In contrast, *banding* involves dividing students into broad 'ability' bands with two or three mixed classes in each. It is a form of streaming in larger schools where the numbers allow schools to stratify students into top, middle and lower bands. Students are mixed within each band, but not between bands. Although banding is formally a less stratified system than streaming, some teachers use the terms interchangeably, often referring to the bottom or top band as the bottom or top stream respectively. *Streaming* is a method of assigning students hierarchically to classes on some overall assessment of general attainment, and the streamed classes are used as the teaching units for all subjects. Finally, *setting* is a practice whereby students are grouped into streams or tracks according to their attainment in a given subject; at junior level it is quite common for schools to set students for English because of the policy on the medium of instruction. However, students with high ability in English may not be so capable in Mathematics, which causes a mismatch in streamed classes when students attend Mathematics classes.

## 2.4 Education reform

### 2.4.1 Catering for students' individual differences: the historical background

In the traditional Hong Kong classroom, catering for individual learner differences was not emphasized. In a review of the Hong Kong educational system, Cheng (1997, p. 39) pointed out that concern for individual needs and diverse goals appeals only to a small minority and that:

> The notions of individual-based and student-centred teaching have been slow to take root in Hong Kong schools. Traditional Chinese classrooms rely heavily on the organization of the class and the social relations among students.

Similarly, Cheng and Wong (1996, p. 44) stated 'Individualized teaching, where teachers work towards diverse targets at different paces, is almost inconceivable in East Asian societies'. In order to encourage increased attention to learner differentiation, Hong Kong's Target-Oriented Curriculum (TOC) placed a greater stress on teachers providing for individual learner differences. The TOC was a multi-faceted innovation developed in the early 1990s and implemented in primary schools from September 1995 onwards. Its main features were the use of targets to provide a clear direction for learning, the use of tasks to involve pupils actively in their learning, and task-based assessment to form an integrated teaching, learning and assessment cycle. Clark et al. (1994, p. 51) stated in their TOC framework document:

> It is the role of the teacher, in so far as it is practicable, to know the particular background and profile of individual learners and to know how to respond to learner differences by providing them with appropriate learning experiences and levels of support.

At that time, the method for handling individual differences appeared to focus principally on the learners' aptitudes and, to some extent, learning styles. Similarly, the Education Department (1994, p. 7) listed one of the aims of the TOC as being 'to value individual student progress, however large or small, and to motivate students towards further learning'. It also suggested that teachers might cater for individual differences by:

— providing pupils with a different amount of input or support;

— providing additional support for less able pupils; and

— using graded worksheets suited to different learning styles or abilities.

Evidence from the early implementation of the TOC (Morris et al., 1996; Carless and Wong, 1999; Clark et al., 1999) indicated that teachers had problems in catering for individual learner differences. For example, Morris et al. noted that most teachers confessed that they did not know how to provide for such differences among their pupils, and they were frustrated as they were able to identify those in need of further support but felt unable to do anything for them. Morris et al. also reported that, for the majority of teachers, attention was directed mainly to trying to assist the weaker pupils and there were few indications of attempting to extend the brighter ones.

A similar picture emerged from the Clark et al.'s 1999 study which explored teachers' understanding of individual differences and the way they responded to them. This involved an evaluation by both teachers and teacher educators, which established that teachers were facing difficulties in this area and needed more professional support.

### 2.4.2 A historical perspective on catering for individual differences from the Quality Assurance Department (QAD) of the Education Department

In the *Report of Review of Compulsory Education* in October 1997, there was a special chapter dealing with the impact of individual differences. It stated that, during the compulsory nine years of schooling, catering for the increasing differences between pupils was a major issue: pupils showed great variations in their abilities and educational attainments at the same year level, and so a single common curriculum was no longer suitable for the needs of all pupils, even in the same class. The chapter first proposed a quality assurance mechanism to ensure that most pupils could reach a certain minimum level of attainment, and then recommended other measures to cope with individual differences, including subject-based setting as well as remedial teaching. Since the curriculum and teaching arrangements were designed to cater for a more homogeneous student population, this led to some achieving a standard far below their year level. When teachers pitch their teaching at only one level for the whole class, some pupils will fail to learn effectively, and the gap will widen as teaching proceeds. Pupils were normally allowed to repeat only once in primary school, which caused some primary school-leavers to be two or more year levels behind their classmates. In spite of their attainment level, they had to be promoted to secondary school and, as a result, in secondary schools the learning gap between high- and low-ability students widened considerably. At that time there were no guidelines available for teachers to use, so they had to face this problem on the basis of their own teaching experience.

For teaching Mathematics, the 1997–98 annual report of the Education Department on areas for improvement stated:

> In the course of compiling the teaching plans and schemes of work, strategies for catering for individual/class differences were not indicated. More consideration should be given to the depth and breath of treatment of individual topics. Alternative teaching methodologies should also be included. (http://www.edb.gov.hk/index.aspx?langno=1&nodeID=833)

The 1999–2000 report also mentioned:

> More effort should be made to help academically low achievers learn Mathematics. A variety of learning activities should be organised to meet the varied needs of the students.
> (http://www.edb.gov.hk/index.aspx?nodeID=787&langno=1)

Following the annual report for 2000–01 on Mathematics, the following major weaknesses were identified:

1. a teacher-centred approach resulting in inadequate teacher-pupil interaction;
2. a lack of variety in teaching strategies and learning activities, especially those catering for learner differences;
3. questioning techniques which were not effective enough to invite active pupil discussion and to inspire higher-order thinking;
4. a low expectation of the pupils such that their potentials were not fully stretched;

5 an emphasis on imparting subject knowledge with inadequate attention paid to developing pupils' skills, attitudes and creativity; and

6 infrequent use of teaching aids, including IT, to help enhance the effectiveness of teaching.

(http://www.edb.gov.hk/index.aspx?nodeID=767&langno=1)

Since these reports all indicated weaknesses in catering for individual differences, more guidelines, which promoted a whole-school approach, were produced by the Education Department to help teachers.

## 2.5 Curriculum innovation in Hong Kong

Both the Mathematics Syllabus and the Mathematics Curriculum Guide were developed by external experts and disseminated via the Education Department to schools. Morris (1995) characterizes the Hong Kong practice of this mode of curriculum development as centralized and bureaucratic. Morris (1992; 1995) also points out that front-line teachers have little input into the content and methods recommended by the Curriculum Guide, and there is a mismatch between curriculum intentions – what the Curriculum Guide suggests should happen – and the curriculum realities – what actually takes place in the classroom. There are a number of factors which inhibit the intended curricula from being implemented effectively, viz.

1 The curriculum innovations are imported directly from the West, especially the UK.

2 The examination-oriented curriculum makes child-centred teaching time-consuming and impractical.

3 The new curriculum innovations are not supported by practical ideas on how to implement them.

4 The new curriculum innovations are inadequately resourced.

5 Teachers rarely collaborate with colleagues because of the conservative school cultures.

### 2.5.1 The emphasis in the Mathematics Syllabus on catering for learner differences

The Mathematics Syllabus section 5.1.2 (see Appendix 1) on catering for learner differences suggested three dimensions. First, in curriculum design, there are foundation and enrichment topics for the students' different learning needs. Second, at the school level, students can be grouped by similar ability, so that teachers find it easier to plan their teaching and learning activities. However, the labelling effect for less able students should also be considered, and these streamed classes still include students with different abilities, interests and needs. So, third, it was suggested that in their daily class teaching, teachers should adopt various teaching styles, such as whole-class teaching and group work, as well as individual teaching. Before teaching, teachers should design different tasks or activities graded according to level of difficulty to ensure that students of differing ability can engage with work that matches their progress in learning. While tackling the tasks or activities, less able students should be provided with more cues. For example, teachers might need to break complicated problems into several parts for weaker students. Also, it was suggested that, when assigning exercises, teachers should vary the amount of work and avoid the mechanical drilling of solutions. In addition, it was recommended that teachers should use IT educational packages which include different levels of exercises or activities for students of different ability to work through at their own pace. These packages could also record students' performance and provide information for diagnosing misconceptions or general weaknesses; and teachers could then readjust the teaching pace or reconsider their teaching strategies accordingly (Curriculum Development Council, 1999).

### 2.5.2 The emphasis in the Mathematics Curriculum Guide on catering for learner differences

In a *Holistic Review of the Hong Kong School Curriculum Proposed Reforms* (Curriculum Development Council, 1999), it was claimed that all the curriculum reforms were designed to improve the quality of teaching and learning, and that the effectiveness of the learning/teaching process had to be enhanced by focusing on the students and their interactions, as well as the learning outcomes. The following are some of the initial suggestions for catering for individual differences in the above document:

— Diversified teaching/learning styles, strategies, contexts and resources are to be encouraged for different purposes and needs of students.

— Based on the belief that all students, including those with special educational needs, can learn, all possible ways – such as alternative curriculum models, different pedagogical approaches, resources and school-based support – should be adopted to cater for students with different learning potentials, abilities and needs.

After a series of open curriculum forums and consultations to discuss these views, a new Curriculum Guide was developed, which included a special section on catering for learner differences. It stated clearly that catering for learner differences is not intended to narrow the gap between individuals or to even out students' abilities and performance. The actions suggested only try to understand why certain students are unable to learn well and find appropriate ways to help them improve. Otherwise, the gap between the high- and low-achievers will widen as students move through the stages of schooling. The practices that have worked are introduced with evidence, including: the use of cooperative learning; varying teaching from the viewpoint of the students; cross-level subject setting; pacing learning and teaching according to the abilities of students; and using information technology as a learning tool (Education Department, 2000, p. 5). It also introduced three aspects of planning strategies to cater for student diversity at the level of the central curriculum, the school and the classroom.

The planning strategies at the school level emphasize arranging the learning contents in a logical sequence for each level, taking into consideration the cognitive development, mathematical ability and interests of students. For low-ability students, the spiral approach to curriculum design can help in organizing bridging programmes to ensure that students of differing ability can follow them. The exemplar shown in Table 2.1 includes the topic chosen for this study. Schools with different bandings are expected to adapt the recommendation to cater for their students. This research aims to check whether the teachers involved in the study are fully aware of this.

**Table 2.1**

**Exemplar on arrangement of learning units at S1 for schools with a majority of academically lower achievers and for schools with a majority of high-ability students**

| S1 | Schools with a majority of academically lower achievers | Schools with a majority of high-ability students |
|---|---|---|
| Measures, Shape & Space | Congruence and Similarity <u>excluding construction</u> (14 – 6 + 3)** | Congruence and Similarity (14 + 3) |

** The numbers in brackets, such as (14 – 6 + 3), are interpreted as follows (CDC, 1999)

14: the number of periods assigned in the Secondary Mathematics curriculum

-6: the number of periods to be deducted because of not treating the topics in the non-foundation part

+3: the additional number of periods for enrichment or consolidation activities.

In relation to the classroom, the Curriculum Guide recommends a number of strategies for teachers when designing classroom activities. As a starting point for establishing the coding system, these strategies are used in the present study as the indicators for assessing whether teachers are catering for students' individual differences. Briefly, these strategies include:

— diagnosis of students' needs and differences;

— variation of the level of difficulty and content covered;

— variation in questioning techniques;

— variation in clues provided in tasks;

— variation in approaches when introducing concepts;

— variation in using computer packages; and

— variation in peer learning and the importance of arousing learning motivation.

In the section about the variation in the level of difficulty and content covered, there is an example in the Key Stage 3 learning unit 'Congruence and Similarity' which is the same as the content in this study. This research topic was chosen because it is relatively difficult for Secondary 1 students as it involves conceptual understanding of triangles and ratio; and also the concept of ratio has been deleted from the primary Mathematics syllabus, a change about which most secondary school teachers were not alerted.

The suggestions for less able and more able students are as follows:

- Recognize the properties for congruent and similar triangles.
- Extend the ideas of transformation and symmetry to explore the conditions for congruent and similar triangles.
- Recognize the minimal conditions in fixing a triangle.
- Identify whether two triangles are congruent/similar with simple reasons.
- Explore and justify the methods to construct angle bisectors, perpendicular

bisectors and special angles by compasses and straight edges.

- Appreciate the construction of lines and angles with minimal tools at hand.
- Explore some shapes in fractal geometry**.

** enrichment topic recommended for the more able students

In the series of lessons for each class, I will try to check which of these objectives the teacher has met.

## 2.6 Summary

This chapter introduced briefly the contextual background to the Mathematics Curriculum Guide, which provides the main guidance for this research. The key factors causing the large learning gap between students in Hong Kong's current situation include the method of allocating students from Primary 6 to Secondary 1 and the mixed-ability grouping system being changed from five to three bandings. Also, the traditional learning context in Hong Kong's secondary schools causes practical difficulties in catering for students' individual differences. For instance, Hong Kong's classrooms are large and crowded (Visiting Panel, 1982); the curriculum is examination-driven; and Chinese parents place great stress on their children's achievement (Ho, 1986). In addition, in the Hong Kong classroom, there is a heavy emphasis on lecturing, rote-learning and preparation for in-school and public examinations (Morris, 1985; 1988).

From a historical perspective, the outcomes of efforts to cater for students' individual differences in Hong Kong are discouraging. Drawing on the experience of the TOC, as well as the issues arising from the Quality Assurance Department, the Mathematics Syllabus and the Mathematics Curriculum Guide have the potential to play a significant role in helping teachers to provide for students' individual differences. This study aims to explore the extent to which the guide's suggestions are adopted in the classroom.

# CHAPTER 3
# LITERATURE REVIEW

## 3.1 Scope of the chapter

To address the research questions for this study outlined in Chapter 1, it is important to note relevant work on individual differences in general, and the Mathematics classroom in Hong Kong in particular, so that this research can be built upon previous findings. In this chapter, the relevant literature in three areas is reviewed and discussed, viz.

1 International research studies on Mathematics classrooms

2 The features of Mathematics classrooms in various countries and Hong Kong which have been studied through video. This aims to give a general picture of teaching practices and also includes a brief consideration of factors which may influence classroom teachers in dealing with student diversity – such as their conceptions about the handling of individual differences and their beliefs about teaching Mathematics using a Curriculum Guide and textbooks.

3 Several important international studies on providing for individual differences in the classroom teaching of Mathematics, particularly Hong Kong research.

Lastly, there is coverage of the literature on theoretical frameworks, which is relevant for deciding the approach to be taken in this study.

## 3.2 Research on Mathematics classrooms

### 3.2.1 International research on Mathematics classrooms

Researchers have for long been curious about students' learning of Mathematics in the classroom, especially when they have low achievement. For example, in the 1980s, a research group directed by Harold Stevenson at the University of Michigan conducted a series of cross-cultural studies comparing the mathematics achievement of Chinese, Japanese and American students. The main purposes were to investigate and identify the relationship between children's mathematics achievement in these three cultures. It was found that students from Japan, Taiwan and China attained significantly higher levels of mathematics competency than did the American students. As pointed out by Stigler and Perry (1988), after they found that US students performed at a lower level in cross-cultural tests, 'what have been particularly lacking … are studies of how mathematics is taught in classrooms in different cultures' (p. 220). In addition, it was found that this attainment level begins at elementary school and persists through high school in East Asia (Stevenson, Chen and Lee, 1993). Researchers have attributed this high Asian achievement to factors related to the classroom and teaching practices (Stevenson and Stigler, 1992), the intended and implemented curricula, and the centralized nature of the examination system (Stevenson and Baker, 1996). Some studies even suggest that Chinese children and children from other countries show differences in mathematics achievement before they receive any formal school education (Ginsburg et al., 2006; Starkey and Klein, 2008) – which relates somehow to aspects of the Chinese culture which enhance students' learning.

Also, in 1988, 800 Mathematics classes in elementary schools from four cities were observed by using systematic time-sampling and narrative observations (Stigler and Perry, 1988; Lee, 1998). A number of differences between East Asian and American Mathematics classrooms were identified. The following conclusions have been drawn regarding East Asian students' involvement in thinking, understanding and learning:

- Students are highly involved in mathematics tasks posed by the teacher.
- The frequency of students offering their ideas is significantly higher.
- Students have more opportunities to produce, explain and evaluate their solutions when solving mathematical problems.
- Students are encouraged to present one mathematical concept in a number of different ways.

As regards East Asian teaching, the aspects below were highlighted:

- Teachers always give comments or even correct students' ideas and answers comparatively.
- Teachers are also commonly involved in students' self-evaluation processes.
- The teachers' role is more like a coordinator than a judge.
- Teachers are more likely to provide learning experiences with concrete operations first, followed by abstract concepts.
- Teachers are more likely to use questioning techniques to facilitate students' constructive thinking and conceptual understanding of mathematics.

In summary, in the East Asian Mathematics classroom, students are actively involved in learning tasks and have opportunities to think mathematically; and teachers are also applying their own teaching strategies to lead students to construct mathematical concepts. Although the stereotypical Asian education system places a strong emphasis on drilling procedural skills, the data illustrated that East Asian students also have frequent classroom experience that facilitates their conceptual understanding of mathematics (Lee, 1998). Furthermore, Stevenson and Lee (1995) asserted that the form of whole-class teaching in Chinese classrooms had its advantages if the lessons were well prepared and conducted by skilful teachers.

Biggs (1996b) claimed that the teaching methods appeared to be mostly expository, focused sharply on preparation for external examinations. The Chinese classes are typically large, usually with over 40 students, and the teachers appear to Western observers to be highly top-down in their teaching and interaction with students (Ho, 2001). A number of previous studies have suggested that teachers in typical Chinese schools are considered to be authorities and superior – students are taught to respect, obey, listen to and follow their instructions, and not to challenge them (Salili, 2001). In 2003, there was an assessment of problem-solving in the Programme for International Student Assessment (PISA) which emphasized the application of cross-curricular knowledge to solving authentic problems. This domain was expected to be the weakest for learners in the East Asian regions, but both Hong Kong and Macao students performed very well in this assessment. This good performance provides us with a new view of Chinese learners, suggesting that they might not just be good at memorizing data (Watkins and Biggs, 1996; 2001) but might also be able to apply their knowledge in solving real problems.

Can we make the assumption that teachers in Chinese classrooms cater for students' individual differences more efficiently than in other countries? For example, are the teaching styles and the whole-class instruction good enough to take care of every student in the class?

### 3.2.2 Video studies

The analysis of video records as a primary data source for studying social interaction has been carried out for about 50 years (Erickson, 2004). Across this time, various approaches have brought together a variety of theoretical and empirical strands of work on:

1 pedagogy focusing on subject-matter content;

2 neo-Vygotskyan activity theory in educational psychology;

3 coding interactional behaviour and speech acts according to discrete function categories;

4 conversation analysis and ethnomethodology in sociology;

5 the ethnography of communication, interactional sociolinguistics and discourse analysis in anthropology and linguistics; and

6 context analysis.

Points 4, 5 and 6 above have emphasized detailed transcription of verbal and non-verbal phenomena. Here the first and third approaches, which relate closely to this thesis, are discussed.

*The first approach*: In educational research, researchers have tended to focus most on subject-matter content. Those studying the teaching of Mathematics use their specialized knowledge of pedagogy to identify on the video record certain phenomena of research interest, e.g. conceptually-oriented instruction to help in teaching for understanding in the Mathematics classroom. They collect first-hand experience by videotaping the lessons and analysing them to investigate closely learners' interactions with instructional materials and the details of their talk with one another and with their teachers. All the interactions between students and teachers are transcribed and then the transcripts of speech are either coded or presented as illustrative examples (e.g. Lampert and Ball, 1998; Yackel, Cobb and Wood, 1999; Sfard and McClain, 2002).

*The third approach*: This involves the coding of various functions of classroom talk. In educational research, this derived from the interactional function coding developed by the sociologist Bales (1950), as adapted by Flanders (1970), Brophy and Good (1973) and others in a variety of systems for the study of classroom interaction analysis (Chi, 1997). At that time, categories such as initiating, responding, teacher talk and student talk were used by coders who visited classrooms and noted predetermined items on scoring sheets in real time in order to identify general patterns in classroom interaction. However, nowadays, coding schemes that identify these interactional functions can be used with videotape, and repeated video review permits a much more precise kind of scoring with higher inter-judge reliability.

### 3.2.3 The characteristics of various countries' Mathematics classrooms from international video studies

Researchers have been increasingly interested in studying classroom teaching by using videotaping techniques since the 1990s because of the uniqueness of video data, which allow multiple perspectives on data analysis and interpretation. Thus, the discovery of new ideas on teaching, study of the process of teaching and merging of qualitative and quantitative analysis (Stigler and Hiebert, 1997) are made possible. The Third International Mathematics and Science Study (TIMSS) (1995–96) included 41 countries and was the largest international comparison study of mathematics and science achievement of primary and secondary students ever conducted. TIMSS also included a video study of eighth-grade Mathematics teaching in three countries: Germany, Japan and the United States. For the first time, national samples of teachers in their classrooms were videotaped. The resulting tapes were analysed both qualitatively and quantitatively to reveal and portray national levels of Mathematics teaching practices in the three countries. The major findings were described in the book *Teaching Gap* (Stigler and Hiebert, 1999). In addition, several studies based on the secondary analysis of TIMSS videos have been carried out (Inagaki, Morita and Hatano, 1999; Kawanaka and Stigler, 1999). For example, Kawanaka and Stigler (1999) described the questioning skills used in Grade 8 Mathematics classrooms in Germany, Japan and the United States. In that study, the classroom discourse was categorized as follows: (1) elicitation; (2) information; (3) direction; (4) uptake; (5) teacher response; (6) provision of answer; (7) response; (8) student elicitation; (9) student information; (10) student direction; (11) student uptake; (12) others. Also, the elicitation questioning was classified into three subcategories: yes/no; name/state; and description/explanation. It was found that, in all three countries, teachers dominated classroom talk (about 70% of the period), and student talk was mostly in the form of responses to teachers' questions. It also showed that the number of higher-order questions asked by teachers was relatively small in all three cultures. This research gave the current researcher some indication of how to analyse teachers' questions asked during lessons, and it allowed a comparison of the data from three countries with Hong Kong teachers' questioning style.

A follow-up study of TIMSS, called the 'TIMSS-Repeat Study' (TIMSS-R or TIMSS 1999), was undertaken from 2001 to 2003. At that time, the present researcher joined the research team as the country associate of Hong Kong to help in coding the videos. In this project, it was hoped to find a new round of national level of achievement. The TIMSS Video Study, in which a total of 231 randomly selected Mathematics lessons were video-recorded in Germany, Japan and the USA, described three different patterns of Mathematics lessons in the three locations (Stigler and Hiebert, 1999). It was found that different patterns shared some basic features: the class reviewing previous material, the teacher presenting problems for the day, and students solving problems at their desks. However, these activities play different roles across cultures. For example, in Germany, when presenting a problem in class, the teacher would spend quite a long time guiding the whole class to develop a solution procedure; in Japan, the teacher would let the students solve a problem individually or in small groups; and in the United States, a problem was presented in context to demonstrate the procedure which students could practise. Also, Stigler and Hiebert argue that teaching is a cultural activity in which 'script' rooted in each culture moulds a unique teaching practice.

Enlightened by the significant findings of Stigler and Hiebert (1999) on Mathematics classroom teaching in Germany, Japan and the United States, the TIMSS-Repeat Video Study (TRVS) – a component of TIMSS-Repeat Study (TIMSS-R or TIMSS 1999) – has been carried out since 1999 and this is a new round of cross-national video study. This time it included seven participant countries and areas: Australia, the Czech Republic, Hong Kong, Japan, the Netherlands, Switzerland and the United States. The goal of the TRVS is to videotape a representative sample of eighth-grade Mathematics and/or Science lessons in each country/area. Through a strict procedure of sampling, a total of 100 Mathematics lessons and/or Science lessons from 100 different schools were videotaped. Based on the TRVS report, supplemented by other small-scale qualitative classroom studies, Leung (2002) identified the following characteristics of Mathematics classrooms in East Asia, which may contribute to better performance in mathematics:

1 More demanding content

2 More deductive reasoning, justification and proof

3 More exploration of mathematics ideas

4 Higher coherence of the lessons.

There is also another international Mathematics classroom study called the 'Learners' Perspective Study' (LPS) (Clarke, 2002). The LPS was a nine-country study (on Australia, Germany, China [both Hong Kong and the Mainland], Israel, Japan, the Philippines, South Africa, Sweden and the USA) focusing on the practices and associated meanings in 'well-taught' Grade 8 Mathematics classrooms (Clarke, 2001). Each participating country used the same method to collect the data by video-recording ten consecutive Mathematics lessons in each of three schools. Post-lesson video-stimulated interviews with at least 20 students in each of three Grade 8 classrooms were then conducted (Clarke, 2002). By examining the findings from Japanese lessons in the TIMSS video study and the LPS, Shimizu (2002) explained that the pattern and the cultural script of Japanese lessons which were identified by Stigler and Hiebert (1999) always followed a common framework.

According to this framework, it was found that teachers always considered the following stages: first, the teacher posing problem(s); second, students solving the problem(s) on their own; third, whole-class discussion; and finally, summing up (exercises/extension). At each stage, the three factors, including the main learning activities, anticipated students' responses and remarks on teaching should be taken into account. Moreover, a large number of lesson plans for particular topics developed by experienced teachers and mathematics educators are available for reference. Thus, teachers, especially new teachers, can follow the framework suggested in the lesson plan and conduct their lessons in terms of the Japanese culture. However, the data in the LPS suggested that experienced teachers valued flexibility in following the Japanese pattern as they would give more consideration to the phase of the entire unit and the level of students' understanding of the topics being taught. When conveying a view of mathematics, Japanese teachers always placed authority, not in the teachers, but in the methods themselves. There are multiple ways to solve a single problem and the methods for solving problems must be evaluated by mathematical discourse and argument.

### 3.2.4 The characteristics of the Hong Kong Mathematics classroom

In addition, several influential observation and video studies on Mathematics classrooms and some small secondary video analysis studies have been conducted in Hong Kong, as noted below:

1 In 1982, a report by an Organization for Economic Co-operation and Development (OECD) Visiting Panel stated:

> The lessons we observed tended to be teacher-centred, with little use of aids beyond chalk and blackboard. In 'non-exam' years, the atmosphere seemed fairly relaxed, but in the examination preparatory focus all was deadly earnest and students were seen taking notes, laboriously completing model answers and learning texts by rote.

Although this study took place thirty years ago, it still reflects the current situation. and is in line with Biggs' (1996) claim that teachers focused on preparation for external examinations.

2 Based on 112 mathematics classroom observations in junior high schools in Beijing, Hong Kong and London, Leung (1992, p. 302) described the structures of Mathematics lessons in Beijing and Hong Kong as follows:

> A typical lesson in Hong Kong consists of firstly reminding students of what they have learned in the last lesson, then explaining and illustrating the new content and presenting some work examples on the board. Thirdly, students are asked to do class-work and write their work on the board. Finally, [the] teacher discusses the exercise, summarizes the lesson and assigns homework. When compared with the lessons in London, it has been found that the lessons in Beijing and Hong Kong are relatively well-structured, there is less or even no off-task time, less group work, more whole-classroom instruction and more emphasis on memorizing mathematical results and presenting solutions in a fixed format.

3 In 1996 the Education Commission observed that:

> Teachers in general adopted the teacher demonstration approach in classroom teaching. Teaching aids were often used by teachers. Class work sessions were arranged in most of the lessons observed but not used to the best effect. Some teachers still assigned class work at the very end of lessons after they had delivered their expository teaching. Some teachers were too text bound. They were unable (or unwilling) to make due adjustments to the depth of treatment of individual topics to cope with different abilities of pupils.
>
> (Morris et al., 1996, p. 2)

4 The classrooms in Hong Kong have consistently been portrayed as involving the 'three Ts: teacher-centred, textbook-centred, and test-centred' (Morris et al., 1996, p. 4).

5 Based on observations of 197 Chinese lessons, Mok et al. (2001) found that a lesson usually consisted of a sequence of learning activities, which involved a teacher-led whole-class discussion with a focus on a specific theme, or completion of a learning task/worksheet by students individually or in groups. Nearly all lessons contained episodes of whole-class teaching and the majority of these episodes consisted of teacher–student or student–student interactions. Furthermore, the analysis of interaction indicated that the teacher spent most of the lesson time in direct teaching and questioning. However, the corollary of the high proportion of teacher-centred activities did not show that the students were learning passively because there was evidence that students were active in the TOC (the Target Oriented Curriculum) classroom.

6 Based on a cross-cultural survey which included 179 secondary teachers in Hong Kong and 249 secondary teachers in New South Wales (NSW), Australia, Perry, Wong and Howard (2002) found that secondary Mathematics teachers in Hong Kong are more likely to use both the child-centred and knowledge-transmission approaches than their counterparts in NSW. The Hong Kong teachers, in an examination-driven climate, experience a community expectation: students have to achieve well in the subject. This explains why these teachers use the knowledge-transmission approach frequently as they have to meet the high expectations of society. At the same time, students' understanding of mathematics is another major concern in secondary Mathematics, and so Hong Kong teachers also employ a child-centred approach more frequently than their NSW counterparts.

7 Based on data from the TIMSS 1999 Video Study, Leung (2005) analysed the characteristics of Mathematics classrooms in Hong Kong. From the quantitative analysis of the coded data, he concluded that teachers dominated the talk and students did not talk much in the classroom – but they were exposed to more new instructional content. Students worked on the mathematics problems which were presented mainly using mathematical language. These problems were more complex, took students longer to solve and involved more proof. In the judgement of an expert panel on Hong Kong lessons, more advanced contents were covered and lessons were more coherent. The presentations of mathematics were fully developed by the teachers, and students seemed more likely to be engaged in the lessons. The overall quality of the teaching was judged to be high.

8 Also, from observations of the Year 1 classes, Mok and Morris (2001) characterized the classrooms as involving 'whole-class teacher-pupil interaction and highly structured group/pair work'. The teachers tried to engage students in discussion, mathematical reasoning and problem-solving, but they were found to lead students on a predetermined solution pathway rather than allowing more open investigation and exploration of mathematical ideas (Mok, Cai and Fung, 2005). More recently, Mok and Lopez-Real (2006) noted little use of group work or open-ended questions suitable for exploratory problem-solving in the lessons of Hong Kong secondary school teachers.

### 3.2.5 The use of Mathematics curricula and textbooks

Recently, in order to meet the challenge of societal change and the advances in technology, the primary and secondary Mathematics curricula have undergone revision. To allow flexibility, the revised Secondary Mathematics curriculum consists of foundation/non-foundation components[1] and enrichment topics, while the revised Primary Mathematics curriculum includes foundation and enrichment topics. The revised Secondary Mathematics curriculum has been in use since September 2001 (Education Department, 1999).

Over the last decade or so, educational researchers have continually pointed out the lack of research on textbooks and their roles in teaching. Park and Leung (2002), who compared the Mathematics textbooks for Grade 8 in China, England, Japan, Korea and the United States, noted that, in many East Asian countries, teachers and students regard the textbook as a 'bible' which contains all the essential knowledge. They argued that, since the public examinations in these countries are based on national curricula, students rely heavily on the textbooks in order to pass the examinations and be promoted to the next stages of schooling. In fact, textbooks are recognized as literally the sole and most important teaching tool, around which class activities are organized. From the research video data, most Hong Kong secondary school teachers are using textbooks to teach as they believe they cover all the contents listed in the curriculum – and so they feel they do not need to worry about the public examination curriculum if they stick to the textbooks.

Textbooks in Hong Kong are published by commercial publishers. Although schools can select their own textbooks (Park and Leung, 2006), the contents and format of all textbooks are basically the same. This happens because publishers have to follow strictly the rationale and contents that are listed in the curriculum issued by the Education Bureau (EDB) if they wish to be approved by the EDB. All textbooks usually follow a standard format: definition of a theorem, proof of the theorem, worked examples and exercises. However, not much emphasis is put on the cultivation of interest or the development of problem-solving abilities.

## 3.3 International views on catering for individual differences in classroom teaching

In Chapter 2 (section 2.3.1), various forms of grouping of students were outlined. The challenge of addressing diverse students' needs encourages us to reflect on the implications of placing students in various ability groups or tracks for Mathematics instruction. Overall, the student should be the reference point for addressing the

[1] The foundation component is the essential part, emphasizing the basic concepts, knowledge, properties and simple application in real-life situations. It represents the topics that all students should strive to master. The remaining topics constitute the non-foundation part of the curriculum.

complex issue of who should learn what Mathematics and when. Whatever form of grouping is adopted, this does not in itself constitute provision to match pupils' needs. The grouping methods should therefore be flexible, regularly evaluated and modified as necessary to meet every pupil's requirements.

### 3.3.1 Research on the effects of ability and mixed-ability grouping on student learning

There has been extensive research on the impact of various types of groupings on student learning. For example, Hallam and Ireson (2006) found that able pupils in the UK prefer to learn in ability sets, and felt that this strategic streaming method may help those students. However, Sukhnandan and Lee (1998) maintain that streaming and setting reinforce social divisions and have no known impact overall on students' attainment, except in the case of those identified as gifted. Similarly, Kutnick et al. (2005a) view the evidence on the effect of grouping strategies as limited, and argue that pupils' abilities vary even within subjects, depending on the aspect of the subject taught, the type of task set and their preferred learning styles

Sometimes, school communities seek to address differences in student achievement by grouping students with similar attainment together, but there seems to be a consensus that this practice has the effect of reducing opportunities, especially for students placed in the lower groups (Boaler, 1997; Zevenbergen, 2003). This can be due partly to the effects of a self-fulfilling prophecy (e.g. Brophy, 1983), and partly to the influence of teacher self-efficacy – that is, the extent to which teachers believe they have the capacity to influence student performance (e.g. Tschannen-Moran, Hoy and Hoy, 1998).

Also, from a research review in the United Kingdom on secondary school studies (Harlen and Malcolm, 1997), it was found that in many cases streaming showed no advantages for students' achievement. On the contrary, the research indicated that there are disadvantages such as the reinforcement of social-class divisions, an increased likelihood of delinquent behaviour in later school years, lowered teacher expectations of the less able, bias and inconsistency in allocating students to ability groups and anxiety for students in the top streams who are struggling to keep up with the pace of the class.

Overall, the research evidence provides no support for separating students according to ability as a solution to the problem of catering for individual needs. Indeed, it shows that, for many, ability grouping reduces both their motivation and the quality of the education they receive. Research suggests that ability grouping does not provide the same educational experience for all students. A study comparing mixed-ability to same-ability Grade 7 and Grade 8 Mathematics classes in one Israeli school found that there were significant losses for middle- and low-ability students in the same-ability classes, and insignificant gains for high-ability students (Linchevski and Kutscher, 1998). Also, in their study of 45 English schools, Ireson, Hallam and Hurley (2002) found that there were gains for high-achieving students in streamed classes, and slight losses for low-achieving students. International studies have pointed out the effectiveness of Japanese mathematics teaching where classes through elementary and middle school are mixed-ability and socially diverse (Schaub and Baker, 1994; Stigler and Hiebert, 1997; Okano and Tsuchiya, 1999).

Besides, instruction in the lower tracks tends to be fragmented, often requiring mostly memorization of basic facts and algorithms and the filling out of worksheets. Higher tracks are more likely to offer opportunities for making sense of mathematics, including discussion, writing and applying mathematics to real-life contexts. There is a conflict between the structure of academic ability groups and the potential academic and intellectual growth of struggling students who may be late bloomers. While students with learning difficulties and gifted students clearly differ substantially, they are both ‘at risk’ of underachieving in mathematics (Diezmann, Thornton and Watters, 2003). Students facing difficulties have also been excluded in more subtle ways such as streaming (or ‘tracking’) (Zevenbergen, 2001, 2003), reduced access to the curriculum (such as ‘core only’ mathematics classes) (Faragher, 2001) or through altered teaching approaches (Norton, McRobbie and Cooper, 2002). Optimally, all students, including those with learning difficulties, need opportunities to engage in a programme that encompasses all strands of the Mathematics curriculum and includes tasks that challenge their mathematical thinking.

Since ability grouping appears at best to help only high-track students, what about the merits of mixed-ability grouping, i.e. grouping students by different abilities for the purpose of cooperative learning? Mixed-ability grouping is believed to increase student equity and achievement – especially for poor and minority students. However, many problems have been identified as resulting from such grouping, such as inappropriate criteria for selecting students in a group, and overrepresentation of either high- or low-ability students in a group when assigning tasks for them (e.g. the group leader being a high-ability student and the time-keeper being a student of low ability). Also, teachers have found that the high-ability students did all the work, and it was not clear that slow students learned anything. In a study of a high school (Rosenbaum, 1999), teachers noted three unexpected outcomes which disappointed them when applying mixed-ability grouping:

1 Mixed-ability grouping presented them with irresolvable conflicts – teachers tried to steer a middle ground by teaching to the middle of the class; but as they did so, they were acutely aware of losing students at both extremes. Besides, they also emphasized the impact on faster students, with all of them feeling that mixed-ability grouping served poorly the needs of these students. The teachers discovered that:

- the faster students were rarely receptive to doing more tasks, especially when they knew that teachers couldn't reward them for it;
- they did not feel they could present demanding topics or approaches without confusing most students and failing to help slower students with basic topics they had not understood;
- as they had to be intelligible to all students, they used language that was generally far below the vocabulary of high-ability students;
- if they slowed the pace and rephrased a point three or four times to make sure that everyone understood, high-ability students gave up; and
- they had to determine one standard or several standards.

2 It imposed a uniformity that deprived high-ability students of challenge and slower students of mastery.

3 It raised doubts about the legitimacy of the class, even in the teachers' own minds.

All the teachers believed that mixed-ability grouping harmed slower students academically because they could not reduce the pace of the class enough to allow them to keep up or give them the individual attention they needed. The teachers found that the slowest students needed extra help they could not provide during the class period, and they urged these students to come after class – but few ever did. They also felt that middle-level students were often overlooked in schools: they rarely got individual attention even when they needed it, and mixed-ability grouping may make this even worse. In short, mixed-ability grouping raises a number of difficulties. For example, it:

- does not abolish inequality among students – it ignores it as much as possible, and therein lies its successes and failures;
- forces teachers to ignore high-level topics;
- makes high-ability students suffer from lower education standards; and

- may be harmful to low-income and minority youth who are high achievers.

Since mixed-ability or ability grouping raise many problems, it is important for teachers to know how to deal with students' individual differences. However, teaching mixed-ability classes has never been easy, and devising effective ways of accommodating students' individual differences and learning difficulties presents a major challenge for all teachers. As Rose (2001, p. 147) has remarked: 'The teaching methods and practices required for the provision of effective inclusion are easier to identify than they are to implement'.

Smith and Sutherland (2003) examined how teachers in schools formulate decisions about student organization, using a small sample of primary and secondary schools from across Scotland. The teachers interviewed from the six schools operating mixed-ability organization perceived the following to be advantages:

- There was less labelling of students.
- It was easier to maintain the motivation of the weaker students.
- There was greater flexibility for students to progress at their own rates.
- More students benefited from peer support.

Disadvantages were also identified, viz.

- Teachers had to do more preparation work.
- It was difficult to provide able students with appropriate challenges.
- It was difficult to undertake whole-class lessons because of the range of student ability

Nine schools were involved in organizing their students by setting – five secondary and four primary schools. The teachers considered the advantages of setting to be as follows:

- It encouraged teamwork and collaboration with colleagues in primary schools.
- A different ethos was created, which focused students' attention on their work.
- Preparation and classroom management became easier for the teacher.
- More whole-class teaching could take place.

Disadvantages were also mentioned, viz.

- Motivating students in the lower sets was difficult.
- The sets were often fairly rigid and inflexible.
- Moving students from one set to another, particularly with those moving up a set, was problematic in two ways. First, if the top set was full, then there was no space for a student who might be better placed in that top set. Second, the curriculum was seen to be so different between sets that a smooth transition between one set and another was difficult to achieve
- Staffing issues arose.

The issue of whether the adoption of particular organizational arrangements has an impact on pedagogy remains to be addressed seriously. A study by Hallam et al. (cited by Ireson, Hallam and Hurley, 2002) found that the teachers involved in set arrangements had a narrower definition of direct teaching than those in mixed-ability arrangements. An assumption of homogeneity led to the belief that all students could work at the same pace and in the same way. This, once again, contradicts what more than one student reported in Smith and Sutherland (2002) – '… although it's ability it's still mixed!' There was a clear perception from the teachers interviewed for this study that setting was easier for them to manage.

In two different research studies in England and the USA, Boaler (2008) followed students through secondary schools to investigate the impact of different teaching and grouping methods upon learning. In both studies, the schools that used mixed-ability approaches produced higher overall attainment and more equitable outcomes. However, in both cases, the Mathematics departments that achieved this employed particular methods to make the mixed-ability teaching effective. The whole-school approach adopted was training students to treat each other with respect: they learned to appreciate the contributions of students from different cultural groups, social classes, genders and attainment levels, and developed extremely positive intellectual relations. The learning environment created in this school was so good that students could feel free to show their differences and contribute their ideas in the group work during the lessons.

Also, in a paper about secondary students' experiences of ability grouping, Kutnick et al. (2005b) suggest that setting in Mathematics has a negative effect on both attainment and motivation, with the exception of slightly improved attainment for top-set students. The authors conclude that setting promotes a more inflexible style of teaching than mixed-ability classes, and creates unreasonably low or high expectations for the students in the lower and top sets. The effects of ability-setting on teaching practices and the curriculum in the secondary school included the following:

- The best teachers were allocated to the top sets, despite evidence that high-quality teaching is more beneficial to students of lower attainment.
- There was curriculum polarization, which meant that moving between sets was very difficult because they followed different syllabuses.
- There were unreasonable expectations of the top sets, reflected in a fast, procedural teaching style
- There was a lack of differentiation within sets, leading to many students finding the pace either too fast or too slow.

The study also found that mixed-ability teaching, by contrast, encouraged teachers to see students as having different needs, abilities and working styles.

Finally, Clarke and Clarke (2008) in Australia addressed the question: 'Is time up for ability grouping?' and listed many issues raised by the practice of ability grouping, as follows:

- Most students are disadvantaged by classes grouped according to ability, with the only gains being slight or non-significant in a statistical sense for higher-ability students (Slavin, 1990; Lou et al., 1996; Boaler, Wiliam and Brown, 2000; Wiliam and Bartholomew, 2004).
- The greater the use of ability grouping in a country, the lower the overall performance of that country on international assessments.
- There is a temptation for teachers to teach the so-called 'like-ability' classes as the middle level since they believe that individual differences have been taken care of.
- Schools assign their least-qualified teachers to the lower ability classes.
- Teachers of lower classes often have low expectations of students.
- Students are often grouped according to narrow criteria, and it is assumed that these classes are appropriate for all kinds of tasks.
- In practice, students rarely move up.

### 3.3.2 The importance of catering for individual needs

Theoretically, heterogeneous instruction emphasizes a differentiated classroom approach, in which teachers diagnose student needs and design instruction based upon their understanding of mathematics content using a variety of instructional strategies that focus on essential concepts, principles and skills. The following instructional elements have been shown to be effective for mixed-ability mathematics classes (Tsuruda, 1994):

1 A meaningful Mathematics curriculum
2 An emphasis on interactive endeavours that promote divergent thinking within a classroom.
3 Diversified instructional strategies that address the needs of all types of learners i.e. presenting information in a variety ways.
4 Assessment that is varied, ongoing, and embedded in instruction. Performance assessments, a portfolio of growth and achievements, projects demonstrating the accompanying mathematics, and solving and reporting on complex problems in varied contexts will provide evidence of student learning.
5 Focused lesson planning that involves understanding what students need to learn (outcomes) and assessing what they already know.

There is a traditional Chinese cultural belief that learning depends upon the capacity and aptitude of the learner. In line with Confucius' theory about the limitations and the reality of individual differences in intelligence, teachers should follow the susceptibility of the learners in communicating knowledge. If several students asked the same question, Confucius answered it differently depending on their varied ability levels and backgrounds (Tong, 1970); and so approaches to teaching should pay attention to the principle of individual differences step-by-step. To help individual students to achieve appropriate learning outcomes, the teacher must first study the learning material in depth to tease out its critical features; and he/she should then ascertain the limited number of qualitatively different ways in which students may understand it, which will subsequently become a useful resource in lesson planning. The learning content does not mean just 'facts'; rather, it refers to knowledge, a skill, or an attitude that is considered to be worthwhile and relevant for the students to learn. Attention should also be paid to what students should be able to do with the content of learning, and the capability that can be developed as a result of learning it.

In 2001, two studies were carried out in Hong Kong about how primary and secondary school teachers meet the personal and academic learning needs of students officially identified with specific learning disability in their classes. They found the teachers involved made relatively few adaptations to accommodate differences among their students (Chan et al., 2002; Yuen, 2002). The following list shows the most commonly used strategies reported by the Hong Kong teachers:

- Individual assistance during the lesson
- Offering more time for students to finish work
- Re-teaching key concepts to students
- Placing students closer to the teacher
- Arranging for peers to give students extra assistance
- Checking students' work frequently
- Asking students questions of the appropriate level of difficulty
- Allowing a longer waiting time to let students answer orally.

One can see that the most commonly applied strategies do not need to be planned or prepared in advance of the lessons. Teachers respond to students' individual needs mainly by the way they conduct and manage the lessons. These results are consistent with similar studies in other countries (e.g. Ellet, 1993; Weston et al., 1998) where the most frequently reported strategies were (i) providing students with extra support, (ii) giving extra guidance, and (iii) simplifying instructions during the lessons.

The research literature suggests that the most powerful teaching strategy for helping those students is peer assistance. If teachers develop a student-to-student support network within every class, students can help each other easily (e.g. Topping, 1995; Arthur, Gordon and Butterfield, 2003).

It appears that, although theorists exhort teachers to teach adaptively, tailor the curriculum and modify resource materials to suit a wider ability range (e.g. Tomlinson, 1999; Janney and Snell, 2000; Lovitt, 2000), many teachers are unwilling or unable to act on this advice. In systems geared closely to progression through examinations, as is the case in Hong Kong, there is also a reluctance to modify curriculum content and the ways in which students are assessed, even though such changes are strongly advocated (e.g. Education Department, 2001; Tomlinson, 2001). Pedagogical training organized for university teachers has been shown to be effective in changing teachers' approaches towards being more student-centred. Gibbs and Coffey (2004) showed that a long training process (over one year) enhanced the adoption of a more student-centred approach to teaching.

The points mentioned above also appeared in Hong Kong schools, where most teachers have not been trained to cater for students' individual differences in mixed-ability classes. Are they handling this issue by using methods suggested in the

Curriculum Guide? (A full discussion of the Curriculum Guide was provided in Chapter 2.) If not, what approaches do they employ? This study tries to explore the kinds of methods teachers are using in practice in teaching Mathematics in Hong Kong secondary schools.

## 3.4 Hong Kong research

In Hong Kong's secondary schools, 'tracking' or 'ability grouping' is the normal practice for grouping students by their academic ability from Secondary 1. Pupils have to sit a pre-S1 test once they are allocated to a school, and schools use these test results to stream them. The assumption is that, if they are grouped by ability, then they can get the instruction they need to learn the academic material. Students assigned to a class are supposed to be in the same track, but actually they are not. This is because, as noted in the previous chapter, schools usually track students by their overall results in three main subjects – Chinese, English and Mathematics – and students in a high-ability group might be weak in Mathematics. Inside the class, there is still a great diversity of ability which, in my experience, Mathematics teachers find difficult to handle.

Wong et al. (1999) carried out an analysis of the views of various sectors on the Mathematics curriculum. In this study, 370 primary and 289 secondary Mathematics teachers responded to a questionnaire in which they were asked whether the following ways of catering for individual differences was implemented in their schools – and, if so, how effective they were. These methods were:

1 streaming according to ability;

2 remedial /small-group teaching;

3 having different teaching schedules for different classes;

4 teaching according to the Guideline for Tailoring the Syllabus issued by the Curriculum Development Council;

5 using different teaching materials (including worksheets) for different classes; and

6 using different assessment standards (including different sets of test papers) for different classes, with the teachers making the adjustments themselves.

The results showed that the most common methods for addressing individual differences in the junior secondary school were:

- teachers handling it by themselves in teaching (65.5%);

- remedial teaching (46.9%); and
- grouping students of like ability into different classes.

Junior secondary schools exhibited more of the methods listed in the questionnaire than at the other levels, with five of them being over 30%.

In the schools where the measures listed above were taken, they were found to be effective, except for the use of different test papers at the primary level. The data showed teachers had a tendency to tackle individual differences by adjusting their teaching themselves and were not inclined to adopt more systematic ways such as setting different assessment standards for different classes, where fairness was an issue of concern. They seldom used the curriculum documents or seminars as a source of help. In the conclusion of this report, mixed-ability, large class size and individual differences were perceived as major problems in teaching Mathematics in Hong Kong. Although this research was conducted over twelve years ago, the findings on how teachers catered for individual differences are still relevant today. However, this study did not look into the classroom practice. The investigation of the means for handling individual differences during lessons should be tackled carefully to check what methods teachers actually used. The Education Department, therefore, funded local universities to work on the issue of providing for students' individual differences in several projects.

### 3.4.1 Funded projects on catering for individual differences

The web-page on 'Catering for individual differences' (EDB, n.d.) states that 'In order to explore ways of catering for student diversity, the Curriculum Development Institute (CDI) conducted the 'Study on Strategies to Cope with Individual Differences in Academic Abilities of Primary School Pupils' from the school year 2000 to school year 2003'. This three-year research and development project involved the tripartite collaboration of the CDI, schools and tertiary institutions on the following projects: (1) 'Building on Variation'; (2) 'Use of Information Technology'; (3) 'Cross Level Subject Setting'; (4) 'Motivation and Models of Learning'; and (5) 'Developing a Community of Learners'. These studies investigated the use of five different strategies for attempting to cope with student differences in the context of Hong Kong primary schools. The findings, examples and recommendations were intended to help teachers to, 'understand what students need, how they learn, and in what ways quality learning can be enhanced'. The five strategies which it was suggested teachers should employ to address students' needs at an early stage were:

1 using co-operative learning;

2 adopting cross-level subject setting;

3 varying teaching from the viewpoint of the students;

4 pacing learning and teaching according to the abilities of students; and

5 using information technology as a learning tool.

(from the same web-page as mentioned above)

### 3.4.2 Local researchers' points of view on catering for individual differences

Since the above projects focused primarily on studying possible methods to cater for individual differences and enhance students' learning, they are quite different from the present study which aims to find out the methods teachers currently employ to cater for student diversity during their daily teaching. However, the projects give insights into various possible recommendations for an actual primary school setting which might also work in secondary schools. Also, some of the ideas in the projects raise issues for the present study, as can be seen in the two projects outlined below.

#### 3.4.2.1 *The conceptions of individual differences among Hong Kong teachers*

In the paper 'Conceptions of individual differences: a phenomenographic study of teachers' ways of experiencing and coping with student diversity' (Tang and Lau, 2001), the research team tried to illustrate the conceptions of individual differences held by primary school teachers by using a phenomenographic methodology. The study identified two orders of perspectives. The first examined certain theoretical positions and derived the 'correct' conception of individual differences in the classroom; and the second focused on how teachers described their own experience of individual differences in their classes. The teachers' conceptions were then compared with their classroom strategies. Finally, the findings were discussed with reference to some phenomenographic studies on the conceptions of teaching and learning. This research is very important for the current study as knowing how teachers perceive individual differences correlated directly with how they catered for student diversity. The paper established a five-level hierarchy to describe the most prominent features of the variation in the conception of individual differences. There were variations in:

1 performance;

2 readiness for learning;

3 speed of learning;

4 styles of learning; and

5 ways of classroom interaction.

Since the ways of experiencing individual differences in the classroom may be related to how the teachers conceive teaching and learning, there were two dimensions of these conceptions in relation to teaching. The first related to the nature of individual differences in the classroom – whether it is a problem to be dealt with, a neutral phenomenon or a potential to be realized in bringing about better learning. The other dimension was concerned with whether the teacher should just accept the situation or should adjust teaching to cope with it, or activate better learning by making use of it. The results highlighted that most teachers perceived individual differences in terms of variation in performance. The performance levels were seen as characteristics of individual students which were inborn, and were believed to be invariant over time and conditions. It was clearly difficult for those teachers to handle the problem if they perceived students' abilities or capacities to be stable – so the project team members had to change teachers' conceptions by leading them to experience the use of cooperative learning to cope successfully with individual differences. It was found that this sometimes repositioned teachers' conceptions.

**3.4.2.2** ***Methods for catering for individual differences – planning before teaching***

The other project 'Catering for individual difference – building on variation', directed jointly by Lo, Pong and Marton, led to the publication of a book *For Each and Everyone*, which mainly reported the research (Lo, Pong and Chik, 2005). The project team worked closely with two primary schools throughout the study period (2000–03) to find ways to help teachers improve their ability to deal with student diversity by putting variation theory into practice. The researchers adopted a lesson study approach, firstly developing a research lesson for a single- or double-lesson time-slot over a series of meetings, and then shared their wisdom and pedagogical content knowledge to better understand and handle the learning content. Finally, the team made conscious and systematic use of variation theory when designing the research lesson by focusing on what was to be varied and what remained invariant. When the time came to conduct the lesson, teachers would take turns in implementing it in several cycles, in each of which one teacher taught while the others observed and took notes. They met after the lesson to discuss its outcomes and any improvements that the teacher needed to make in the next cycle. In this project, the research lessons were also videotaped to allow detailed analysis, and student learning outcomes were measured by a pre- and post-test. At the conclusion of the process, the team evaluated the lesson and suggested further improvements to it.

A total of 27 lesson studies were conducted, and the results showed a remarkable improvement in student learning outcomes. In all but two of these studies, the weaker students showed significantly greater gains than did the higher achievers, which narrowed the achievement gap between the two groups. The results gave support to the team's belief that the adoption of more systematic methods of planning and carrying out lessons, aided by variation theory, can have a much stronger effect on students who are classified as academically less able, enabling them to learn almost as well as their counterparts who have been classified as more academically able (Kwok and Chik, 2005, p. 121). The team attributed these improved student learning outcomes also to the improvement in the teachers' teaching approaches. It was found that, although each lesson study focused on only one lesson, the teacher learning that resulted went far beyond a single lesson.

From the above studies, it is clear that Hong Kong researchers have been trying different approaches to help teachers to cater for student diversity by introducing methods such as cooperative learning or lesson studies. They wanted to change teachers' normal practice of teaching as they play a key role in shaping student learning (Darling-Hammond, 2000; Pong and Morris, 2002; Fishman and Davis, 2006), which is a somewhat difficult task. For example, in the first study above, the research team needed to alter most teachers' conceptions of individual differences and get them to believe that cooperative learning among students could be used to enhance their learning. In the second study, teachers needed to prepare well for their lessons and build the variation theory into their teaching in order to help students. Both projects were changing the original practice of teaching but might not be maintained in the long run. To avoid rote implementation of an innovation, there is a need to explicate the innovation mechanism (Lewis, Perry and Murata, 2006). Therefore, a manual for conducting a learning study (Ko and Kwok, 2006) and a number of case studies were published (e.g. Lo, Chik and Pang, 2006; Lo, Hung and Chik, 2007) to explain in detail the mechanism by which a learning study results in instructional improvement.

In the present study, it is hoped to discover the general methods teachers adopt in providing for individual differences, if any already exist, and further elaborate on them. In this regard, it is useful to look at the research in various countries, in addition to Hong Kong's Mathematics classrooms, to know more about the characteristics of these lessons.

## 3.5 Theoretical framework

### 3.5.1 Introduction

Eisenhart (1991) described a theoretical framework as 'a structure that guides research by relying on a formal theory … constructed by using an established, coherent explanation of certain phenomena and relationships' (p. 205). Marshall and Rossman (1989) explain how a researcher locates a research problem in a body of theory: the location is chosen on the basis of the researcher's own underlying assumptions, and these assumptions must be explicitly stated. Thus, theoretical frameworks can be expected to invoke a host of values and beliefs, not unique to the researcher, but shared in a common paradigm with other scholars.

On the other hand, a conceptual framework is described by Eisenhart (1991) as 'a skeletal structure of justification, rather than a skeletal structure of explanation' (p. 209); and this structure is based on either formal logic or experience. As such, it consists of an argument which can incorporate differing points of view, and which culminates in the articulation of a rationale for the adoption of some ideas or concepts in favour of others. The chosen ideas or concepts serve to guide the data collection and analysis:

> Crucially, a conceptual framework is an argument that the concepts chosen for investigation or interpretation, and any anticipated relationships among them, will be appropriate and useful, given the research problem under investigation (ibid.).

What I have chosen to do is organize some main assumptions underlying the study in what I call the theoretical orientation of social constructivism. These assumptions are intended to cover broadly the domains of knowledge and learning, and the teaching effectiveness. Also, in establishing the perspective of the study, it is shown how these views are derived from or tied to existing bodies of theory in the literature on the nature of mathematical knowledge, how one comes to learn and what this means for effective teaching. While the theoretical orientation lays out a more general attitude, what I refer to as the conceptual framework looks more specifically at the issue of dealing with individual differences, which are closely related to the notion of variation. As such, a working model for studying conceptions of catering for individual differences is established. This framework guides the study by helping to inform not only the statement of the research questions, but also the design of the data collection and subsequent analysis to help answer the questions. It also indicates what concepts related to catering for individual differences should be examined, and in what context.

### 3.5.2 Constructivism: a philosophy of knowledge and learning

As I mentioned briefly in discussing my research interest, my study of how individual differences are handled in the teaching of mathematics is based on constructivist theory – an area in which my perceptions have developed considerably over and beyond the period of research. Arguments are rife in the mathematics education community regarding constructivism as a theory for learning mathematics, as well as about its status and underpinnings (Ernest, 1994; Lerman, 1994). The perspective presented here largely traces the development of my own thinking, related to what others have written, up to and including the period of the study.

Radical constructivists call into question the notion of a body of knowledge independent of the knower and capable of being transmitted to passive learners. Rooted in the work of Piaget, radical constructivism holds that knowledge is not passively received but rather actively constructed and interpreted by learners as they try to make sense of their experiences. 'Learning is not a stimulus-response phenomenon. It requires self-regulation and the building of conceptual structures through reflection and abstraction. Problems are not solved by the retrieval of rote-learned "right" answers' (von Glasersfeld, 1995, p. 14).

This study of the process of catering for individual differences during whole-class teaching was situated within a particular way of thinking about the teaching and learning of mathematics. Therefore, I begin with a description of the epistemological and pedagogical perspectives that informed my work. Cobb and Bauersfeld (1995) identify two general theoretical positions on the relationship between individual and social processes and learning, both of which are significant for the present study. The first position involves the treatment of learning as an individual constructive process; and the second considers learning as acculturation into social practices and traditions. Each of these positions is outlined below and then a third position that accommodates both the social and psychological processes of learning is considered. Finally, a way of thinking about the process of teaching that builds upon the third perspective is described.

There are two theoretical perspectives on learning which have dominated the research area for a considerable time. One is radical constructivism (e.g. Piagetian theory), which considers learning to be mainly an individual psychological process. The other, so-called ‘situated cognition’ is a notion which includes a range of perspectives (e.g. social constructivism, the Vygotskian perspective) and emphasizes the importance of cultural practices, language and other people in bringing about knowledge (Marton and Booth, 1997). Radical constructivists call into question the notion of a body of knowledge independent of students and capable of being transmitted to passive learners. However, radical constructivism holds that knowledge is not passively received but rather actively constructed and interpreted by learners as they try to make sense of their experiences. Radical constructivists believe that the individual’s environment, including social processes, plays an important role in learning; but they view learning as primarily an individual cognitive activity. The sociological perspective, which is now examined, focuses on learning as participation in social processes, with individual cognitive activities contributing to the development of the social.

While the radical and social constructivist perspectives have their particular emphases, Ernest (1994, p. 485) derived a set of theoretical underpinnings common to both, viz.

1 Knowledge as a whole is problematized, not just the learner’s subjective knowledge, including mathematical knowledge and logic.

2 Methodological approaches are required to be circumspect and reflexive because there is no ‘royal road’ to truth or near truth.

2 The focus of concern is not just the learner’s cognitions, but the learner’s cognitions, beliefs, and conceptions of knowledge.

3 The focus of concern with the teacher and in teacher education is not just with the teacher’s knowledge of subject matter and diagnostic skills, but with the teacher’s beliefs, conceptions, and personal theories about subject matter, teaching, and learning.

4 Although we can tentatively come to know the knowledge of others by interpreting their language and actions through our own conceptual constructs, the others have realities that are independent of ours. Indeed, it is the realities of others along with our own realities that we strive to understand, but we can never take any of these realities as fixed.

5 An awareness of the social construction of knowledge suggests a pedagogical emphasis on discussion, collaboration, negotiation, and shared meanings ... .

However, both schools are clearly dualist in nature as they locate the mind inside and the world outside. Therefore, they face a serious problem: how can the mind create and self-correct at the same time if the mind is separated from the world (Marton and Booth, 1997; Prawat, 1999)? It is because of this paradox that some non-dualism theories such as interactionism and phenomenography have come to the fore. For example, according to phenomenography, 'the world we deal with is the world as experienced by people, by learners – neither individual constructions nor independent realities; … There is only one world, but it is a world that we experience, a world in which we live, a world that is ours' (Marton and Booth, 1997, p. 13).

Moreover, as is emphasized by several researchers, there is a pressing need to seek a new approach to address learning in the research enterprise (Bauersfeld, 1992, 1995; Saxe and Bermudez, 1992; Cobb and Bauersfeld, 1995; Confrey, 1995). For instance, Cobb and Bauersfeld (1995) acknowledged that they draw on constructivism, which characterizes learners as active creators of their ways of mathematical knowing, and on interactionism that sees learning as involving the interactive constitution of mathematical meanings in a (classroom) culture. Confrey (1995) asserted that we need to recognize that individual and social development shape each other as experience and context are intermingled, and seek an appropriate balance between them. According to the above argument, it is critical to balance the relationship between the individual and world when studying the process of teaching and learning in classrooms. Also, over the last decade, there has been a change from seeing education as a process of transformation to a process with actively involves learners. Subsequently, the learning process that takes place in classrooms has been of interest to many classroom researchers, such as Jaworski (1994; 1998) who studied how teachers enhance students' active construction of mathematical knowledge. There are studies of 'investigative teaching' which can be characterized under the following headings: management of learning, sensitivity to students and mathematical challenge. Another way of analysing classroom interaction was reported by Voigt (1994, 1995, 1996; Krummheuer, 2011), in which the unit of analysis is the negotiation of meaning that takes place in the interaction between the teacher and students or among the students themselves. Voigt attaches great importance to the interaction and the negotiation of meaning for learning. Some examples of interactions are repeating questioning, requesting, telling or managing.

My study does not consider students' mathematical development directly. Rather, I examine teachers' efforts to engage students in certain kinds of classroom discourse. Although I focus on the classroom community as a whole, and the efforts of the teachers to establish norms and practices at this level, I consider teachers' efforts to be informed and constrained by their perceptions of students' understandings. In addition, I view the teaching activity of facilitating discussion to be both a social classroom process and a cognitive activity on the part of individual teachers.

Simon (1997) has developed a view of the teacher's role that includes both the psychological and the social, and it is upon his view of teaching that I base my analysis of facilitating discourse. Simon attempted to answer the question: 'If we give up showing and telling as the teacher's principal means for promoting students' mathematical development, what do we have to replace them?' (p. 68). He suggested two activities in which teachers can engage: posing problems and facilitating discourse. When teachers choose to pose problems they may be thought of as taking a cognitive view of the learning process, and when they attempt to facilitate classroom discourse they may be considered to be adopting a social view.

According to Simon, selecting problems for students can be thought of as an attempt to influence the growth of cognitive structures by intentionally promoting and supporting accommodation and assimilation. The challenge for the teacher is to identify student tasks that result in an appropriate balance between assimilation and accommodation (p. 69). There are many ways to judge the quality of mathematical activities or problems. For example, adopting the notion of 'level of cognitive demand' (Stein and Smith, 1998), problems with a low level of cognitive demand require only that students perform an algorithm by rote, whereas high-level tasks need pattern-finding, generalizing and making connections. The relationship between the use of high-level tasks and teachers' attempts to engage students in discussion is not entirely clear. However, if students are to take part in justifying their ideas and arguing about ideas, then it is reasonable to believe that high-level tasks have the potential to support discourse in ways that low-level tasks do not. Thus, there is an obvious relationship between teachers' efforts to pose problems that influence cognitive processes and their attempts to influence social processes. Although students and teachers constitute what is an appropriate activity interactively, the teacher as the facilitator of classroom discourse exerts a great influence over what is viewed as legitimate mathematical activity. The types of problems a teacher poses and the way he/she facilitates classroom discourse contribute to the 'interactive constitution of classroom practice'. Teacher–student interaction, including the teacher's efforts to understand students' mathematics through observation and communication, influences teacher knowledge. Whole-class discussions may also be viewed as learning activities with both content- and process-related goals. Teachers make decisions about the appropriate placement and content of discussion based on their hypotheses about the process of learning and in response to their interactions with students. Recently, Beswick (2007, p. 98) summarized a list of observable features of constructivist classroom environments, including:

1 a focus on the students – their needs, backgrounds, interests and particularly their existing mathematical understandings;
2 facilitation of dialogue by means of which shared understandings of the relevant mathematics can be negotiated. An important factor in this regard is the existence of social norms that include requiring students to justify their ideas;
3 purposive use of tasks, materials, questions or information to stimulate reflection on and possible restructuring of students' understandings.

I situate my examination of the process of facilitating discussion within the larger process of teaching, as described above. The aim of the study is, first, to capture the variation in teachers' daily teaching in detail and, more specifically, to identify variation in approaches to teaching on an individual, as well as general, level. This influenced my data analysis in that I gathered data and then looked for evidence of teachers' efforts to facilitate discussion during implementation. Of course, the actual discussions occurred within the 'interaction with students' portion of the cycle, but when teachers are asked to reflect on the discussions they are attempting to add to their 'teacher knowledge' about catering for individual differences during discussion – which then influences them when they plan for discussion. This framework was useful in allowing me to investigate teachers' efforts and struggles, not as isolated activities but rather with respect to a specific way of thinking about teaching.

### 3.5.3 General variation of teaching

The basic idea behind this research is to make use of the variation in students' abilities and ways of understanding to look at how teachers cater for their students' individual differences. Such ideas are derived from a learning theory which concerns variation and learners' structure of awareness (Marton and Booth, 1997; Bowden and Marton, 1998). The following section outlines briefly a theoretical perspective on learning and the general variation of teaching which have been drawn from the theory of learning to develop strategies for coping with individual learning differences. According to Gu, Huang and Marton (2004), there are two fundamental uses of variation in classroom teaching leading to students' experiencing discernment. One is varying a set of the integral elements of a concept in demonstration problems to enable students to develop a thorough understanding of the concept (Marton and Booth, 1997; Wong, 2004); and the other is creating variations in the instructional procedures to develop basic mathematical skills. Teaching with variation helps students to try things out actively, and then to construct mathematical concepts that meet specified constraints, with related components richly interconnected (Watson and Mason, 2005). Building on this idea, teaching with variation matches the central idea of constructivism – that is seeing learners as constructors of meaning (ibid.).

#### 3.5.3.1 *A theoretical perspective on learning*

Learning means to develop a new way of seeing something, and learning to see something in a certain way amounts to discerning certain critical features of that phenomenon and focusing on them simultaneously (Marton, 1999). As Bowden and Marton (1998, p. 8) argue:

> Thanks to the variation, we experience and discern critical aspects of the situations or phenomena we have to handle and, to the extent that these critical aspects are focused on simultaneously, a pattern emerges. Thanks to having experienced a varying past we become capable of handling a varying future.

If learning is defined as learning to experience something, it is necessary to elaborate what is meant by 'experiencing something' and 'experiencing something in a certain way'. First, 'experiencing something' is related to the structure and organization of human awareness. What happens when we experience an object? It is that we direct our awareness to some aspects of the object. Therefore, the variation in ways of experiencing the same object is a function of differences in how the awareness is structured and organized at a certain moment. In other words, those aspects of the object that are discerned and held in the individual's focal awareness simultaneously define a way of experiencing something. The difference in ways of experiencing the same thing is related to a difference in the structure of awareness (Mok et al., 2001).

Since learning is defined as learning to experience something in a certain way and experiencing presupposes discernment, discernment becomes a significant feature of learning. How does discernment come about? Bowden and Marton (1998, p. 35) argue that 'variation is a necessary condition for effective discernment'. Without variability, many of the concepts we are now using would become meaningless and would not exist at all – thus, discernment presupposes variation. Drawing on his cross-cultural research of more than 25 years, Marton (2008, p. 1) related the so-called Chinese paradoxical phenomenon to the benefits resulting from the Chinese practice of variation pedagogy:

> Chinese students do very well when compared to students from other cultures. Teachers spend much more time on planning and reflecting than teachers in other countries and they develop their professional capabilities by the teaching, in which patterns of variation and invariance, necessary for learning (discerning) certain things, are usually brought about by juxtaposing problems and examples, illustrations that have certain things in common, while resembling each other in other respects. By such careful composition, the learner's attention is drawn to certain critical features and each problem and example make a unique contribution to the things that the learner will hopefully pay attention to in the future, instead of just going through problems that are supposed to be examples of the same method of solution.

Some other studies (e.g. Huang, 2002; Gu, Huang and Marton, 2004; Huang, Mok and Leung, 2006) also identified variation practice as reflecting advantages in Chinese mathematics education. Through different areas of variation, different aspects of student learning can be captured. Also, different variations occurring in a period or on a certain occasion can arouse students' awareness of the relationship between different aspects of learning. By making codes in different area of variations, some teaching patterns can be identified, and this is one of the ways in which learning takes place.

The starting point is that students understand what they are supposed to learn in a limited number of different ways. This research aims to explore whether teachers who pay close attention to such variation are better able to bring about meaningful learning in their students. Students learn better not only because they become more focused on the learning, but also because they are exposed to the different ways in which their classmates deal with or understand the same content.

The general variation of teaching is an approach for analysing the classroom practice of teachers, which includes how they diagnose students' needs and differences, and vary the level of difficulty and content covered, the questioning techniques, the approaches when introducing concepts, and peer learning. These concepts are elaborated further below.

#### 3.5.3.2 *Diagnosis of students' needs and differences*

Teachers have daily encounters with students, and from these they build up a bank of knowledge about the different ways in which students deal with particular concepts or phenomena, as well as a working knowledge of how to handle these differences. This knowledge, which becomes part of their daily teaching, is so powerful that sometimes it is unnoticed by the teachers themselves. Such knowledge is extremely valuable: by knowing in advance the prior knowledge and understandings of students, teachers can be more effective in helping them to learn what is intended. Therefore, instead of letting this knowledge remain at the back of the teacher's mind, it should be identified, sharpened and systematically reflected upon.

Consequently, it is important to capture how teachers diagnose students' prior knowledge and correlate the learned knowledge with the new knowledge by reminding students of key concepts.

#### 3.5.3.3 *Variation in the level of difficulty and content covered*

In recent years, researchers have become increasingly interested in adopting learning theory in research into classroom teaching (Runesson, 1997, 1999, 2001; Ko and Chik, 2000; Mok, 2000; Ng, Kwan and Chik, 2000; Mok and Morris, 2001; Ng, Tsui and Marton, 2001; Pang, 2002). These studies not only help in understanding the classroom but also, more importantly, provide a powerful method for studying it in depth. Runesson (1999) demonstrated how the theory of learning can be used as a tool for analysing teaching in a study which aimed at investigating the various ways in which teachers handle specific content in mathematics. She showed that, even when teaching the same topic and organizing their teaching in a similar way, teachers handled the content differently; and she also discovered that the teachers used variation, though in different ways, in order to make students discern the critical aspects of the content. When a teacher focuses on some aspects of the content, she/he can open up a dimension of variation – that is, she/he exposes to the students a variation in respect of a particular aspect of the content. Watson and Mason (2005, 2006) further pointed out that the two important parameters of mathematics structure – the dimensions of possible variation and the associated ranges of permissible change – should be emphasized in using examples. Some researchers (e.g. Rowland, 2008) have investigated how variation practices in structure and sequencing facilitate teaching and learning if teachers can organize examples appropriately. However, Rowland (2008) found that the extent of variation usage in structured exercises differs considerably from country to country and from text to text – it is essential to consider cultural features in variation practice. Also, Watson and Chick (2011) highlight the importance of teachers selecting mathematical tasks and examples with adequate variation to ensure that the critical features of the intended concept(s) are exemplified without unintentional irrelevant features. However, Zodik and Zaslavsky (2008) found that experienced secondary Mathematics teachers were largely unaware of the differences in the quality of their choice of examples.

In the current study, it will be important to capture the difficulty level of the tasks that the six secondary school teachers gave to students during lectures or seatwork. By coding students' worked tasks, the level of difficulty of the selected content may be identified. In addition, the sequences of simple and challenging tasks may also show the ways in which teachers plan to guide students to learn.

#### 3.5.3.4 *Variation in questioning techniques*

During a guided public discussion, the teacher constructs knowledge with students by making comments and asking questions to develop their understanding of mathematics concepts. This knowledge involves more than memorizing facts and executing procedures; the students are expected to refine what they already know in order to comprehend complex concepts. During open discussions, the teacher is responsible for eliciting and facilitating the students' thinking, and the students for expressing their own ideas. In examining the purposes of teachers' questions – such as making polite requests, reviewing and reminding students of classroom procedures, gathering information, discovering student knowledge and guiding student thinking to develop appreciation – Kellough and Carjuzaa (2006) suggest that they: diagnose learning difficulty; emphasize major points; encourage students; establish rapport, evaluate learning; give practice in expression; help students in their own metacognition; help students to organize materials; provide drill and practice; offer a review and/or summarize what has been presented; and show agreement or disagreement. This is especially significant when students are unable to provide teachers with the expected answers. Ongoing assessment thus involves monitoring evidence of changes in individual students' understanding as well as in the evolving consensus of the group.

Therefore, this research will attempt to capture the sequences of questions which are asked by teachers or answered by students. By coding students' answers, it is hoped to identify the level of difficulty of the questions. The sequences of low-level and high-level questions may also show the questioning skills of teachers in attempting to cater for students' individual differences.

#### 3.5.3.5 *Variation in approaches when introducing concepts*

When a new concept is first introduced, students are able to build strong foundations for further learning if teachers can introduce mathematical ideas in meaningful contexts by extending concepts with which the students are already familiar. Through this approach, teachers of Mathematics may see that pedagogical efforts in each lesson are connected through meaningful introductory activities. Simon and Tzur (2004) provide a useful aspect of the idea behind variation when they argue that a well-designed sequence of tasks invites learners to reflect on the effect of their actions so that they recognize key relationships. Likewise, Watson and Mason (2005) point out that mathematics is learned by becoming familiar with tasks that manifest mathematical ideas and by constructing generalizations from tasks. In addition, Gu, Huang and Marton (2004) suggest that during the process of solving problems, if separate but interrelated learning tasks are reorganized into an integration, this can provide a platform for learners to make connections between some interrelated concepts. Thus, the structure of the tasks as a whole, not the individual items, can promote common mathematical sense-making (Watson and Mason, 2006). In this study, although everyone was teaching about similar triangles, there are still many ways to introduce this topic.

#### 3.5.3.6 *Variation in peer learning*

The expectation within this teaching and learning context is that individuals should develop better mathematical thinking by discussing mathematical ideas with peers, giving explanations, responding to questions and challenges, listening to peers, making sense of others' explanations, and asking for clarification of ideas. The use of such conceptually orientated explanations, involving alternative solution strategies, assists in building robust knowledge structures, thus strengthening students' mathematical achievements (Fuchs et al., 1996; Stein, Grover and Henningsen, 1996; King, Staffieri and Adelgais, 1998). Many institutions now promote instructional methods involving 'active' learning that present opportunities for students to formulate their own questions, discuss issues, explain their viewpoints, and engage in cooperative learning by working in teams on problems and projects. 'Peer learning' is a form of cooperative learning that enhances the value of student-student interaction and results in various beneficial learning outcomes. To realize the benefits of peer learning, teachers must provide 'intellectual scaffolding'. In this way, teachers prime students by selecting discussion topics that all students are likely to have some relevant knowledge of; and they also raise questions/issues that prompt students to move towards more sophisticated levels of thinking.

Therefore, this study will aim to measure the range of changes in teaching mode, such as giving a lecture, and setting up group work or individual seat work. The Curriculum Guide recommends that, in their daily class teaching, teachers should adopt various teaching styles, such as whole-class teaching and group work, as well as individual teaching. The group work provides an opportunity for students of varying ability to cooperate with and learn from each other. Also, while tackling tasks or activities during individual work, less able students should be provided with more cues.

## 3.6 Summary

In this chapter, a range of important international research studies on the classroom teaching of Mathematics have been outlined, including video studies of features of Mathematics classrooms, as well as Hong Kong research, to give a general picture of the normal practice in local classroom teaching.

In addition, the benefits and limitations of different methods of grouping students have been explored in the context of the optimum method(s) for catering for individual differences.

On the basis of the discussion above, for the current research it is reasonable to adopt constructivism as the principal theory and variation as a tool for investigating classrooms. In particular, these ideas will be used as the basis for studying how the specific content of ‘Similar triangles’ is taught by different teachers in different schools. The Hong Kong Mathematics Curriculum Guide recommends certain strategies for teachers when designing classroom activities to cater for students’ individual differences. In this study, these are used as indicators for checking the extent to which teachers catered for students’ individual differences.

Finally, a review of possible theoretical frameworks provides perspectives for interpreting the findings of the current research.

Overall, this literature review has provided a foundation for building on in the present study.

# CHAPTER 4
# THE DESIGN OF THE STUDY

## 4.1 Scope of the chapter

As the basis for my study, I used the *Mathematics Education Key Learning Area Curriculum Guide (Primary 1 to Secondary 3)* (CDC, 2002) produced for schools in Hong Kong. While there is also a Mathematics Syllabus to help teachers prepare for their teaching, the Curriculum Guide is a more appropriate reference for this research as it contains more suggestions on how to cater for students' individual differences. All teachers in Hong Kong are supposed to implement both the Mathematics Syllabus and the Curriculum Guide in their daily teaching.

The central focus of the study is to examine the extent to which six teachers in schools with different bandings were implementing the approaches suggested in the Curriculum Guide for dealing with individual differences in their Secondary 1 classrooms – and to explore their perceptions of these issues. The rationale underlying the study and the research questions were stated in Chapter 1.

This chapter explains the research paradigm adopted to study the above issues, indicating why a case study approach was chosen, and describes the three data collection methods: classroom observation, interviews and questionnaires. The summary case study protocol was as follows:

**Table 4.1** Summary case study protocol

| | | |
|---|---|---|
| 2002–03 | Purpose | To describe and analyse how teachers implement the Curriculum Guide to cater for students' individual differences in six secondary classroom settings |
| 2003–04 | Participants | Six secondary school Mathematics teachers working in different schools, teaching Secondary 1 and implementing the Mathematics Curriculum Guide |
| 2004–05 | Research questions | The research questions are listed in Chapter 1, section 1.4. |

| | | |
|---|---|---|
| 2003–06 | Data collection procedures | Data collection for the participants involved:<br>• *classroom observation* of 5–6 consecutive lessons at six different times in the school year;<br>• two semi-structured *interviews* with each teacher;<br>• a semi-structured *interview* with a group of six students from each class;<br>• two *questionnaires* administered at the beginning and the end of the classroom observation for each teacher; and<br>• a *questionnaire* administered to each class of students. |
| 2006–09 | Data analysis | Data reduction, coding, categorizing, and drawing of conclusions |
| 2009–11 | Data re-checking and verification of findings | Determining and establishing internal validity; seeking counter-evidence and verifying or disproving findings |

## 4.2 Research paradigm

This research project uses a mixed-method design, though with a primarily qualitative focus. The issue of how far quantitative and qualitative paradigms are distinct or overlapping has been the subject of considerable discussion (e.g. Bryman, 1988, 1992; Brannen, 1992). Quantitative researchers characteristically isolate and define variables, which are linked together to frame hypotheses and then tested on data; and they extrapolate from samples to general populations. Such an approach has limitations in dealing with a very complex topic such as curriculum implementation. In contrast, the qualitative researcher uses a wider lens, looking for patterns and relationships between concepts. A researcher who adopts a qualitative approach focuses on description, explanation and analysis, in an effort to interpret and understand behaviour rather than seeking to extrapolate to a wider sample. For qualitative researchers, truth is multi-faceted and context-specific. As the research issues in this thesis are exploratory in nature and may require informants to give complex discursive answers, a mainly qualitative method seems most suitable (Brannen, 1992).

Mixed-method research has a number of objectives, as described by Greene, Caracelli and Graham (1989), Rossman and Wilson (1994), and Waysman and Savaya (1997), which can be summarized as follows:

- *Expansion* – to extend the breadth and range of inquiry by using different methods for different components of the inquiry
- *Development* – to use the results of one method to inform the development of the other methods
- *Initiation* – to generate new lines of thinking by searching for provocative, paradoxical or contradictory findings
- *Complementarity* – for elaboration, illustration and clarification of the results from one method with the results from other methods
- *Triangulation* – for convergence and corroboration of results from the different methods.

In this study, different data sets were analysed to explore more deeply the phenomenon under consideration. Also, triangulation was used, with different methods being employed to examine the phenomenon. It was hoped that the mixed research design could strengthen the validity and reliability of the findings.

### 4.2.1 Naturalistic observation

A naturalistic research design was chosen to examine behaviour without the experimenter interfering in any way. A case study approach was adopted to observe, describe, interpret and explore events in the natural context of the classroom. One of the key requirements of naturalistic observation is the avoidance of *intrusion*, which Dane (1994, p. 1149) defined as ‘anything that lessens the participants’ perception of an event as natural’. For instance, if the participants are aware they are being observed, their behaviour may not be entirely natural. In this study, the researcher was in the same room as the participants when videotaping lessons, and they were certainly aware of being observed. To reduce this intrusion effect, the researcher videotaped a series of lessons, not just one, in order to become a more familiar and predictable part of the situation, before any observations were used. Both the teacher and students got used to the researcher being present and were less aware they were being observed.

Though naturalistic observation can provide a rich and full picture of the teachers’ approach, one needs to be conscious of its possible limitations. For example, the researcher has essentially no control over the situation, which can make it very difficult (in some cases, impossible) to be certain about what caused the participants to behave as they did. In addition, there can be problems related to the validity of the observational measures because of bias on the part of the observer or because the categories into which behaviour is coded are imprecise. The fact that observations are typically interpreted or coded prior to analysis can also cause problems with the validity of the measurements (see section 4.7); and there are often problems of replication with studies involving naturalistic observation.

Teachers' practices are guided by systematic sets of beliefs (personal theories), which Cornett (1990) defined as 'personal practical theories' (PPTs), deriving from both non-teaching activities and experiences in designing and implementing the curriculum. Such previous studies of PPTs illustrate the relationship between teachers' beliefs and their classroom decision making. Teachers' actions in the classroom may not match their stated opinions. For example, they may express a need to cater for individual differences among their students, but it may be difficult to detect instances of their doing so in practice. To investigate the relationship between action and opinion with the aim of strengthening the internal validity of the study, a variety of procedures was employed, namely classroom observation, semi-structured interviews and questionnaires. The classroom video observations generated both quantitative and qualitative data; the interviews produced qualitative data; and quantitative data was collected using questionnaires. It was intended that the mixed-method research design for this study would draw on the strengths of each paradigm to construct a valid and reliable – or, in qualitative researchers' favoured terminology, credible and dependable (Lincoln and Guba, 1985) – picture of the process of implementing the Curriculum Guide in school settings with different bandings. The researcher attempted to ensure high reliability by using precise categories to code the videotaped records and by involving another observer to examine inter-rater reliability. The author coded all the lesson tables and a colleague from the Open University coded five of them (out of a total of twenty-four) which, while randomly selected, represented those from the beginning, middle and end of the series of videotaped lessons. The inter-rater reliability was initially 88%, and any differences between the two coders were discussed and resolved through consensus. Once all the lesson tables were coded, percentages were calculated for each category. This was done for each teacher, for each of the videotaped lessons taught in two classes.

## 4.3 Case study methodology

### 4.3.1 The nature of a case study

In this section, some of the main features of the case study as a research strategy are outlined. A case study, which is an ideal method when a holistic, in-depth investigation is needed (Feagin, Orum and Sjoberg, 1991), has been used in a wide variety of investigations, particularly in educational studies. Case studies are the preferred strategy when 'how' or 'why' questions are being posed, when the researcher has little control over events, and when the focus is on a contemporary phenomenon within some real-life context. They are designed to bring out the details from the viewpoint of the participants by using multiple sources of data.

Case studies are analyses drawing on multiple perspectives, which involve the researcher in considering not just the voice and perspective of the actors, but also of the relevant groups of actors and the interaction between them. The case study is a triangulated research strategy. Stake (1995) referred to the protocols used to ensure accuracy and alternative explanations as 'triangulation'. Also, Snow and Anderson (cited in Feagin, Orum and Sjoberg, 1991) asserted that triangulation could occur with data, investigators, theories, and even methodologies. The need for triangulation arises from the ethical requirement to confirm the validity of the processes.

Stake (1995) argued for another approach centred on a more intuitive, empirically-grounded generalization, which he called 'naturalistic' generalization. His argument was based on a harmonious relationship between the reader's experiences and the case study itself; and he expected that the data generated by case studies would often resonate experientially with a broad cross-section of readers, thereby facilitating a greater understanding of the phenomenon. The current research also used this method to discuss all the six cases.

In order to explain what I perceive to be the key elements in the above discussion, I define a case study as 'an intensive holistic empirical investigation of a single phenomenon within its natural real-life context' – in this case, the phenomenon of the classroom teaching of the mathematics topic 'Similar triangles'. The data generated by the six cases will not be over-generalized but will allow readers to reflect on the results from their own teaching experience.

### 4.3.2 The advantages and disadvantages of case study approaches

The traditional (Yin, 2009) arguments against the case study approach are listed below, and are then addressed. First, there can be a lack of rigour when case-study investigators have been sloppy and have allowed equivocal evidence or biased views to influence the direction of the findings and conclusions. Second, materials may be deliberately altered to demonstrate a particular point more effectively, but this is strictly forbidden and every case-study investigator must work hard to report all the evidence fairly. Third, there is little basis for scientific generalization – in fact, scientific facts are rarely based on single experiments, but usually on multiple sets of experiments which have replicated the same phenomenon under different conditions. In this sense, the case study does not represent a 'sample', and the investigator's goal is to expand and generalize theories (analytic generalization), not to enumerate frequencies (statistical generalization): the goal is to do a 'generalizing', not a 'particularizing', analysis (Lipset, Trow and Coleman, 1956, pp. 419–20). Besides, because of the prominent role of the researcher in data collection, there is also a potential problem of bias and subjectivity that threatens validity. Last but not least, it may be difficult to conceal the identity of the respondents which can cause ethical problems. To minimize these potential problems, this study uses a mixed research approach which includes quantitative and qualitative methods, where neither type of method is linked to any particular inquiry paradigm (Greene, Caracelli and Graham, 1989). Thus, different methods are employed to understand different phenomena within the same study, therefore avoiding bias and subjectivity.

However, case studies have many potential advantages [see Adelman et al. (1980); Cohen, Manion and Morrison (2000)], as summarized below:

1 The collected data is strong in reality, is practical and is related to the reader's own experience; it encourages readers to make comparisons with their own experiences.

2 The case study presents information in an open and accessible format that is more expressive than other types of academic report.

3 The delicacy and complexity of the case is investigated holistically within its own context, providing scope for analytic generalization, and building or generating theory.

4 The case study can represent conflicts or discrepancies between participants and offer support to alternative interpretations. It also provides rich thick description that allows interpretations and re-interpretations.

5 The case study begins in a real world of action and provides many ideas for further development.

A case study approach has been adopted in this thesis in recognition of the complexity of the classroom context and processes, and the varied interpretations that can be placed upon classroom events. Its use highlights the potential of case study data to provide insights which can be applied directly by teachers, teacher educators and officers of the Education Bureau. The aim of the case studies was to engage in an in-depth analysis of the teaching and learning of mathematics; and in the context of this overriding objective, the study was designed to examine the perspectives of Mathematics teachers and their students on this process.

#### 4.3.3 Multiple case study design

A multiple case study means studying more than one case within the same research (Yin, 1994). Each case must be carefully selected so that it either (a) predicts similar results (a literal replication) or (b) produces contrasting results but for predictable reasons (a theoretical replication). The ability to conduct six to nine case studies, arranged effectively within a multiple-case design, is analogous to the ability to conduct six to nine experiments on related topics; a few cases (two or three) would be literal replications, whereas a few others (four to six) might be designed to pursue two different patterns of theoretical replications. If all the cases turn out as predicted, these six to nine cases, in aggregate, would have provided compelling support for the initial propositions. If the cases are in some way contradictory, the initial propositions must be revised and retested with another set of cases.

The advantages of the multiple-case approach are to:

1 make comparisons between the cases and to test hypotheses derived from one case on others; and
2 strengthen the possibility that findings may be generalized to the class they represent.

Wolcott (1992) argues that the amount of time devoted to multiple cases may weaken the study and the researcher can study the case in more depth if only a single case is involved. Overall, however, it will be more convincing if the interpretation draws on several cases rather than a single one as this allows greater scope for generalizing the findings.

For the current research, the rationale for choosing a multiple-case approach was both practical and theoretical. It was more practical to depend on several teachers: not only might focusing on one teacher put great pressure on him/her when faced with the extra workload in preparing the lessons for videotaping and observations, but also the whole research would be put at risk if the teacher became ill or moved to another post. So, in this study, six teachers were observed and, while this was a limited sample, it allowed the cases to be analysed in greater depth than if more teachers had been involved. From a theoretical perspective, Yin (1994) claims that a multiple-case approach is useful for the analysis of school innovations as the researcher can investigate the progress of the innovation at different sites. By comparing data across cases, the researcher can increase the potential for the development of a general theory of innovation or a theory relevant to the specific innovation.

### 4.3.4 Sample and access to the field

The research design here comprises mainly classroom observations and interviews. As this could be quite threatening to the teachers involved, the researcher had to find teachers who were willing to take part in the study and agree to have their lessons observed and videotaped. In selecting the sample, the quality of teachers' practice was not taken into account as the study was not concerned with exploring the general effectiveness of the teaching. The teachers to be involved had to:

- be teaching two Mathematics classes in Secondary 1;
- be confident in teaching the topic 'Similar triangles';
- be willing to take part in the research study; and
- have some knowledge of the Mathematics Curriculum Guide, as this was one of the research foci.

Potential participants were sought in the year preceding the start of data collection, via personal contacts through my students, colleagues and friends. A more formal and less personalized approach to getting participants was precluded by the lack of any funding support for the study. Three teachers were involved in piloting the whole data-collection procedure, including lesson observations, teacher questionnaires, student questionnaires and interviews with both teachers and groups of students. At this time, finding other informants proved to be very difficult but, finally, data were collected from all six teachers over two years.

The cases above were to some extent self-selected, and it seems that the respondents may have certain characteristics not universally present in the wider sample. It is suggested that they may be rather more confident, and have a higher standard in teaching Mathematics and a higher level of professional commitment.

The method for choosing the schools was based on a combination of criteria. It was essential that they were representative of different types of schools; and they were selected also on the basis of their regional location, and the type of grouping system they operated. In addition, classes at the top, bottom and middle streams or tracks across the schools were chosen systematically, to ensure that the teaching of Mathematics was observed at different levels. The sampling process appeared to contain elements of purposeful sampling, defined by Patton (1990, p. 169) as ‘the selection of information-rich cases so that the researcher can learn a lot about the important issues for the study’. Patton lists fifteen types of purposeful sampling and, while the current study does not fit directly into any these categories, it contains elements of some sampling strategies, viz.

1 *Typical case sampling*, which illustrates or highlights what is typical, normal and average. The schools selected seem to be quite typical, including schools with different bandings, a boys’ school and mixed-gender schools, although the teachers have some common and some different characteristics.

2 *Maximum variation sampling*, which purposefully picks cases to illustrate a wide range of variation on dimensions of interest and identifies important common patterns that cut across variations. In this research, there is variation between the schools and the teachers, but there was no attempt to maximize the variation.

3 *Criterion sampling*, which involves selecting cases that meet some criterion. Here, all the teachers were teaching two Mathematics classes in Secondary 1.

4 *Convenience sampling*, which includes individuals who are available or cases as they occur, saving time and effort.

### 4.3.5 Complete observation

Atkinson and Hammersley (1994) point out that the dichotomy between participant and non-participant observation is too superficial and prefer the use of four categorizations: complete observer, observer as participant, participant as observer and complete participant. The categorization of complete observer – that is, having no interaction with those observed – best represents the role adopted in this research.

Complete observation is a good method for studying how teachers and students communicate during lessons and for examining the details of how they talk and behave together. However, it may provide limited insight into the meaning of the social context studied. As contextual understanding is important, a series of lessons was videotaped to provide a detailed recording of the communication involved, both verbal and non-verbal.

The decision to video-record depends in large part on what is permissible in the setting, but the following points should be borne in mind:

- Deciding how to record observational data depends largely on the focus of the research question(s) and the analytical approach proposed.

- Video is very valuable when trying to understand how teachers and students behave together; without the visual information on non-verbal behaviour, which plays an important role in the teaching process, it may not be possible to understand fully what transpires. Capturing such behavioural details using field notes will be difficult.

- Audio and video recordings afford the researcher the opportunity to transcribe what occurs in a setting and play it over and over, which can be very useful in the analysis process.

### 4.3.6 Ethical issues

In such a classroom-based study, it is essential to obtain informed consent, preserve anonymity and meet the authenticity criteria for qualitative inquiry developed by Guba and Lincoln (1989). At the time, the criteria which seemed particularly relevant to my study were that: I should negotiate an understanding with the research participants (for educative authenticity); all participants should learn through the research (for ontological authenticity); and the research should stimulate future action (for catalytic authenticity).

#### 4.3.6.1 *Informed consent*

The idea of gaining informed consent is that research participants and other stakeholders are informed fully about the research, and understand what it involves, before they decide whether or not to take part. However, as Wax (cited in Howe and Moses, 1999) puts it succinctly, informed consent 'is both too much and too little' (p. 41). If one tells too much, this can predetermine the results; but what you tell is always too little, as one cannot predict all the outcomes and so cannot warn participants about them. A solution to 'telling too little' is to discuss eventualities on an ongoing basis with participants and renegotiate their consent (Brickhouse, 1991), at the risk of confounding the problem of predetermining the results. Other potential outcomes of openness and negotiation are that participants modify or reduce their participation (Punch, 1998) or become more circumspect (less honest) in their interactions (Kelly, 1989) – and so there is a risk of losing access to what is being investigated.

My approach was to discuss the research with (a) the principals of the secondary schools that were the sites for the study, (b) the teachers and (c) the students, and I also sent letters to both the principals and the teachers. I sent information about the research to all parties (see Appendix 2 for sample letters); and I made it clear that, should they agree to be involved in the project, they could still choose to withdraw at any time. I also obtained permission from the principals and teachers, particularly for video recording lessons, interviewing students in groups and the completion of questionnaires. Again it was indicated that participants could withdraw at any time. I anticipated some problems with the video-recording, but none occurred. Students could sit outside the camera's field-of-view if they wished. Assurance was given that the students involved in the lessons would not be seen by the public; and, for the students' group interview, no parental permission was required as students used different names and the audio data did not show any individual student's point of view. During the fieldwork, I discussed the progress of the study with the teachers and, to a lesser extent, with the students.

#### 4.3.6.2 *Anonymity and confidentiality*

Protecting anonymity requires that the identities of individuals are not specified in the data gathered, and maintaining confidentiality ensures that identity-specific data are not revealed (Howe and Moses, 1999). The dilemma with both anonymity and confidentiality is that 'key individuals will always be identifiable, at least to those within the case. This may be just as threatening or more . . . than being identifiable to those outside the case to whom the study might be disseminated' (Simons, 1989, p.

117).

Because I used audio- and video-recording, anonymity was not feasible, which is typical of qualitative inquiry (Howe and Moses, 1999). I pursued confidentiality by: always using pseudonyms in publications and presentations; not identifying the schools; and not using photographs or video clips. In addition, one reason for my taking care to be fair in my representation of the students and the teachers was the possibility of identification by insiders.

Since the study is a naturalistic one, no attempt was made to manipulate the classroom situation in any way. Teachers were specifically asked to teach their classes in their normal manner, as the stated purpose of my research was to examine what was happening in real lessons. In addition, special care was taken to minimize the disruption to the teachers' normal school duties.

### 4.3.7 Bias and subjectivity

In any valid study, the bias of the researcher must be made explicit. The interpretative paradigm recognizes that the interpretation of data plays a central role in science. Any interpretation made is inherently biased and the role of science is to decide how to handle its effects. In science, the researcher bias can be minimized by replication studies. However, in educational research, such replication poses serious problems – it would be impossible to gather the same participants and expose them to the same study in the same situations. The solution to the interpretation problem in educational research lies in full disclosure of the methods, researcher bias and results. The intent is for a knowledgeable reader to be able to make the same claims based upon the same data. If this condition can be met, then there is validity in the study.

Researcher bias and subjectivity has long been viewed as a threat to the validity and reliability of qualitative case studies. As Silverman (1985) put it, 'The critical reader is forced to ponder whether the researcher has selected only those fragments of data which support his argument' (p. 140). There are a number of strategies which qualitative researchers employ to mitigate this threat. For instance, Bogdan and Biklen (1998) indicate that, by spending considerable time on collecting detailed information in the field, qualitative researchers are forced to confront their superficial prejudices. In addition, the researcher's aim is not to pass judgement but to add to knowledge on a topic. The value of a study is not about whether it proves a point but whether it generates description, understanding or theory (Bogdan and Biklen, ibid.).

Olesen (1998) suggests that a major way of facing possible researcher bias is for the researcher to develop sufficient reflexivity to enable the data to overcome any potential prejudices or biases. Rather than provoking bias, previous knowledge and experiences can be used to guide data collection, understanding and interpretation (Olesen, ibid.). Reflexivity acknowledges the complexity of natural phenomena and accepts that multiple interpretations of reality may all be equally valid. For the present project, the researcher employed the strategies discussed later in this chapter (section 4.7) to reduce the impact of potential bias and enhance the validity of the study.

### 4.3.8 Summary of case study rationale

In summary, a multi-site case study approach was chosen in order to focus on naturally occurring real-life events as they appeared in the classroom setting. The sample of six teachers enabled a relatively intensive study, involving both classroom observation and interview data. This study of the curriculum implementation over an extended period of time facilitated probing into what the teachers were doing in the classroom and why, and to relate this to their attitudes to and perceptions of the Curriculum Guide.

Case studies involve developing an understanding of a phenomenon from the participants' viewpoint. As indicated before, teachers are the individuals who will decide to implement faithfully, adapt, ignore or reject a curriculum innovation. Therefore, a major aspect of this thesis is to highlight teacher perspectives on the Curriculum Guide. The case studies focus on the teachers' classroom behaviour, attitudes and opinions as they relate to the Curriculum Guide; and they permit an in-depth description and analysis of the areas concerned through the use of mixed-methods and multiple data collection instruments.

In addition, a case study seems to be a suitable method for studying innovation as too little is known about how innovations are actually tackled in the classroom in the implementation phase. An in-depth focus on implementation can produce insights into how teachers are, or are not, carrying out an innovation. As Gummesson (1991) indicates, a case study is particularly appropriate within the area of the management of change because 'the change agent works with cases' (p. 73). The case study protocol presented in tabular form below summarizes and cross-references the design and procedures of the case study model used for this study.

Given the complex nature of the issues to be addressed in gaining insight into the teaching of Mathematics in classrooms, a system of triangulation was adopted as the aspects being studied will not be readily understood by employing a single research methodology (Seale, 1998). The process involves using a range of research strategies to elicit different perspectives on a single phenomenon. In this case, it included listening to the views of teachers and students on the teaching and learning of Mathematics, as well as videotaping the classroom teaching of the subject. The use of a multi-faceted methodological approach enabled me to study the complex interface between the teaching and learning of Mathematics from a range of different standpoints. By listening to teachers and students, and by observing and recording a series of lessons on video, I was able gain a holistic understanding of how the subject is taught and how learning takes place – and was therefore in a good position to understand whether students of different ability had different experiences in learning mathematics.

The invitation to teachers to participate in the study took place through direct contact with them. Eventually, six schools were selected in which teachers had volunteered to be part of the study, and the principals had agreed that they could take part. These schools were also willing to seek the permission and cooperation of students. Having chosen the teachers and the year level of the classes to be involved, it was found that they reflected the top, middle and bottom school bandings, which fulfilled the study's objective of ensuring that the teaching of Mathematics at different ability levels was observed. I knew from existing research that high-track, mixed and lower-track students were generally taking the same Secondary Mathematics curriculum – with only some enrichment content or less content for the high track and lower track respectively, as suggested in the curriculum.

Classes within schools were chosen from among the first-year students. The reason for focusing on Secondary 1 Mathematics was because first-year students seemed an appropriate research group as they covered the Mathematics topic of interest – 'Similar triangles' – and were not undertaking public examinations during the course of the study. The fact that they were not examination classes meant that school principals, teachers and students were more likely to have time to participate in the project. The topic of 'Similar triangles' was chosen because it involved both concepts of triangles under the areas of shapes and space, and the calculation of ratio which might have been mentioned in primary school. However (as noted earlier in Chapter 2, section 2.5.2), the new syllabus for primary Mathematics does not include the teaching of the concept of ratio – a fact some secondary teachers were unaware of – and so students' prior knowledge needs to addressed before teaching this topic. I was interested in examining how secondary teachers deal with students who do not have prior knowledge of ratio.

For this research, every case included a sequence of data collection procedures. First, there were five to six consecutive lesson observations with videotaped records. During this time, I conducted a semi-structured interview with the teachers and two group interviews for students in two classes. Also, at the end of the lesson observation, a questionnaire was administered to each class of students. In addition, two questionnaires were administered to teachers at the beginning and the end of the classroom observations. The following sections provide a brief rationale for the research methods employed.

## 4.4 Classroom video observation

### 4.4.1 Nature and purpose

Classroom observation is the most effective research method for exploring interaction in the classroom, as well as the patterns of behaviour of teachers and students. According to Croll (1998), systematic classroom observation is a research method which uses structured observation procedures to gather data. The two main schools of classroom observation research – the quantitative tradition (e.g. Croll) and the qualitative ethnographic approach – are discussed below. Croll (ibid.) outlines six main purposes for systematic classroom observation: to provide a description of the features of classrooms; to measure teacher effectiveness; to monitor teaching approaches; to monitor individuals; and for teacher development (e.g. action research) and the initial training of teachers.

This study intends to provide a description of features of classrooms and to monitor teaching approaches. The classroom observation aims to identify the main features of the classroom teaching of the six case study teachers. To monitor teaching approaches, it investigates the extent to which the teachers were using approaches consistent with the Curriculum Guide's suggestions on catering for students' individual differences.

Classroom research can expose the 'black box' of the classroom (Hitchcock and Hughes, 1995). It has the potential for discovering the factors that mould and influence pupils' experiences of school and classroom life, and actually provides the whole picture of what teachers and pupils do in the classroom – which might be opposed to what administrators, teacher educators and syllabuses advise them to do. So it is appropriate to carry out classroom observation in this study to explore how teachers really teach inside the classroom and what strategies they are using to cater for students' individual differences. Bauersfeld (1986, p. 15), among others, describes the following advantages of using video documents and transcripts in teacher education:

- One can react to classroom interaction in a detached and reflective way because, other than the classroom participants, one is not exposed to continual assessment and decision-making pressures.

- The documents can be viewed as often as required. One can change the focus of attention without being dependent on one's memory. In particular, one can break away from the bias resulting from routine interpretation patterns that have developed in one's own classroom practice.

- The structures of incidents which are either hidden or too obvious can be revealed. The backgrounds of individual actions, interactive processes and mathematical topics can be related to evidence from the documents.

- The sensitive multi-layered interpretation of student activities which the teacher involved would perceive as vague or accidental can yield new insights into the students' world of imagination.

### 4.4.2 Approaches

Several classroom research approaches were used this study. I consider the nature of the interactions between teacher and student in the classroom to be of central importance. Since questioning is the dominant mode of interaction between them, teacher–student questions account for the majority of the public interactions. The remaining interactions comprise either instructions to students or organizational or social exchanges. Teachers tend to use questioning to ensure that students are equipped with facts and procedures. The teacher's role is to demonstrate and explain, while the role of the student is to memorize and practice. For the aspects of classroom interaction in language teaching, Banbrook and Skehan (1989) and Wu (1993) studied the questioning techniques in an ESL classroom. They used both quantitative and qualitative analyses to find out the characteristics: they tallied the interactions quantitatively and analysed the transcripts quantitatively and qualitatively. Foster (1996) mentions a number of advantages of such mixed approaches as quantitative data can provide information on frequency, duration and intensity while qualitative data complement this by providing thick description which explores meanings and interpretations. Explanatory qualitative data may be useful in interpreting numerical quantitative data.

Other approaches to classroom observation were also used for reference in this study. Since classroom interaction in everyday mathematics classes is a complex issue and seems situated, its course is contingent upon the perception and realization of those involved. It nevertheless can be reconstructed as four dimensions that provide a structure for analyses of what happens in mathematics classes (cf. Krummheuer, 2004, p. 14), viz.

- The mathematical concepts, theorems, procedures, and models, which students and teachers talk about.
- The arguments and argumentation patterns which students and teachers produce.
- The patterns of interaction.
- The forms of participation of active and silent students.

These four dimensions were taken as a minimum model for understanding the processes of mathematics teaching and learning. In particular, these dimensions facilitate differentiation between two opposite forms of interaction in the mathematics classroom: interactionally steady flow vs thickened interaction. The first of these is characterized by fragmental argumentation, interaction patterns with inflexible role distribution, and less productive participation of all students; and the second, in contrast, shows rather complete collectively produced arguments, flexible student roles and scope for their involvement in the educational process. These two forms provide different favourable opportunities for student learning. Teacher development may be seen as a path towards providing better opportunities for students' learning of mathematics, i.e. to facilitate thick interactions that interrupt the interactionally steady flow of everyday mathematics lessons.

In addition, there are three techniques for interpreting classroom interaction: interaction analysis, argumentation analysis and participation analysis. These originated in the academic field of qualitative classroom research in mathematics education (e.g. Cobb and Bauersfeld, 1995; Krummheuer, 2000; Steinbring, 2000). In view of the above points, for the current study it was decided to collect both quantitative and qualitative data, so as to build up a richer and deeper picture of the Curriculum Guide's innovations through a complementary use of the two paradigms. The research has the broader aim of studying how teachers cater for students' individual differences by looking at the content of lessons, the interaction pattern in classrooms and the questioning style of the teachers. For the content of lessons, the teaching plans related to different classes were studied; and, for the teaching process, the dynamics of interaction within the classroom – for example, the patterns of engagement between teachers and students and the nature of questioning and instructing – were examined.

A qualitative, process-oriented research approach is employed to explore what goes on in the classroom. The advantage of this classroom research approach is that the classroom is treated as a cultural entity and this can generate more in-depth insights than other more superficial research methods. However, the disadvantage of this method is that it takes a long time to carry out the research.

### 4.4.3 Rationale and procedures

There is often a mismatch between the intentions of curriculum developers and what actually happens in classrooms. Classroom observation thus forms an essential part of the study on the grounds that it is the most appropriate research method for exploring whether an innovation is actually being implemented in a manner consistent with its espoused principles. Research from the TIMSS study suggested that videotaping is a very valuable tool for understanding how mathematics is actually taught in classrooms (Stigler and Heibert, 1999). Contrary to my initial expectations, I did not find that the videotaping interfered greatly with the flow of the lessons. Following an initial interest in the mechanics of the video camera itself, the classes settled down to a normal lesson routine, especially after the second lesson. The purposes of the classroom observation using videotapes were to:

- identify the extent to which the six teachers were able to carry out the Curriculum Guide's recommendations in their classrooms to cater for students' individual differences;

- describe and interpret the teaching process by studying the interaction patterns and teachers' questions; and

- triangulate the findings from the interviews and questionnaires.

The classroom observation was carried out during two academic years in the period 2003–06 because not enough teachers were involved in the first year. The age of the Secondary 1 students was around twelve to thirteen. For each observation, a sequence of five or six consecutive Mathematics lessons for each teacher for each of two classes was observed and videotaped. A total of eight to twelve lessons were observed in this way for each teacher. The corpuses of the sixty-one observed lessons were all recorded, but only twenty-five lessons were coded using the protocol in Appendix 3.

Choosing only twenty-five lessons made the analysis manageable and yet provided a good opportunity to analyse the teachers' approaches. These twenty-five lessons were selected from the first two lessons in which the teachers introduced 'Similar triangles'. Focusing on the same teaching content allowed comparisons to be made easily.

As noted in section 4.2, a combination of quantitative and qualitative methods was used. A classroom observation instrument using a coding system was prepared to collect mainly quantitative data about the lessons. The rationale for using a coding system was to provide numerical data that could be compared across teachers and the classes observed. The codes were labels for assigning units of meaning to the descriptive or inferential information collected during the study (Miles and Huberman, 1994). The coding was mainly based on the Curriculum Guide's section 4.3 on catering for student individual differences. The coding is explained in more detail Chapter 6. It was hoped this would reveal patterns and regularities in the lessons and would provide quantitative data for comparison with the qualitative data.

Guided by insights gained from the TIMSS study of mathematics classrooms (Kawanka et al., 1999), a small pilot study was undertaken prior to the main study. The pilot study involved the videotaping of six mathematics classes in three schools. The classes included mixed-ability grouping and tracked classes. In addition, pilot interviews were undertaken with both teachers and students. Different types of secondary schools, such as those with a whole-school planning policy and those without any special planning for catering for students' individual differences, were involved in the pilot study. After the pilot study, it was decided to focus exclusively on secondary-level study, largely because it would have been impossible to make any meaningful statements about the teaching of mathematics at primary level without engaging in an in-depth study like that planned for secondary-level. It was not possible to complete such an intensive study of primary-level mathematics within the time and resources available. The whole process of collecting video data and sound recordings, delivering questionnaires, and interviewing teachers and students were tried out. Many technical problems involving the data collection were resolved in order to get much more interaction between teachers and students.

In the analysis of the video material, I was guided by the procedures utilized in the TIMSS study (Stigler and Heibert, 1999). When the video material was collected, the tapes were coded and viewed by me and a colleague, both individually and collectively. After the initial viewings, the lessons were transcribed in tabular form and analysed systematically in terms of their public discourse and interactions. The analysis focused on the style of teaching and teacher–student interaction patterns. The initial interpretations were read and re-read.

In the light of the colleague's comments and further viewing of the material, interpretations were revised and edited further. Coding systems based on the Curriculum Guide were devised and a content analysis of these was undertaken systematically for all classes. The teachers who had been videotaped, and who had expressed an interest in a continuing dialogue with me about the study, were also invited to read our interpretations of the video material.

Students were also asked to complete a detailed questionnaire, which focused mainly on their attitudes to, and experience of, learning mathematics, and to provide other relevant personal background information. The details of the research instruments devised for measuring teacher attitudes, and examining students' experience of mathematics, are in Appendices 4 and 5. Further analysis is presented in Chapters 6 and 7.

On the basis of a preliminary analysis of both the videotapes and questionnaires, a number of students from each of the twelve classes were asked to take part in a short focus group discussion about their experience of learning mathematics, focusing especially on their current class experience. The teachers chose students who were high, middle and low participants in class, as well as students who were getting high grades, middle grades and lower grades. In all, twelve focus group interviews were undertaken with an average of six students in each. There were no gender issues for the students as teachers were requested to try to balance the number of male and female students.

The questionnaire data were analysed, while the interviews were transcribed in full and analysed rigorously. As with the classroom material, a coding scheme for analysing key themes was drawn up and each interview was analysed within that frame.

How students approach the learning of mathematics and how they learn is not just influenced by their views and interest in the subject – it is also strongly determined by the attitudes of their teachers. Because of this, two semi-structured interviews were held with the six mathematics teachers, the objective of which was to explore in particular their views on the teaching of mathematics. The teachers also filled out two questionnaires giving their professional profiles and general views on the subject of mathematics. A detailed profile of individual teachers is not included here to preserve the anonymity of those who participated.

### 4.4.4 Features of the Curriculum Guide

A core element of the classroom observation was looking for the extent to which teachers were implementing the suggestions in the Curriculum Guide. The identification of classroom aspects for the observation schedule was accomplished using the following steps:

1 There was an intensive review of the curriculum framework documentation that lists the classroom activities to be identified. (Appendix 3)

2 Colleagues with experience of both the Mathematics Curriculum Guide for teacher education and the Hong Kong Secondary school context were consulted to suggest a number of features that might provide evidence of the implementation of the Curriculum Guide's suggestions on catering for students' individual differences.

3 The list of classroom activities was further improved during the piloting process. (Appendix 3).

### 4.4.5 Lesson transcriptions

It was impossible to transcribe the entire collection of lessons which were videotaped. The lessons chosen were those in which the teachers were introducing the topic of 'Similar triangles'. One or two full lessons from both classes of each of the six teachers were selected for transcription. Such lessons provided data for discussion of the extent of classroom implementation of the key classroom features of the Curriculum Guide on catering for individual learner differences.

### 4.4.6 Lesson tables

An additional source of qualitative data was the completion of lesson tables. These contained detailed written descriptions of the lessons, including the classroom interactions, the nature of the mathematical problems worked on, goal statements, lesson summaries and other relevant information. The purpose of the lesson tables was to provide some written information on the videotaped lessons (refer to Chapter 5). This would triangulate with the verbal perceptions of the teachers in the interviews and the data from the classroom observation.

## 4.5 Interviews: semi-structured and focus groups

Different kinds of interviews were employed in this research, with semi-structured interviews and focus group interviews used for teachers and students respectively. The use of interviews to collect more in-depth information from teachers and students was a very important aspect of this research.

### 4.5.1 Purposes

The main purpose of the interviews was to capture the teachers' and students' perspectives in more depth and allow them to reflect on the issue interactively with the researcher. The interviewer identified the issues to be addressed beforehand, but how and when to raise those issues was decided during the course of the interviews. In this research, the teacher and the groups of students were interviewed separately. Each teacher was interviewed twice, once before the series of lessons was videotaped and again after a few months. The interviews were open-ended in the sense that the questions asked allowed plenty scope for various kinds of answers. However, the interviews were structured and used a formal procedure in which all the interviewees were asked precisely the same core questions. These core questions were not presented in the same order and so involved flexibility when interacting with the teachers, who could further explain their answers whenever they wanted. The setting of core questions allowed an easy comparison of the responses of different interviewees – although follow-up questions such as 'Can you give me examples?' or 'Why do you think that?' were asked to enable me to collect data beyond the core questions. It was hoped this would provide good reliability and make it easier to analyse the data obtained from them.

The advantages of interviewing the *teachers* were that it:

- allowed the researcher to learn about things that could not be directly observed;
- added an inner perspective to outward behaviours;
- allowed for probing;
- increased the accuracy of responses;
- allowed respondents to raise concerns; and
- enabled modification to the lines of inquiry

*Students* were interviewed using *focus groups*, which Kreuger defines as a 'carefully planned discussion designed to obtain perceptions in a defined area of interest in a permissive, non-threatening environment' (1988, p. 18); and he also suggests that 'the purpose is to obtain information of a qualitative nature from a predetermined and limited number of people' (p. 26). Also, Merton et al. (1990, p. 135) note that a focus group interview with a group of people '...will yield a more diversified array of responses and afford a more extended basis both for designing systematic research on the situation in hand ...'. Focus group interviews for students were adopted in this study in order to triangulate teachers' comments on their classes. Students were chosen by the teachers to include a range of abilities and different views on studying Mathematics. Small groups (four to six students) were adopted in line with Kreuger's view (1988, p. 94) that they are preferable when the participants have a great deal to share about the topic or have had intense or lengthy experience with it.

The details of the questions are in Appendix 6. The whole interview was recorded on an MP3 and the researcher also held the interview and took notes simultaneously. At the beginning of each interview, I introduced my research briefly to the students and got their consent to record what they said. Howe and Lewis (1993) suggest that members of a group should identify themselves before they speak, and so the students were asked to give their names when they spoke. When it was completed, the entire interview was first transcribed into Cantonese, thus providing a complete record of the discussion and facilitating analysis of the data. After analysis of the content of the discussion, some parts of interviews were also translated into English for further investigation (see Chapters 6 and 7).

In addition, as outlined by Frost and Sullivan in the following website (n.d.) (http://www.frost.com/prod/servlet/mcon-methodologies-focus-groups.pag), the advantages of using focus group interviews with students were that:

- Opinions or ideas of individual group members can be taken and refined by the group, resulting in more accurate information.
- A 'snowballing' effect can occur, causing the ideas of individual members of the group to be passed around the group, gathering both momentum and detail.
- Focus group interviews are generally more interesting to the respondent than individual interviews. As a result, answers are likely to be longer and more revealing.
- As the questions of the moderator are directed at a group rather than individuals, the degree of spontaneity of resultant answers is often greater in a focus group interview.

However, focus group interviews also have a number of limitations, e.g.

- The number of questions that can be asked is limited.
- They require considerable group process skills.
- Conflicts may arise.
- Status differences may become a factor.
- It is impossible to guarantee confidentiality.

On balance, the researcher considered that the advantages of interviews outweigh the disadvantages.

### 4.5.2 Rapport

There was some prior contact between the researcher and the teachers, which helped to create a situation in which the teachers would state their views openly. Establishing good rapport with teachers is important when interviewing (Taylor and Bogdan, 1984). Although some of the teachers were students of the researcher a few years ago, this was not a threatening situation for them as they had all graduated from the university and could feel free to state their points of view to the researcher. In addition, the teachers were aware of the procedures to be followed and (in the second interview) the purpose of the research; and they knew that the researcher was interested in their opinions and insights only. The interviews were carried out in the teachers' first language, Cantonese, so they had no problem in expressing themselves.

### 4.5.3 Procedures for the interviews

The interviews were recorded with an MP3 placed on the desk near the speakers. All the interviews were conducted in school after classes or during a break or lunchtime. An empty classroom or meeting room was used and very few interruptions were experienced. There was sometimes a relatively limited time available for carrying out extended interviewing, so I was conscious of the fact that I should not put too much of a burden on the respondents in terms of workload and time. The duration of the interviews was approximately as follows: forty-five minutes for the baseline of both post-observation interviews and the summative and post-analysis interviews; and thirty minutes for the students' group interviews. These time limits meant that, although a certain amount of probing was carried out, it was not always possible to go as deeply into certain issues as might have been desirable in an ideal world.

### 4.5.4 Content

The first interviews were held before videotaping the lessons. The main purpose of these interviews was to elicit more information about the actual performance of the teachers. This instrument (see Appendix 7) mainly comprised four parts: the teaching atmosphere during the lesson; lesson planning; teachers' perceptions of their students' individual differences and teacher's teaching characteristics and styles. These were the core questions designed by the researcher based on the idea of moving from general to specific then to go back to general questions.

The main purposes of the post-observation interviews were to explore the teachers' perspectives on the recorded lessons and to permit triangulation between the teacher view and that indicated by the video observations. In addition, the teachers might be able to explain issues that were unclear to the researcher, for example previous incidents or specific class background knowledge. The researcher checked the first interview data and designed another checklist for each interviewee in order to collect any missing data. In addition, the interviews focused on various issues in the Curriculum Guides about handling students' individual differences, to elicit teachers' opinions on various aspects of the guidance.

For the students' focus group interviews, a summative interview was carried out following one or two videotaped lessons after a few days in the school. The purpose of the summative interviews was to elicit students' opinions on some of the main issues emerging from the lessons and to gauge their reaction to some emerging propositions. There were a number of general questions that were common to the students, for example questions about their attitudes towards answering questions actively and raising questions. There also tended to be a more individual line of questioning in accordance with the specific events occurring during the observation of each class. For details refer to the Appendix 6.

A post-analysis interview was carried out two years later with all six teachers as the data description and analysis had almost been completed by that time. This permitted member checking, the testing of suppositions, the clarification of ambiguities and the revisiting of issues not been covered in sufficient depth in previous interviews.

### 4.5.5 Transcriptions

The interviews were transcribed verbatim in Chinese by a research assistant, a part-time worker recommended by a colleague, after the completion of the interviews.

Extracts from the interviews were then translated into English by the researcher and used in the later chapters to allow the teachers' voice to be heard. For these extracts, the original words of the informants were retained but very minor modifications were occasionally made to translate the local language to formal English. Care was taken with these small modifications not to alter the original sense of what was being said. Square brackets are used occasionally to indicate what was being referred to or to clarify something which appeared to be implied but was not actually stated. Since the interview data was more than was needed, the most significant extracts were carefully selected and translated to express the teachers' views.

## 4.6 Attitude scale

### 4.6.1 Rationale for the study of attitudes

The teachers and students were asked to fill out questionnaires in this study as the researcher wished to understand their demographic and cultural characteristics. Teacher attitudes have been identified as affecting teachers' classroom behaviour (Pajares, 1992; Shavelson and Stern, 1981) and a main factor influencing the degree of implementation of the Curriculum Guide. Mathematics teachers are often prone to adopt their perspectives on the nature of mathematics in their teaching (Ernest, 1989; Ball, 1990; Frank, 1990; Foss and Kleinsasser, 1996; Andrews and Hatch, 1999a). Indeed, as Thompson (1984) notes;

> ... the observed consistency between the teachers' professed conceptions of mathematics and the manner in which they presented the content strongly suggests that the teachers' views, beliefs and preferences about mathematics do influence their instructional practice (Thompson, 1984, pp. 124–125)

The relationship between belief and practice appears to be generally consistent (Andrews and Hatch, 1999a), although there may be inconsistencies (Thompson, 1984) related to the depth and consciousness of a teacher's beliefs and the particular schools in which they operate (Ernest, 1989). However, it has also been noted that classroom behaviour may not be compatible with the attitudes expressed. Teachers may express positive attitudes to the Curriculum Guide although they have never implemented it in the classroom. In this research, data on attitudes is triangulated with data from direct classroom observation and video analysis. Although an attitude scale is a relatively crude instrument, the quantitative information it provides complements the other research strategies of classroom observation and semi-structured interviews.

### 4.6.2 Purposes

The purposes of the questionnaires in this study are both descriptive and analytical – that is they are intended to estimate the parameters for characteristics of the six teachers and the students. The researcher was also interested in comparing characteristics among those teachers and students and in exploring relationships among the variables. This thesis investigates both attitudes and behaviour in the classroom to explore the relationship between teacher attitudes and classroom implementation. The attitudes of the six case study teachers were sampled at the beginning and end of the period of classroom observation in order to elicit their attitudes towards a number of key components in Mathematics teaching and learning, and towards the Curriculum Guide. The purposes of the teacher attitude scale were to:

- measure teacher attitudes towards the Mathematics Curriculum Guide and related constructs; and
- permit triangulation between teachers' expressed attitudes in interviews, their classroom behaviour and their attitude scale responses.

### 4.6.3 Procedures in developing the attitude scale

The development of the attitude scale involved several procedures. Before drafting the possible attitude statements, the Mathematics Curriculum Guide was studied carefully. The statements were designed either in a positive or negative form in order to cover different aspects of the attitudes, such as: the teachers' orientation to the suggestions in the Curriculum Guide for dealing with students' individual differences; the constructivist theories of learning in mathematics; and teacher and student interactive style during the lessons. The items were designed in short, clear, unambiguous and easily understandable statements for both the teachers and students. No statements included special technical jargon which might confuse the respondents, and all the statements were within the frame of reference of Hong Kong secondary school teachers and students. The researcher discussed the draft version with an experienced teacher and made some amendments to the wordings of items in order to make it more user-friendly. A Likert scale was used with the columns headed, 'Strongly disagree', 'Disagree', 'Neither agree nor disagree', 'Agree' and 'Strongly agree'. A total score for each respondent was computed by giving a score of five for strong agreement with a positive statement about the attitude under consideration down to a score of one for strongly disagreeing with a positive statement about an attitude. Similarly, a score of five was given to strongly disagreeing with a negative statement, and a score of one for strongly agreeing with a negative statement. In this way, a total score can be computed to indicate the overall strength of the respondents' attitudes towards principles commensurate with the Curriculum Guide initiatives. The higher the overall score, the more positive is the overall orientation of the respondent as measured by the scale. A Likert scale was used in view of its relative ease of construction and its high face validity for respondents (Oppenheim 1992). It was recognized that Likert scales have some weaknesses, such as the fact that the same overall score can be formed in quite different ways. For example, respondents seem to be cautious in selecting 'strongly disagree' or 'strongly agree' with items, and it is therefore difficult to decide on including a midpoint for the choices. Finally, the researcher included the midpoint 'neither agree nor disagree' rather than other terms which might have been used, such as 'uncertain', 'neutral' or 'undecided'. The provisional rating scale of the two teacher questionnaires, each comprising around 45 items, were piloted in three schools. The purpose of this piloting was to determine which items were most representative in measuring teachers' attitudes towards the Curriculum Guide and related principles. This was done by correlating each teacher's score on a particular item with the total score. In the light of the findings from the piloting, the wording of questions was revised to make them clearer.

## 4.7 Validity

### 4.7.1 Construct validity

Construct validity is especially problematic in case study research, and the researcher needs to consider validity seriously and plan the whole study design before data collection. This type of validity has been a source of criticism because of potential investigator subjectivity. Yin (1994) proposed three remedies to counteract this, viz.

1 The use of multiple sources of evidence, in a manner encouraging convergent lines of inquiry during data collection.

2 The establishment of a chain of evidence, also relevant during data collection.

3 Having a draft case study report reviewed by key informants.

Stake (1995) and Yin (1994) identify at least six sources of evidence in case studies. The following is not an ordered list, but reflects the research of both Yin (1994) and Stake (1995):

- Documents
- Archival records
- Interviews

- Direct observation
- Participant observation
- Physical artefacts.

As indicated earlier, for the current study, the researcher collected different sources of data including the Curriculum Guide, a document from the Education Bureau; two kinds of teacher questionnaires (one for the teachers' general background information and one for their teaching attitude); student questionnaires; two teacher interviews (one before and one after the whole series of lesson observations); student group interviews; and the direct observation of lessons and their video-recorded data.

For constructing validity, Chaudron (1988) suggests the importance of criterion validity, which is determined by making comparisons with events or behaviours that are related to or predicted by the data on the instrument. This was done by triangulating the findings of the observation instrument with the opinions of the teachers themselves during the post-observation interviews. For instance, a finding from the lesson video observation coding which indicated the presence or absence of tasks during a sequence of lessons could be validated to some extent through the post-observation interviews. The teachers' responses to the questions about tasks might provide some confirmation or disconfirmation of the observational data (although discrepancies might also indicate different perceptions of the term 'task'). In this way, the classroom video observation findings are to certain extent verified or modified by the interview comments of the participants. The longitudinal aspects of the study also enhance its validity. The repeated observation of five or six consecutive lessons in a cycle and the six cycles of observation during the academic year increase the likelihood that the videos of the observed lessons reflect the reality of the classrooms under investigation.

### 4.7.2 Internal validity

Critics [see Cohen and Manion (2000)] typically state that single cases offer a poor basis for generalizing. However, they are implicitly contrasting the situation with survey research, in which a 'sample' readily generalizes to a larger universe. This analogy between samples and universes is incorrect when dealing with case studies because case studies rely on analytical generalization, in which the investigator is striving to generalize a particular set of results to some broader theory. Internal validity is concerned with the extent to which the findings accurately capture the phenomenon under investigation. For this study, internal validity denotes the extent to which the findings represent a true picture of the Hong Kong Secondary I classrooms of the six teacher respondents, in terms of the individual classroom processes in implementing the Curriculum Guide and how they cater for students' individual differences. As noted before, the focus of this study is on mathematics teachers' classroom teaching and their views on the Curriculum Guide – in other words, what the innovation means for the teachers, how they interpret and implement it and the rationale for their actions. According to the observations of Lincoln and Guba (1985), validity in qualitative research concerns the representation of the multiple sets of mental constructions made by those under investigation. The reconstruction of these interpretations should be credible to the informants, the original constructors of these multiple realities and so, in this study, the findings should make sense to the six teachers. Guba and Lincoln (1989, p. 237) use the term 'credibility', instead of 'internal validity', for 'the match between the constructed realities of stakeholders and those realities as represented by the evaluator and attributed to various stakeholders'.

For this study, several strategies developed by Merriam (1988) were used to strengthen the internal validity, viz.

1 Triangulation is employed when a subject is complex and is not readily understood by employing a single research methodology (Seale, 1998). For this reason, the current study involves a range of research strategies to elicit different perspectives on a single phenomenon by collecting data through classroom observation, interviews and questionnaires. For example, the researcher can draw comparisons between the video observation data, the interview data and the quantitative data on both the teacher and student questionnaires. Also, the interviews allowed the researcher to listen to the views of both teachers and students on the teaching and learning of Mathematics. By listening to the major education partners (i.e. teachers and students), and by observing teachers teaching and recording their work on video, it was possible to get a holistic understanding of how the subject is taught and how learning takes place.

2 The researcher checked and rechecked the data collected throughout the study, and all the participants were given the opportunity to confirm the interview findings as they were shown the transcripts.

Also, disconfirming checks were carried out in the following ways. First, as a function of the drafting and redrafting of the thesis, unconvincing or irrelevant arguments were amended or discarded. For example, the original sub-group of codes about questioning (C) included a code of 'opening question' in addition to low- or high-level questions; but it was found that it actually belonged to the code for high-level questions and so was deleted. The final codes were more practical and less complicated, which aided the analysis. (For details, please refer to Appendix 8.) Secondly, working hypotheses were modified during member checking. Thirdly, in the iterative process of moving from the primary data to the interpretations and analysis, points were refined or discarded as appropriate.

### 4.7.3 Reliability

The traditional quantitative view of reliability is based on the assumption of replicability or repeatability. Essentially, it is concerned with whether the same results would be obtained if the same thing is observed twice, but this is clearly impossible in a study such as the present one. According to Lincoln and Guba (1985), instead of the term ‘reliability’, alternative terms such as ‘dependability’ or ‘consistency’ may be more appropriate for the qualitative paradigm. The idea of dependability, on the other hand, emphasizes the need for the researcher to account for the ever-changing context within which the research occurs: he/she is responsible for describing the changes that take place in the setting and how these changes affect the way the research approaches the area of study.

To ensure the dependability of the qualitative case study, the researcher tried to employ the following strategies:

1 The use of a case study protocol outlining the procedures to be used in the study.

2 The use of multiple methods to triangulate or converge on a set of dependable interpretations.

3 Stepwise replication, which requires two qualitative researchers (the researcher and her colleague) to compare their interpretations at different times (sometimes daily or at critical points where previous qualitative research plans need to be reconsidered).

4 Dependability audits in which experts are called in to examine the process and the interpretations involved in the qualitative research.

### 4.7.4 External validity and generalizability in case studies

External validity deals with knowing whether the results are generalizable beyond the immediate case. Some of the criticisms of case studies in this respect relate to single-case studies. However, that criticism is directed at the statistical and not the analytical generalization that is the basis of case studies. For qualitative case study research, the researcher has no intention of seeking universal laws of human behaviour. Instead, this study focuses on individual interpretations of a phenomenon. Given the particularistic nature of case studies, they tend to lead less clearly to generalization to a wider sample when compared with experimental research conducted according to standard sampling procedures. In this case study research, it is neither possible nor is it the aim to extrapolate to a wider population. As Stake (1988) points out, the major preoccupation of case studies is with the understanding of the particular case, and a thorough discussion of its uniqueness and its complexity.

In qualitative educational research, it is not intended to refer findings to outside the context being studied. Eisner (1991) claims that, although the logic of random statistical sampling is sound, it does not correlate with the reality of daily life, where lessons are learned from events that are ad hoc episodes or single-shot case studies, rather than units constituting a random sample. However, people tend to identify the similarities and differences between events and transfer those elements which are applicable to a different situation. Eisner (ibid.) continues by arguing that in qualitative studies the research can generalize only when the readers can determine whether the research findings fit the situation in which they work. Woods (1996) recommends this approach, which he refers to as 'dynamic triangulation', while Guba and Lincoln (1982) choose the term 'fittingness' and argue that the degree to which the situation under study is similar to other situations provides a more realistic way of treating the generalizability of qualitative research rather than more classical methods of extrapolation.

In the current research, the researcher uses three strategies (see Merriam, 1988) to improve the generalizability of the case study findings:

1 A rich description is provided to let interested readers make a judgement.

2 A multi-site analysis is conducted, while only six teachers are investigated.

3 The researcher discussed the particularities of the cases with other teachers to see any differences. Readers can compare their own situation to the cases.

## 4.8 Summary

This chapter has justified the use of a case study in the naturalistic observation approach adopted in this thesis. The study is placed primarily within the qualitative research paradigm, although it also makes some use of quantitative data. The research strategy used for the study, a multiple case study design focusing on six teachers in different secondary school settings, is outlined; and the three main data collection methods, namely classroom video observation, semi-structured interviews and an attitude scale are described and justified. The chapter ends by discussing the validity of the whole design of this research.

# CHAPTER 5

# TEACHERS' UNDERSTANDING, ATTITUDES AND PERCEPTIONS

## 5.1 Scope of the chapter

The chapter begins by outlining briefly the six teaching contexts and then examines the features of each of the teachers' approaches in the classroom to set the scene for discussing later how far they put the guidance in the Curriculum Guide into practice.

Lesson tables are used in this chapter (and the following one) in order to exemplify a number of themes arising in the lessons of the six teachers. It is not claimed that the transcripts are necessarily representative of the larger corpus of lessons. Their choice was based on the fact that they: (a) exemplify aspects of the teachers' classroom modus operandi; and/or (b) have particular implications for the implementation of the Curriculum Guide; and/or (c) enhance understanding of the process of implementing the Curriculum Guide.

It should be noted that, in all cases, the students (and sometimes the teacher) were rather sensitive to the presence of the video-recorder in the first lesson and seemed embarrassed when asked to respond to the teachers' questions. However, after three lessons, they were becoming used to the video-recorder and behaved naturally.

## 5.2 School profiles and the classes

Given the complex nature of the issues to be addressed in gaining insight into the teaching of Mathematics in classrooms, a system of triangulation was adopted as the aspects being studied will not be readily understood by employing a single research methodology (Seale, 1998). The process involves using a range of research strategies to elicit different perspectives on a single phenomenon. In this case, it included listening to the views of teachers and students on the teaching and learning of Mathematics, as well as videotaping the classroom teaching of the subject. The use of a multi-faceted methodological approach enabled me to study the complex interface between the teaching and learning of Mathematics from a range of different standpoints. By listening to teachers and students, and by observing and recording a series of lessons on video, I was able gain a holistic understanding of how the subject is taught and how learning takes place – and was therefore in a good position to understand whether students of different ability had different experiences in learning mathematics.

Before presenting the findings from the case studies, it is important to give a brief profile of the schools and classes involved in the research, to provide the reader with the context in which the study was conducted. All the schools were aided secondary schools; and one was a boys' school and the others were mixed schools.

Noted below are some of the key characteristics of the schools and the classes, based on the classroom observation and interview data (e.g. banding, setting and mixed-ability grouping which were discussed in Chapter 2, section 2.3.1). For comparative purposes, Tables 5.1 and 5.2 summarize briefly selected key elements of the respective teaching contexts. The student ability level was judged by the teachers on the basis of their schools' allocation policy.

**Table 5.1** Case study schools and classes

| Case study schools | Banding | Class names | Status (high/mid/ low ability) | Grouping procedure | School-based catering for student diversity | Remarks on teachers |
|---|---|---|---|---|---|---|
| A | II | 1B | high | Set (good) | After-school tutorials | Extra-curriculum master |
| | | 1D | mid | Set (weak in Mathematics) | | |
| B | II | 1A | mid | Mixed | Split class for language teaching only | Discipline teacher |
| | | 1D | mid | Mixed | | |
| C | III | 1D | low | Set (low) | Split classes for Mathematics | Teaches two subjects |
| | | 1E | low | Set (lowest) | | |
| D | III | 1CD | high | Specially set (good in Mathematics) | Continue setting by using test scores | Extra-curriculum master |
| | | 1A | low | Set (lowest) | | Form teacher |
| E | I | 1Y | high | Mixed (better in English) | Special classes for both high/ lower ability students | |
| | | 1S | high | Mixed (lower in English) | | Form teacher |
| F | II | 1A | high | Set (good) | 1 Remedial class for lowest 100 | |

| | | 1E | mid | Mixed | students taught by school teachers<br>2 Collaborative meetings for Maths teachers | Form teacher |
|---|---|---|---|---|---|---|

**Table 5.2** Summary data on case study classes

| Case study schools | Class size (no. of students) | Gender | No. of students who like/dislike Mathematics | Students' perceptions of their own ability level | Special features of the class | No. of observed lessons | No. of lessons coded |
|---|---|---|---|---|---|---|---|
| A | 1B (38) | Boys: 25<br>Girls: 13 | Like: 28<br>Dislike: 10 | Good: 4<br>Average: 25<br>Poor: 9 | Active | 4 | Double lessons |
| | 1D (19) | Boys: 7<br>Girls: 12 | Like: 7<br>Dislike: 12 | Good: 0<br>Average: 7<br>Poor: 12 | Passive | 4 | Two single lessons |
| B | 1A (41) | Boys: 24<br>Girls: 17 | Like: 21<br>Dislike: 20 | Good: 4<br>Average: 25<br>Poor: 12 | No discipline problems | 5 | Double lessons |
| | 1D (42) | Boys: 25<br>Girls: 17 | Like: 12<br>Dislike: 30 | Good: 3<br>Average: 33<br>Poor: 6 | Serious discipline problems | 5 | Double and a single lesson |
| C | 1D (16) | Boys: 6<br>Girls: 10 | Like: 3<br>Dislike: 13 | Good: 0<br>Average: 4<br>Poor: 12 | Discipline problems | 6 | Double lessons |
| | 1E (16) | Boys: 10<br>Girls: 6 | Like: 10<br>Dislike: 6 | Good: 1<br>Average: 5<br>Poor: 10 | Serious discipline problems | 6 | Two single lessons |
| D | 1CD (20) | Boys: 10<br>Girls: 10 | Like: 17<br>Dislike: 3 | Good: 6<br>Average: 12<br>Poor: 2 | Very good concentration | 4 | Two single lessons |
| | 1A (36) | Boys: 24<br>Girls: 12 | Like: 14<br>Dislike: 22 | Good: 2<br>Average: 18<br>Poor: 16 | Lack of confidence | 5 | Double lessons |
| E | 1Y (42) | Boys: 42 | Like: 37<br>Dislike: 5 | Good: 3<br>Average: 32<br>Poor: 7 | Think they know everything | 6 | Double lessons |
| | 1S (42) | Boys: 42 | Like: 40<br>Dislike: 2 | Good: 11<br>Average: 30<br>Poor: 2 | More concentration | 6 | Two single lessons |
| F | 1A (40) | Boys: 21<br>Girls: 19 | Like: 32<br>Dislike: 8 | Good: 8<br>Average: 27<br>Poor: 5 | Think they know everything | 4 | Double lessons |
| | 1E (39) | Boys: 23<br>Girls: 16 | Like: 26<br>Dislike: 12 | Good: 4<br>Average: 23<br>Poor: 12 | More attentive to and cooperative with teacher | 4 | Two single lessons |

In discussing each teacher's classroom approach, I will always refer to the following lesson table (Table 5.3) and the coding summary (Table 5.4). For every class, two or three lessons were selected for coding in the lesson table format in order to do an intensive comparison. The lessons selected were mainly the first two lessons on the concept of ‘Similar triangles’. The reason for choosing these lessons was to provide an easy comparison across the six teachers. Each table represents only one or two videotaped lessons according to the data collected. The complete lesson tables are not included in the appendices due to their length – only some episodes significant for the analysis were extracted from the passages. Since the lesson tables are not attached, their overall format is introduced here briefly with reference to Table 5.3.

Each column represents one main theme or one kind of code. For example, the first column ‘**Time**’ records the start time of a section of classroom activities; and the second column, ‘**Codes for ID’**, includes all five types of codes on catering for students’ individual differences. (In the column, there is a brief description of each code, and for more details of these codes, see Appendix 8). The third column ‘**Content segment’** includes a short summary of the classroom activities; and the final and biggest column ‘**Description of content segments’** includes a general description of what the teacher did and the teacher–student conversations.

**Table 5.3** Lesson table for elaborations

| Time | Codes for ID | Content segment | Description of content segments |
|---|---|---|---|
| 01:18<br>(time the activity began) | A – Diagnosis of students’ needs and differences<br>B – Variation in levels of difficulties and contents covered (B1: simple task, B2: challenging task)<br>C – Variation in questioning techniques (C1: low-level question, C2: high-level question)<br>D – Variation in approach (D1: concrete example, D2: symbolic language)<br>E – peer learning (E1: whole-class learning,<br>E2: group learning,<br>E3: individual learning) | e.g. Topic specified<br><br>Revision of previous day’s learning | *Transcription conventions*<br>T = Teacher<br>S = Student<br>Ss = Group of learners choral<br>Ws = Whole-class choral<br>S1, S2, etc. = identified student<br>[ *in italics* ] = commentary<br>… = pause<br>/ = overlapping speech<br>// = interrupted |

**Table 5.4 Summary of the six teachers' coded lesson tables**

| **Teachers** | **A** | | **B** | | **C** | | **D** | | **E** | | **F** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The classes | 1B | 1D | 1A | 1D | 1D | 1E | 1A | 1CD | 1Y | 1S | 1A | 1E |
| Class size and ability level | (big, high) | (small, mid) | (big, mid) | (big, mid) | (small, low) | (small, low) | (big, low) | (small, high) | (big, high) | (big, high) | (big, high) | (big, mid) |
| **A**: Diagnosis of students' needs and differences | 3 | 2 | 3 | 5 | 14 | 14 | 12 | 10 | 6 | 5 | 6 | 5 |
| **B1**: Simple tasks | 3 | 5 | 8 | 4 | 4 | 6 | 4 | 2 | 8 | 9 | 4 | 7 |
| **B2**: Challenging tasks | 3 | 2 | 8 | 2 | 2 | 0 | 2 | 5 | 6 | 9 | 7 | 7 |
| **C1**:low-level questions | 7 | 7 | 12 | 13 | 65 | 44 | 75 | 69 | 45 | 36 | 53 | 93 |
| **C2**: high-level questions | 5 | 4 | 16 | 10 | 78 | 57 | 68 | 78 | 31 | 41 | 66 | 90 |
| **D1**: Concrete examples | 2 | 2 | 4 | 1 | 25 | 18 | 5 | 6 | 14 | 8 | 8 | 17 |
| **D2**: Symbolic language | 1 | 0 | 4 | 3 | 13 | 16 | 1 | 13 | 6 | 12 | 5 | 7 |
| **E1**: whole class | 10 | 6 | 5 | 3 | 4 | 3 | 10 | 10 | 8 | 6 | 5 | 3 |
| **E2:** grouping students | 1 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **E3**: individual student | 13 | 20 | 3 | 5 | 11 | 11 | 17 | 14 | 16 | 12 | 8 | 4 |
| No. of individual students involved in discussion | 70 | 90 | 16 | 15 | 84 | 85 | 54 | 21 | 28 | 27 | 73 | 54 |
| No. of times Ss involved in discussion | 20 | 32 | 0 | 0 | 0 | 12 | 74 | 29 | 13 | 7 | 9 | 91 |
| No. of times Sw involved in discussion | 4 | 0 | 0 | 0 | 21 | 9 | 0 | 46 | 2 | 0 | 34 | 3 |

It is also important to understand the teachers. The following is a detailed description of the six teachers involved in the study.

## 5.3 Teacher A

### 5.3.1 General description of Teacher A

At the time of the study, *Teacher A* had fifteen years of experience as a Mathematics teacher and had been working in his current school since 1975. He was a very experienced teacher with high status in school as the panel head of extra-curricular activities. Teaching Mathematics was his minor subject as he taught Physical Education in the first few years, but over the years he had come to teach more and more Mathematics classes, and at the time of the research was teaching four Mathematics classes of different levels. In terms of training, he took Mathematics as a major subject in the part-time, two-year Certificate of Education at the University of Hong Kong. However, he had studied only first-year university mathematics, which he felt was not enough for teaching the subject. After that, he had no other in-service training. When I asked him whether he had attended any in-service classes held by Education and Manpower Bureau (EMB), he claimed that he had studied other subjects and would join those classes later.

From the first questionnaire (see Appendix 4), the data showed that *Teacher A* was keen on teaching Mathematics and said that, if he could choose again, he would still want to be a Mathematics teacher. He felt good in teaching this subject as he considered it was interesting, rewarding, and neither difficult nor time-consuming. Also, he had a positive image of himself, believing that the principal, students' parents and the students themselves appreciated his teaching. For teaching, he strongly agreed that students require a clear statement of problems and time to think about them, and need silence to understand and work. Also, in his view, to consolidate newly learned concepts, they have to have drill. Besides the textbook problems, he also strongly agreed on the need to provide students with experience of open-ended problems which had multiple answers or for which there might be no clear answer at all. On the other hand, he strongly disagreed that students would like to solve problems in different ways, as he found when he had tried to introduce open-ended problems: for him, students need clear single answers for problems.

*Teacher A* believed that it was better to separate slower students from more advanced ones while teaching. Using this criterion, he agreed that student learning could happen in leaps or chunks of understanding – and those leaps might come from solving problems. He also felt that students need to be guided to learn and understand concepts so that they could see the whole concept and its relationships; and he was confident that when they had mastered the basic concepts, they could figure out problem solutions by themselves and do more creative or thoughtful work. On the issue of teaching through discussion, *Teacher A* believed that students could learn to develop mathematical language and understanding during discussion, especially when it was well planned, before showing the answers, results or decisions; and he also considered that teachers and students often benefited from exploring together. Finally, he agreed that it was essential for parents to motivate their children to learn.

### 5.3.2 Teacher A's attitude towards the Curriculum Guide

I examined *Teacher A*'s attitude through discussing his general image of the Curriculum Guide. He mentioned the Curriculum Guide only when asked about his school-based curriculum planning for teaching Secondary 1 Mathematics. He just told me how the teachers chose the textbook and designed the teaching content according to the Curriculum Guide at the beginning of the school term. They would follow the suggestions in the Curriculum Guide to choose the enrichment topic for the high-ability class and tailored the teaching content for the lower-ability students in the split class. During the year, they would mainly follow the textbook to teach and forget the Curriculum Guide.

#### 5.3.2.1 *Teacher* A's *general beliefs about the teaching and learning of Mathematics*

After the series of videotaped lessons, another questionnaire (again see Appendix 4) was given to teachers, which focused on their perception of their teaching characteristics and style. *Teacher A* strongly agreed on the importance of using worksheets to help students to learn. During the lesson, he encouraged students to talk and ask questions, and when solving problems, he focused on the relevant concept(s) and accepted different approaches to a problem. He also allowed students to present their solutions on the blackboard after they had finished their work. At the end of the lesson, he could tell what they had learned. In his lowest rating, *Teacher A* responded that he did not like to use computers to teach.

There were a number of questions *Teacher A* rated at the middle level as 'neither agree nor disagree' – for example, lecturing to the whole class, using group activities or competitions, introducing a debate, and using projects and presentations. When mentioning how he used most of the time in teaching, he had no preference for demonstrating how to solve textbook or real-life problems and getting students to solve problems independently. When discussing a problem, he also showed no preference for establishing good rapport with students or encouraging brainstorming, problem-solving with active participation and discussion. In assessing students, he again showed no preference for various assessment modes to test students or for facilitating immediate self- and peer evaluation.

For the other issues – such as encouraging student learning beyond the curriculum and textbooks, empowering students with responsibility and leadership, trying to be imaginative and creative, as well as his views on students handing in their homework without difficulty – *Teacher A* also showed no preference.

#### 5.3.2.2 *Teacher A's specific attitudes towards catering for students' individual differences*

*Teacher A*'s attitudes towards dealing with students' individual differences, and his sense of different students' needs, appeared to be reasonably good. He claimed to know students' prerequisites very well and recognize their individual needs, potentials and strengths. He also claimed that he had frequent interaction with students during lessons. Students seemed to want to ask *Teacher A* questions when they did not understand. He agreed that most students could answer his questions correctly, which might be because he varied their level to match student ability. However, when assessing students, he did not intend to use a variety of assessment modes.

At the second teacher interview, I asked *Teacher A* whether he knew the section in the Curriculum Guide on catering for students' individual differences. He replied that he recalled this part, but had never tried to follow the suggestions there because he did not think his students had any special needs. From his perspective, only those students with, for example, low IQs or short-sightedness required special help in the classroom. He felt that low-ability students should not be treated in any special way in class. Although he said he had never tried any of the suggestions in the Curriculum Guide, he actually did something for those low-ability students. Further investigation of these findings will be covered in Chapter 6.

### 5.3.3 Features of Teacher A's teaching

After looking at the series of videotaped lessons of *Teacher A* teaching his two classes, some differences were found between his questionnaire responses about teachers' general beliefs and his actual practice, as follows.

*Teacher A* rated four (refer to Chapter 4, 4.6.3 for the scale) in the questionnaire (in Appendix 4) about knowing students' prerequisites very well and recognizing students' individual needs, potentials and strengths. As regards knowledge of the students' prerequisites, his planning appeared suitable for both classes. However, on close analysis of the videos, it was found that he recognized the individual needs of students in Class 1D more than in the larger Class 1B. In preparing lessons, there was evidence that *Teacher A* did not stick totally to the textbook when teaching and used worksheets to help students learn. Also, although *Teacher A* claimed to be neutral about giving lectures to the whole class, it was clear that he liked to do so. When solving problems, he would focus on the procedures, and in the process he would encourage free association of thoughts. To motivate students, he used teaching aids such as the overhead projector but not the computer. However, in the coded lessons, *Teacher A* was found to ask only four or five challenging or open-ended questions, which is a low total. As regards the overall classroom atmosphere, in both classes he did encourage students to talk and ask questions, and let them use trial-and-error or make mistakes when answering his questions. Surprisingly, *Teacher A* rated himself as neutral on the statement about establishing a good rapport with students. In addition, on the question related to interaction, he indicated that there was frequent interaction between him and students during lessons – but no examples could be found of students asking him questions when they did not understand.

### 5.3.4 Data from lesson tables

**Class 1B**: According to the video data selected for Class 1B, *Teacher A* generally established a friendly classroom environment. Although some students had to be given frequent verbal reminders to calm down, the overall learning spirit was high and students concentrated on their learning tasks.

In the second interview, *Teacher A* said that he usually used questions at the very beginning of a lesson to revise the previous lesson's content; and that, by using this approach, he could diagnose students' needs and differences about the concept of congruent triangles which related closely to the new topic of similar triangles. He gathered students' background information first and then related their existing knowledge to the new topic. Next, he designed a worksheet to test whether students could work out the basic concepts of similar triangles and identified their strong and weak points in this written assignment. Since this was an introductory lesson, the basic concept could not be varied to cater for students' individual differences. However, *Teacher A* designed two concrete triangles, one bigger and one smaller in size, to arouse student's drive to learn by putting them together to compare whether they were similar or not – a task which was quite suitable for this purpose. In order to sustain students' interest, he then gave out a worksheet about finding the methods to define similar triangles.

Although *Teacher A* used the same worksheet with the whole class, he did vary his approach by giving additional support to less able students during the seatwork. Most of the time, he tried to provide active forms of seatwork practice clearly related to the learning goals and circulated frequently among the students to assist them and monitor their progress. He also managed the transition from whole-class lecturing to individual seatwork by scanning the students and moving round the class.

Overall, according to the coded lesson table for 1B, I could see that *Teacher A* used several techniques to help individual students in this class, regardless of the large class size – for instance, walking round the whole class to check each student's progress or searching for any students with difficulties in completing the worksheet. He also catered for students' individual differences by varying his approaches when introducing concepts, giving clues for tasks and using methods of variation in questioning.

**Class 1D**: In Class 1D, *Teacher A* also established a friendly classroom environment. Students could seek help freely and got immediate feedback. In this class, students were more disciplined and I could see hardly anyone misbehaving – there was no need for *Teacher A* to use any verbal reminders to draw students' attention to the work. However, despite the fact that students concentrated on their learning tasks, the overall learning spirit was not very high. Most of the students were not interested or capable of learning Mathematics and were unable to finish tasks by themselves; and they worked slowly.

Nevertheless, the teacher let the students work out problems by using alternative methods. In solving one of worksheet problems, he told students to count the number of squares in representing the length of triangles.

In terms of variation, *Teacher A* gave concrete examples to introduce the concept of similar triangles. Although he used the same worksheet for the whole class, he gave extra support to individual students by suggesting a method for working out the problems. He gained the attention of the whole class at the beginning of the lesson and this continued for most of time. As this was a small class with only nineteen students, it was straightforward for him to move from a whole-class lecture to individual seatwork by scanning students and moving among them. He also maintained students' attention by providing active, relevant forms of seatwork practice and circulating frequently among the students to assist them and remind them to make suitable progress.

Overall, from the coded lesson table, it was clear that *Teacher A* attempted to cater for students' individual differences mainly by varying his approaches in introducing concepts and giving clear procedural solution methods for the tasks.

### 5.3.5 The similarities and differences in Teacher A's teaching of Class 1B and 1D

Referring to the coded summary table (Table 5.4), we can see *Teacher A* catering for students' individual needs during the lecture time by frequently diagnosing students' prerequisites for the learning task. Code A was identified for both classes about five or six times, which showed that he was concerned about students' learning needs and could guide students to relate their present knowledge to the new knowledge. Therefore, most students could follow his talk and attended to it for most of the period. Also, in both cases, he moved from a whole-class lecture to individual seatwork by scanning students and moving round the class. During the seatwork time, he clearly catered for 1D student's individual needs more as this was coded the same number of times (fifty-three) in both classes, but 1D had only nineteen students.

Lastly, when *Teacher A* was asked in the second interview how he catered for students who could work out assigned problems quickly, he mentioned that there were only one or two students who could finish the work quickly. He suggested to them privately that they should try some more difficult problems as they did not seem to mind working on more problems. For the low-ability students, he indicated that they should do the basic problems only and skip the difficult ones. He argued that those he assigned were basic problems, so all students in this class should learn how to work them out – that was the minimum requirement for students.

#### 5.3.5.1 *General differences in catering for student diversity*

*Teacher A* could vary his approach and style of teaching to cater for different classes of students, even if the core content to be covered was the same. As the following table shows, he asked many open-ended questions in Class 1B to arouse students' thinking before letting them explore the methods to prove similar triangles. He mentioned the method of comparing the angles as well as measuring the length of the sides, and then found the ratios of each pair of corresponding sides. In Class1D, he was keen to tell students how to follow the instructions to complete the work and then showed them the ways to prove similar triangles.

**Table 5.5** Comparison of Teacher A's teaching in the two classes

| Class 1B | Class 1D |
|---|---|
| T: I have two triangles. Do you think they are similar or not?<br><br>Ss: Similar.<br><br>T: Do you know how to put them together to check whether they are similar or not?<br><br>S4: Put the angle A over the other triangle's angle X and put the angle B over the other triangle's angle Y, so their three angles are correspondingly equal.<br><br>T: Good, let's give him a big clap.<br><br>T: Any other method to check these two triangles?<br><br>S5: Put the side AB over the other triangle's side XY and put the side BC over the other triangle's side ZY.<br><br>T: Can any student give us more? Can we compare the sides more accurately? We can compare one triangle's longest side to the other triangle's longest side and the shortest side to the shortest side in order to do the comparison. However, is that enough? Can we say they are similar after comparing all these sides? How can we do it more accurately?<br><br>S6: Measure the angles too!<br><br>T: We have already compared the angles – how about the lengths? You, do you have any suggestions?<br><br>S7: Check whether their ratios are equal or not.<br><br>T: Let's measure the length of each side and check their ratios. Good points! | T: What do you think about these two triangles?<br><br>S1: They look similar.<br><br>T: How can you put them together n order to show they are similar?<br><br>S overlaps the two triangles by making one angle overlap.<br><br>T: Could you overlap more angles? Can anyone help to overlap more angles? (A student raises her hand and would like to come out but fails to match all three corresponding angles. The teacher asks another student to try, but he still could not complete all three corresponding angles.)<br><br>T: Anyone tried to place the smaller triangle in the middle so that all three corresponding angles appeared equal?<br><br>T: It's your job to try to find out what criteria to use to decide those triangles are similar. The teacher gives a few introductions and lets students work out those three questions.<br><br>T: The first question asks you to draw a triangle which is smaller than the original one. Do you know how to make the smaller triangle? Are you going to make it smaller by cutting the area or shortening each side of the triangle?<br><br>S2: Shortening the length of each side of the triangle<br><br>T: If you are not clear how to do it, you can ask your neighbour to help. |

| | |
|---|---|
| Students, help the teacher to measure all the length of the sides by counting all the squares together and find that their ratios are equal to one and a half.<br>T: I am now not going to tell you how to write it. | |

**5.3.5.2** ***Differences in questioning style and techniques***

**Class 1B**: In this class, *Teacher A* used questions to get students' attention. Most of the time, the students were unable to answer him and felt embarrassed, so he reminded them to pay more attention to his lecture. His questioning therefore served not only to assess students' level of understanding and give them appropriate help but also to remind them to pay attention.

In the second interview, *Teacher A* was shown video extracts specially selected to allow in-depth questioning about the issue of providing for individual differences. The first video-clip from this class captured information about his questioning style, and he said:

> I am used to asking the whole class questions as I do not want to ask one student specifically and let other students get the wrong impression that they need not pay attention to the question.
>
> (*Teacher A*: second interview)

> In the video-clip, we saw the teacher asking one student a question. He recalled the occasion and explained why he had done so:

> At that time, I found this student was doing something else and was not paying attention to my lecture, so I got close to him. However, he still continued chatting with others and I asked him a question to remind him to stop doing other things.
>
> (*Teacher A*: second interview)

The next video-clip from Class 1B showed a student raising his hand and asking the teacher a question, but we could not tell what the student had asked as his voice was unclear. The teacher commented that normally when students began the seatwork they would ask some logistical questions about how to write the problem statement or how to represent the answer, but not about how to work out the problem. He said that students in 1B could usually work out the problem by themselves.

**Class 1D**: From his second interview about 1D class video-clips, *Teacher A* said he preferred telling students directly how to work out problems step-by-step rather than asking guided questions to help them think. When the first video-clip showed him asking a specific student (rather than the whole class) a question, he explained this 'special situation' as follows:

> Students in 1D always do not pay attention to the lesson. So I would like to remind the students who are talking to someone else to attend to the lesson by asking a question. Besides, I could check whether or not they really understood the meaning of supplementary angles.
>
> (*Teacher A*: second interview)

The next video-clip for 1D showed a student raising his hand and asking the teacher a question privately. Unexpectedly, the teacher remembered the student only wanted to get his permission to throw away rubbish. There was only one other video-clip showing a student raising her hand to ask a question. *Teacher A* could only think that she probably wanted to know how to work out the cross-multiplication that was closely related to the problem-solving procedure. In his view, students in this class would normally raise their hands to ask about the arrangements for questions, such as which question they needed to do or on which page of the textbook it appeared.

For most of the seatwork time, *Teacher A* walked around giving hints or telling students directly how to work out the problem regardless of whether or not they had asked.

***Teacher A*'s questioning techniques in Class 1B**: When introducing how to complete the tasks, he asked many questions which varied from high-level open-ended ones for capable students to closed low-level ones for less able students, as shown in the following segment:

| | |
|---|---|
| Teacher A | Do you know how to put them together to check whether they are similar or not? You cannot just hold them and look only, right? You just put the small triangle in the middle of the bigger triangle. Any other methods? |
| S5 | Put the triangle in the back! |

| | |
|---|---|
| Teacher A | That's all? You just put the small triangle in the middle of the bigger triangle then you can tell they are similar? You try to use angle A to match angle X, right? How about the lower part, which angle matches angle Y? OK, you match all three angles and find they are equal. |
| S6 | They are the same. |
| Teacher A | Is it that if you can fulfill the condition of three angles equal then they are similar? Does any other student want to try? He just compares the angles. Any other thing we can compare? Student XX, come out to try! Good, let's give him a big clap. How to compare the sides? Let other students look at it, OK? Can you tell to which side of the other triangle the side AB compares? |
| S7 | Put the side AB over the other triangle's side XY and put the side BC over the other triangle's side ZY. ZX matches the side CA. |
| Teacher A | OK, anything you would like to add on, student XX? Any other students who would like to add on? He just compares the sides one-by-one – are you satisfied with what he did? We can compare any two triangles' sides actually. Do you want to compare the sides more accurately? How can we match the sides? |
| S8 | Put the sides together closely! |
| Teacher A | What it mean 'closely'? |
| S8 | Overlap them. |
| Teacher A | Yes, we have already overlapped the two sides. However, we could do this in any two triangles. So you all are very smart to compare the side which is shortest side to the shortest side of the other triangle, and the longest side to the other triangle's longest side and the middle one with the other triangle's middle one. But do you think that is enough to say these two triangles are similar? Can we say they are similar after comparing all these sides? How can we do it more accurately? |
| S9 | Measure the angles too! |
| Teacher A | We have already compared the angles, how about the lengths? It's different from the angles, right? |
| Ss | No! |
| Teacher A | Please separate them into two different things. You, do you have any suggestions? Please tell the classmates. |
| S10 | Check whether their ratios are equal or not. |

| | |
|---|---|
| Teacher A | Yes, check their ratios. If the three sides' ratios are equal that means the triangle is either enlarged or decreased. Very good point. |

(*Teacher A*'s teaching in Class1B)

***Teacher A*'s questioning techniques in Class 1D**: In this class, *Teacher A* did not use as much time to introduce the basic concepts as in Class 1B. He employed the same method of introducing concrete triangle figures but went to the worksheet directly. By observing the videotaped lesson, I could tell *Teacher A* tried to ask many questions in order to stimulate students to think, but the questions were not appropriate and so not many students could answer them. He preferred to ask low-level open-ended questions first, and then tell students how to deal with the problem directly and let them follow his method, as shown in the following segment:

| | |
|---|---|
| Teacher A | What do you think about these two triangles? Do you think they look similar? |
| S4 | They look similar. |
| Teacher A | How can you put them together in order to show they are similar? Student XXX, would you please come out to put them together? Since you find they are similar, how can you put them together so that they will be easy to compare. Let's try this activity as the warm-up exercise.<br>(Student XXX overlaps the two triangles.) Can you explain how to overlap them? Are you overlapping them randomly? Or do you have some idea how to overlap them? You matched one angle to the other triangle's angle. You only matched one angle – can you overlap more angles? Can anyone help to overlap more angles? Good, student XXX. |
| Note | A student raised her hand and would like to come out but she failed to match all three corresponding angles. |
| Teacher A | Think about how to prove these two triangles are similar. You can match one more angle. Can you do it? |
| Note | (The teacher asks another student to try, but he still could not compare all three corresponding angles.) |
| Teacher A | He is very creative, right? Can you think again! Any other method? He is not that successful, right? Would anyone like to try? Student XXX, come out, try! They could match two angles – how about you? |
| S5 | I will match the third angle. |

| | |
|---|---|
| Teacher A | Students could match the smallest angle A to angle X and the biggest angle B to angle Y. So the last angle C matches angle Z, right? So all these three angles can be matched, right? |
| S6 | Then these two are similar. |

(*Teacher A*'s teaching in Class 1D)

During teaching, *Teacher A* used many questioning techniques to cater for different ability levels. He would raise an open-ended question to the whole class first and prompt other students to answer it step-by-step. More students in Class 1B were involved in the discussion and thought about the methods for proving similar triangles. The questioning techniques he employed was lowering the level of questions to cater for students of different levels and giving positive reinforcement to encourage students. In Class 1D, not many students could answer his questions, which might have been because of their lower ability. In my view, *Teacher A* did not seem to grasp the problem fully and kept asking inappropriate questions. As can be seen, he sometimes had to answer the questions himself. Because students in 1D were not very confident in answering questions, *Teacher A* gave them more hints, an approach which somehow worked in this class. For instance, he asked 'Do you know how to make the smaller triangle? Are you going to make it smaller by cutting the area or shortening each side of the triangle?'; and, because of this hint about shortening each side of the triangle, students were able to give the correct answer.

#### 5.3.5.3 ***Students' questioning***

As illustrated below, during direct teaching, students preferred to stay calm and pretend to be listening and understanding when they had problems with mathematical concepts. They did not want to interrupt the teacher's talk and would delay asking the teacher questions until they were assigned classwork later. In the student group interview data, students said that it was rare for them to ask any questions. For example, when I asked them how they reacted if they did not understand the lesson, they gave the following responses:

*Class 1D students*:

S1: I will keep it and think about it again at home, or read the examples again and again, or ask my sister.

S2: I will ignore it and not listen to the teacher and then go home and ask my mother.

S3 and S4: I will read the book's examples during the lecture.

S5: If I do not understand, I will pretend to sleep.

(*Teacher A*'s 1D student interview)

*Class 1B students*:

S1: After the teacher has taught the chapter, I will read the books and try to work out the examples to make sure I understand. If I find myself confused during the lecture, I will ask the teacher to clarify during the class.

S2: If I find something difficult and do not understand it, I will ask promptly during the lesson.

S3: If the teacher uses simple language to explain, normally, I find it easy to understand.

S4: This teacher explains the procedure step-by-step so clearly that he makes me understand. Besides, he will ask us whether we understand or not and, if not, he will explain it again. He will not repeat and repeat.

S5: If my two classmates who sit next to me didn't talk frequently, I would understand more.

(*Teacher A*'s 1B student interview)

In the videotaped lessons for both classes, it was not easy to find students asking questions. Fortunately, during the seatwork, the teacher would walk round and check whether students had started the work or were stuck on the problem. This was a good opportunity for the teacher to cater for students' needs and help them to learn directly. In the teacher interview, when he was asked about the type of questions students asked in these two classes, he responded:

Some 1B students like to ask why we do the problems in this way. I give them hints to solve problems.

Most 1D students like to know the procedures for working out the problems. I have to tell them all the steps in order to solve the problems.

(*Teacher A*: first interview)

#### 5.3.5.4 *Seatwork*

During the seatwork, the teacher not only walked around to take a look at students' work but also talked to students. To explore further what the teacher said to them, I selected another section of videotape in which *Teacher A* found a student who had still not started working. He said he would ask why, and show his concern for such students as 'a type of discipline'. He noted that some students of average ability might want to finish the classwork in the tutorial centre or at home as they would like to have their work corrected by a tutor or relatives. He explained that they did not seem to have enough confidence to complete the work correctly in class and did not want the teacher to know about their progress. Although *Teacher A* believed it was not good to let them finish classwork after lessons, he could not prevent them from doing so, and therefore could not assess these students' learning effectively during the class.

In the next video-clip, as noted earlier, when *Teacher A* was asked how he catered for students who could not understand the assigned problems quickly, he mentioned that, with low-ability students, he just asked them to do the basic problems. He also said there was one student who was unable to keep up with the pace of the class but, fortunately, she could seek help from her friends and the teacher's assistant.

**Students' questions during the seatwork**: *Teacher A* said that he believed that the most effective method he implemented to handle student diversity was to help each student during the seatwork. However, I could not find any very clear evidence to support his statement. I could see that most students were kept on-task to work on problems. Some students did ask the teacher questions during this time, but in investigating further the nature of the questions the students asked, it was found that they did not actually involve mathematics conceptual problems but something related to the working procedure, such as in class 1D:

S4: Sir, what should I cut?

T: You should cut the number two's figures.

or in class 1B:

S8: What's that dotted line?

T: The dotted line is the divided line. The above asks you to fill in the number of squares of XY. The lower part asks you to fill in how many squares of AB, OK?

As revealed in the student interview, students were not used to asking about problems related to the concept of similar triangles. Although those who were interviewed reflected that they would ask questions during seatwork without any hesitation, they asked about procedural problems when they were stuck in continuing their work. For the large Class 1B with the more able students, the students could do more or less anything they wanted to during this time as the teacher could hardly keep an eye on all of them. *Teacher A* could only glance at students' work quickly to check whether they were on- or off- task, e.g.

T: Please remember to write down the question number.

T: Have you finished filling in the blanks? Please be quick!

T: You have still not finished filling in the blanks – please be quick!

T: You've still left out question number three! You are falling behind your classmates.

In contrast, for the small class and less able students in 1D, it seemed that students could ask for help easily during this period of time. However, the interaction between the teacher and students during the seatwork could not be captured easily in the video data, so the quality of interaction was in doubt. In this school, I had not used the MP3 to get the conversation between the teacher and students during seatwork which limited the quality of the data. Anyway, here are a few examples of questions 1D students asked about the work during the seatwork time.

S20: What should I write for the reason for these questions?

T: I am going to ask you all about this.

S21: I do not know the reason.

T: Leave it then!

S22: I know the reason should be 'Given'.

T: Yes, I had taught you a reason 'Given'.

#### 5.3.5.5 *Assessment*

When assessing students' classwork, *Teacher A* would let students work out their solutions on the blackboard. He checked the solutions together with other students and gave instant feedback to clarify any wrong representations, and then went on with his teaching strategy. *Teacher A* clearly liked this practice very much as it could be seen in almost every videotaped lesson. At the end of a lesson, he used to round up the whole lesson by asking students what they had learned. However, in the videotaped lesson data, it was not easy to see students answering the questions directly. Most of time, the teacher would simply repeat the main points to remind students. In line with this, according to responses to the student questionnaire question 'After the lesson, we can tell what we learned', only two out of the nineteen (11%) 1D students and eighteen out of thirty-eight (47%) of 1B students could tell what they had learned.

Going through all the videotaped lessons of *Teacher A*, it appeared that he actually did not like to pose problems that related to the real world – he used textbook problems only during the lesson. He had no intention of trying to develop students' skills in problem solving as he showed students how to solve problems with a typical solution method, even though he claimed to believe that students could learn to think critically by tackling a variety of solution methods and to see the advantages and disadvantages of different solution method processes.

### 5.3.6 Summary

After viewing all the videotaped lessons and specially selected lessons for coding, overall *Teacher A* was found to be trying to cater for each student by checking them during the seatwork in each lesson. In the main, he used three methods in an effort to handle student diversity. First, he attempted to diagnose students' differences before introducing new concepts by means of questioning – but the questions he asked were found to be too general and the limited number of students who raised their hands to answer was selected randomly. The students who lacked previous knowledge were 'hidden' by the selected students. This method of diagnosis was not very effective and could not provide him with an accurate picture of his students' needs.

Second, when I looked at the teaching content *Teacher A* chose to teach for both classes, it was almost the same. The variation in the content was bounded by the textbook as well as the syllabus. Teachers in Hong Kong are supposed to go through all the content included in the textbook which meets closely the requirements of the examination syllabus. It was therefore difficult to have significant variation in the content, so one can see why *Teacher A* insisted on assigning foundation problems for all students and would not let them complete less.

Third, *Teacher A* believed his most effective method for providing for individual differences was by helping each student during the seatwork. However, there was little evidence to support his statement. Most students were kept on-task to work on the problems and, while some students did ask him questions during this time, they were not concerned with mathematics concepts.

In the second teacher interview, when asked about the seatwork time, *Teacher A* recalled that the students' questions were not related to mathematical concepts, which indicated that this method of catering for students' individual differences was not efficient. As seen in the video data, in certain circumstances, *Teacher A* approached students to give working hints, positive encouragement and support that helped students to work satisfactorily, but this was not enough to enable students of different ability levels to learn the mathematics content.

## 5.4 Teacher B

### 5.4.1 General description of Teacher B

When the study was conducted, *Teacher B* had six years' experience as a Mathematics teacher but had been working in his current school for only a year. While a relatively new teacher in his present school, he had taught for two years at a private tutoring school and had three years of normal secondary school teaching experience. He was also a discipline teacher and noted:

> I am a discipline teacher in this school. I have to manage all the students' discipline problems once I come across them. I love to do it as I feel very satisfied in helping students. I think it is worthwhile to give my heart to help students as they will change and behave well once they feel that you really care about them.
>
> (*Teacher B*: first interview)

Mathematics was his major teaching subject, but his university degree was not in Mathematics. In terms of training, he took Mathematics as a major subject in the part-time, two-year Certificate of Education at Institute of Education. In his school, he took four Mathematics classes of different levels, mainly in lower forms. From the first questionnaire (see Appendix 4), some of the findings for *Teacher B* were very similar to the responses of *Teacher A*: *Teacher B* was very keen on teaching Mathematics; he would still want to be a Mathematics teacher if he could choose again; and he felt good in teaching the subject as it was interesting, rewarding, and neither difficult nor time-consuming. However, he had an uncertain image of himself. He selected 'neither agree nor disagree' on whether the principal, students' parents and the students appreciated his teaching. For teaching, he strongly agreed that students need clear statements of problems; that they require instant feedback when they encounter difficulties and time to think about them; and require silence to understand and work. He also agreed that, to consolidate new concepts, students have to be guided to learn and understand the whole concept and its relationships with other concepts by drilling them on new ideas introduced in a lesson. Apart from the textbook problems, he neither agreed nor disagreed on the need to provide students with experience of open-ended problems with multiple answers or no clear answers, and on whether they would like to solve problems in different ways. However, he felt that students have to be given opportunities to create and think in all parts of mathematics to master basic concepts for doing more creative or thoughtful work.

*Teacher B* did not take sides on the issue of separating slower students from more advanced ones for teaching. He was uncertain about whether student learning could happen in leaps or chunks of understanding from solving problems. On the value of teaching through discussion, he disagreed that students could learn much during the process, even when it was planned well, but did feel that teachers and students often benefited from exploring together. Lastly, he agreed that students underrated mathematics achievement and it was essential that their parents motivated them for learning.

### 5.4.2 Teacher B's attitude towards the Curriculum Guide

In discussion with him, *Teacher B* also mentioned the Curriculum Guide only when I asked him about his school-based curriculum planning for teaching Secondary 1 Mathematics. He simply told me that it provided the framework and progress. He indicated that the Secondary 1 Mathematics teachers chose which topics to teach and skip at the beginning of the school term. This teacher had his own method for preparing the materials for his teaching.

> I prepare the lessons by referring [to] and copying the previous textbooks. I check the important issues which I should address and the software which I could use again. For example, my previous school bought a set of software – I forget the name. Now, when I teach some topics by using the current textbooks, I find that most of the activities mentioned in the textbooks require the software program to work on. However, I do not think this school will buy this software as it most likely costs a few thousands dollars.
>
> (*Teacher B*: first interview)

#### 5.4.2.1 *Teacher* B's *general beliefs about the teaching and learning of Mathematics*

In response to the second questionnaire about how teachers viewed their teaching style, *Teacher B* agreed that he knew where to get teaching resources and liked to use computers in his teaching. He also liked to pose challenging questions, such as open-ended questions, and he would allow students to learn by trial and error. Also, when solving problems, he focused on both the procedures and relevant concepts. He believed that he established good rapport with students and accepted their different approaches to a problem. He also encouraged logical, analytical thinking and infused thinking strategies and skills into learning. In addition, he said he always checked whether or not students understand concepts by asking them questions, and evaluated students' learning outcomes by setting different learning standards, so that he could tell what students had learned after lessons. *Teacher B'*s lowest rating related to his response that he did not like to have group activities or competitions; and he disagreed that most students handed in their homework without any difficulty.

There were several questions on which *Teacher B* rated at the middle level – neither agreeing nor disagreeing. For instance, he was unsure if he prepared his lessons well. Also, he was neutral about sticking closely to the textbook when teaching, using worksheets to help students to learn, giving lectures to the whole class and using teaching aids. He commented:

> I will select extra problems for them in different ways. For 1D, I will select problems which are easier; in contrast, for the 1A, I will go through the content more deeply and show them more difficult problems. Since 1A has no discipline problems, I have time to talk about more problems and more thoroughly. For 1D, I can only cover the basic problems and have no time to talk other problems.
>
> (*Teacher B*: first interview)

In addition, he was neutral about encouraging students to talk and ask questions, or participate and discuss actively; and he indicated no preference on introducing debates, projects and presentations to enhance students' independent learning and thinking. Other areas in which he indicated no preference included: demonstrating how to solve textbook or real-life problems; getting students to solve problems independently; giving students sufficient time to think and answer questions or solve problems; encouraging brainstorming; and using a range of assessment techniques, including immediate self- and peer evaluation.

He also gave neither 'agree' nor 'disagree' responses on yet more issues, such as encouraging student learning beyond the curriculum and textbooks; giving responsibility and leadership to students; trying to be imaginative and creative; and on whether students handed in their homework without difficulty.

#### 5.4.2.2 *Teacher B's specific attitudes towards catering for students' individual differences*

*Teacher B*'s attitudes towards dealing with students' individual differences and his sense of the abilities of different students were weak. He indicated that he neither disagreed nor agreed about knowing students' prerequisites very well and recognizing students' individual needs, potentials and strengths. Besides, he felt that his interaction with students was not frequent during lesson, with students seeming not to want to ask him questions when facing difficulties in understanding. He did not intend to use a variety of assessment modes to test students. Also, he was neutral about whether most students could answer his questions correctly, which could be because he did not vary the level of questions according to student ability.

At the second teacher interview, I asked *Teacher B* whether he was familiar with the Curriculum Guide's section on catering for individual differences. He replied that he remembered this part as he had read it when studying at the Institute of Education:

> At that time, I realized the guide suggested using different levels of assessment papers such as a computer program setting ABC three levels of papers to let student choose. High-ability students can choose the highest level one … and low-ability students can choose the basic level one. It is also similar to public examinations with sections A, B and C which divide high, middle and low level problems. I think this is the Curriculum Guide's suggestion for catering with student diversity.
>
> (*Teacher B*: second interview)

When asked what the Curriculum Guide suggested for teaching students with diverse needs, he said that he had never tried to implement the suggestions because of his heavy workload and tight schedule.

### 5.4.3 Features of Teacher B's teaching

After looking at the series of videotaped lessons on the two classes *Teacher B* taught, there appeared to be some differences between his questionnaire responses on his general beliefs and his actual practice.

For example, *Teacher B* rated three in the questionnaire (in Appendix 4) about knowing students' prerequisites very well and recognizing students' individual needs, potentials and strengths. In the former case, it did not seem that his planning was suited to both classes as not many students were attending to the lesson, which may have been due to his poor classroom management. The videos showed that *Teacher B* did not take care of students' individual needs as they were large classes. In his lessons, there was evidence that he did not stick totally to the textbook but also used other material to help students learn. Although he claimed to be neutral on giving lectures to the whole class, it was clear that he liked to do so and did not wish to use group activities or competitions. In the process of solving problems, he would pin-point both the procedures and relevant concepts, and would allow the students to adopt a trial-and-error approach. To motivate students, he used a computer in addition to other teaching aids such as an overhead projector. The coded lessons showed that *Teacher B* asked ten or sixteen challenging or open-ended questions, which is a medium total compared to the other case study teachers. As regards the overall classroom atmosphere, *Teacher B's* questionnaire response was 'neutral' about encouraging students to talk and ask questions, and about giving students enough time to think and answer them. While he rated himself as 'four' on the statement about establishing a good rapport with students, this could be found only for Class 1A. Finally, for the question on interactions with students, *Teacher B* again rated himself as 'neutral', but there were no examples of students asking him questions when they did not understand something.

### 5.4.4 Data from lesson tables

**Class 1A**: According to the video data selected for Class 1A, in general, *Teacher B* tried to establish a routine and firm classroom environment. Although some students misbehaved and frequent verbal reminders were needed, the overall learning spirit was fine and students concentrated on their learning tasks.

From both the videos and the coded lessons (see Table 5.4), it was clear that *Teacher B* used only a few techniques to help individual students in this class. At the beginning of the lesson, he asked a few simple low-level questions about recalling the five reasons for identifying congruent triangles which he thought were closely related to the new topic of similar triangles. He could not diagnose students' needs and differences at all. Since he only directed questions at specific students, he was unable to gather information about students' previous knowledge to which new knowledge could be related.

Then he assigned seatwork in which students had to draw different sized triangles and work out basic concepts about similar triangles by measuring the length of the sides and the number of degrees of each angle. Since this was an introductory lesson, the basic concept could not be varied to cater for students' individual differences. However, *Teacher B* asked students to draw two concrete triangles, one bigger and one smaller, by using a triangular ruler which was given before the seatwork. He also asked students to measure the lengths of the sides and the number of degrees of each angle, thinking that this activity about exploring the special properties of similar triangles could motivate them. When introducing how to complete the tasks, he did not ask questions but told students directly how to draw two different sized triangles by outlining the perimeters of a triangular ruler and the hole in the ruler. He then asked them to measure the length of the sides, calculate the ratio of two corresponding sides and measure the corresponding angles to explore the properties of similar triangles.

As regards variation in approach, although *Teacher B* used the same worksheet for whole class, he gave additional support to less able students during the seatwork. He managed to get the attention of most students at the start of the lesson and maintained this for his instruction. Besides, he also monitored the transition from a whole-class lecture to individual seatwork by scanning the class and circulating among the students. During seatwork, he kept the attention of around half the class for most of the time by providing active forms of seatwork practice clearly related to the academic outcomes. He often moved around the students as they were doing their work to help them and check on their progress.

Overall, according to the videos, I could tell that *Teacher B* catered for students' individual differences mainly by giving clues in tasks.

***Class 1D***: For Class 1D, *Teacher B* also established a routine classroom environment. However, the students did not seem to care about their studies. They never sought help from him and hardly any student could be seen to be behaving appropriately to the teacher. The teacher often needed to use verbal reminders to draw students' attention to the work; and, although they seemed to be working during the seatwork, the overall learning spirit was very low.

According to the videotaped lessons, *Teacher B* gave concrete examples to introduce the concept of similar figures, such as a TV set and photos, and stated clearly that the learning target was to find out other properties of similar triangles: 'Today, we are going to discuss the second main point about the characteristics of similar triangles and how to define the similar triangles'.

Although he used similar figures to introduce the concept of 'similar', he did not point out the main properties of similarity and relate them to the similar triangles. He only told students: 'Similar triangles are the same in their corresponding angles but the length of their sides are in ratio'. Then he gave an example to show students how to calculate the lengths of a triangle by using the properties of similar triangles:

| | |
|---|---|
| Teacher B | XXX student, what is the ratio of the side's length changed from 3 to 1.5? |
| S2 | Half |
| Teacher B | Yes, it's cut down half – also from 4 to 2. |
| Teacher B | Refer back to congruent triangles again, since congruent triangles can be made by rotation, reflection and moving along. For similar triangles, we have to enlarge or cut down to make the similar triangles. Let's turn to page 101 to work on the exercises. |

(*Teacher B*'s teaching in Class 1D)

Overall, according to both the video data and the coded lesson table (Table 5.4), it was apparent that *Teacher B* hardly catered for students' individual differences if the students were not really cooperating with him. He could not get much information from interacting with students and could only follow the general teaching format for introducing the basic concepts of similarity from figures to triangles and give a procedural solution method for the problems.

As can be seen in Table 5.4, *Teacher B* could not cater for students' individual needs in Class 1D, where the coding (E3) was much less than for Class 1A. One reason for this could be that the teaching time for the 1D lesson was less than for 1A. However, the coding shows *Teacher B* had correlated the learned knowledge five times in 1D which was more than the two times in 1A. The table also shows that he was not really concerned about the less able students' learning needs. During direct instruction, he asked ten high-level questions (C2) in 1D but sixteen in 1A, although sometimes no student could answer him. The most obvious differences between the classes were at seatwork time as *Teacher B* used only a short time for seatwork in 1D, while there were ten codings of E3 in 1A.

### 5.4.5 The similarities and differences in Teacher B's teaching of Class 1A and 1D

As can be seen in the coded summary table (Table 5.4), *Teacher B* catered for students' individual needs during the lecture time by diagnosing students' prerequisites for the learning task. Code A was identified for both classes, three times in Class 1A and five times in Class 1D. However, while he was concerned about students' learning needs, he could not guide students to relate known knowledge to the new knowledge – so most students could not follow his teaching. The number of individual students involved in discussion was only sixteen and fifteen in 1A and 1D respectively. The interaction between the teacher and students during the discussion time showed low figures for both classes.

When the teacher was asked how he dealt with students who could figure out the assigned problems quickly, he said he did not suggest to this small number of students that they should attempt more demanding problems since they seemed reluctant to work on further problems. Again, he advised low-ability students to tackle only the basic problems and not attempt the difficult ones. According to the teacher, the problems were fundamental ones which all students should be able to work out as a minimum requirement.

*Teacher B* varied his teaching style to cater for different classes of students, even if the core content to be covered was the same. Although the variation in content was limited by the textbook and syllabus, *Teacher B* used different activities to guide the two classes:

**Table 5.6** Comparison of Teacher B's teaching in the two classes

| **Class 1A** | **Class 1D** |
|---|---|
| T: Today and tomorrow, what we are going to learn is 'similar'. Let's look at the sign for 'similar'. The symbol for 'congruent' is like a snake and an equals sign, and the symbol for 'similar' is only the snake without the equal sign.<br>Now I am going to give you a worksheet to do an experiment in order to find out the characteristics of similar triangles. Please take a look at the textbook, page 98. There are many figures there which could give you some hints about the characteristics.<br>(After ordering the student helper to hand out the worksheet, *Teacher B* also distributed triangular rulers which he wanted the students to use for the experiment.)<br>T: Please use the triangular ruler to draw | T: Today, we are going to discuss the second main point of the characteristics of similar triangles and how to define similar triangles.<br>T: Let's look at the text book page 98. XXX student, when you see two television sets, one bigger and one smaller, what you can tell about them?<br>S1: They are square.<br>T: Are you sure they are square? You should use a ruler to measure their lengths.<br>S1: They are a four-sided polygon.<br>T: Yes, when you have not measured them, you're better to say they are a four-sided polygon. That would be correct.<br>T: The lengths of this four-sided polygon are 3 and 4, with the lengths of the smaller one cut down proportionally as 1.5 and 2. Both figures are rectangular, just like the |

| | |
|---|---|
| the triangles. For the smaller one, you can outline the inner triangle which is the hole in the triangular ruler. After that, outline the triangular ruler to draw the bigger triangle. When you have finished, you can measure all the angles and all the lengths to check what kind of special features they have. What is the relationship between the two triangles? Are they similar? Which angles are equal? And the lengths of sides have some special relationship. | photos with bigger or smaller sizes. So their shapes are the same but they are not equal in size. What are the characteristics of the same shape actually? Refer back to congruent triangles, which are congruent because their corresponding sides are equal and corresponding angles are also equal. But in similar triangles, they are different. Let's look at the textbook page 99, the blue box. Similar triangles are the same in their corresponding angles but the lengths of their sides are in ratio. |

*Teacher B* asked many low-level questions in Class 1D to guide students to think about the meaning of 'similar', by relating it to the idea of concrete figures like a TV set and different sizes of photos. It seemed good to use real-life objects to introduce the idea of similarity. However, he could also have used objects to explain the properties of similarity more thoroughly, rather than jumping to the idea of ratio and the lengths of 3 and 4 being cut in half to become 1.5 and 2. *Teacher B* then highlighted the properties of similar triangles' corresponding sides and angles which correlated with the concepts of congruent triangles. He quickly raised another example of the ratio of two corresponding lengths of sides. Although students were guided to answer his question successfully, it was apparent that they still had no clear concept of similarity. I also doubted whether they really understood the basic concept of ratio since they never discussed this in detail in the lesson. For 1A, he let students explore the characteristics freely by doing an experiment; and after the two triangles were drawn, he told the students directly to measure the angles and lengths to check the special features of the two triangles. Students just followed his instructions in working on the experiment and then found out the properties of similarity. *Teacher B* thought he did not need to ask students in 1A questions to discipline them as they were of higher ability. He was willing to offer the triangular ruler to let students explore freely, which was a more concrete method for constructing the basic concept of similarity than that used with 1D.

#### 5.4.5.1 *Differences in questioning style and techniques*

**Class 1A**: In the second interview, *Teacher B* was shown video extracts that were selected to allow in-depth questioning about the issue of catering for individual differences. The first video-clip was about his questioning style. His response was as follows:

> Usually, my questions have many functions. If I find students are not paying attention, I will ask them to stand up and answer my questions. That is one of the functions of my questioning. For the higher-ability class, where students concentrate during the lesson, I will select students randomly by choosing number cards which include all students' class numbers. Sometimes, I will encourage students to answer me by adding marks.
>
> (*Teacher B*: second interview)

As shown above, *Teacher B* liked to use questions to attract students' attention. For most of the time, he pointed to a specific student to answer a question; and if the student chosen was unable to answer, he would lower the question level – but these simple questions did not get students to pay more attention to his talk. Most of the students did not need to listen as they were not asked anything, and the questions posed therefore could not assess students' level of understanding and give appropriate help to them. Fortunately, the students in this class cooperated more with the teacher and would still answer the teacher's questions right after the specific question to a student.

| | |
|---|---|
| Teacher B | Let's ask XXX. We would like to compare these two lengths AB and XY. Since AB is 4 and XY is 0.8, how many times is the ratio of these two lengths? You can calculate the ratio by using the calculator. |
| S11 | Five times. |
| Teacher B | Yes, this is exactly five times since five times eight is forty. How about the next two sides? To compare BC and YZ while they are 4.2 and 0.9 in length. How many times are they this time? |
| S12 | 4.6 |
| Teacher B | The last two sides, comparing AC and XZ while they are 5.7 and 1.2 in lengths, how many times are they? |
| S13 | 4.7 |
| Teacher B | That means their ratios are approximately around 5 since the error of measuring by this ruler. For the conversion, that means the bigger triangles times 1 over 5 will be the smaller triangle. So in this way, when student XXX draws the third triangle which bigger than triangle ABC, that's really good to see you draw in this way. |

(*Teacher B*'s teaching in Class 1A)

***Teacher B*'s questioning style with Class 1D**: Most of the students in 1D were not interested or very capable in learning Mathematics and were not able to finish tasks by themselves. On this occasion, *Teacher B* did not spend as much time introducing the basic concepts by using the method of drawing different sizes of concrete triangles with a triangular ruler as he had in Class 1A. Instead, he went directly to using the textbook. He did not ask many questions to stimulate their thinking and, when he did, he preferred to ask low-level questions first, then tell students how to handle the problem directly by following his method. This is illustrated in the Class 1D column in Table 5.6.

Generally, *Teacher B* could not use questions to cater for students' diversity in this class as only very few students could answer him actively. Most of time, he had to answer his own questions during the teaching or pick specific students to answer him. So, he preferred telling students directly how to work out the problems step-by- step.

Although *Teacher B* thought his questioning skill was effective in reminding students to concentrate on the important concept, when observing his the lessons, it was obvious that these low-level questions were not effective.

**5.4.5.2** ***Students' questioning***

While the teacher was talking, the students appeared to be pretending to listen and understand, though it was difficult to be certain about this. In the group interview, when students were asked whether they would answer teacher's questions, Class 1A students' responses were:

> S1: Sometimes.
> S2: I will answer if I know.
> S3: Most of time I will answer when he asks me.
> S4: All the time I will answer when he asks me.
> S5: Sometimes I will raise my hand to answer.
>
> (*Teacher B*'s 1A student interview)

When Class 1D was asked whether they knew how to answer the teacher's questions, they answered:

> S1: I don't know how to answer. In today's lesson, the teacher asked me twice and I did not know how to answer. He had to remind me a lot in order to answer him correctly. Actually, I did not know how to answer.

S2: The teacher also called me to answer his questions. Sometimes I know and sometimes not. Actually, I think his questions are useless.

S3: I remember the teacher asked me twice. I think if I could work out the problem on blackboard I will have a deeper memory.

S4: The teacher called me before. Most of the time, I know how to answer his questions.

S5: All the time, I know how to answer his questions as those questions are useless. I already know the answers.

S6: Sometimes I know how to answer but sometimes not. When I am stuck, the teacher will remind me or tell me how to answer. The question was of no use to me.

(*Teacher B*'s 1D student interview)

From the student questionnaire in Appendix 5, thirty students in each class indicated that they disagreed or strongly disagreed with answering the teacher's questions. When they were asked a question specifically, they would seek help from other students.

The student group interview data also indicated that it was rare for them to raise questions of their own. In the videotaped lessons, it was difficult to find students who raised their hands to do so. In response to whether they would ask questions when they came across difficulties in learning, 1A students responses were:

S1: Sometimes, I will raise my hand and ask.

S2: If I get stuck on a problem, I will ask after the lesson.

S3: I also will ask but during the lesson.

S4: It depends. I will ask sometimes during the lesson.

S5: Sometimes, I will ask when the teacher passes by. He will ask us too when he walks around.

S6: I will ask the teacher when he asks us whether we understand or not.

S7: No, I do not want to ask.

(*Teacher B*'s 1A student interview)

To the same question, 1D students said:

S1: I do not care, I will not ask! I will study it by myself.

S2: I do not need to ask as the teacher will discuss it again for us since other students will ask.

S3: I will ask my classmates.

S4: Sometimes I will ask the teacher after the lesson.

S5: I will ask before the examination.

S6: I will try my best to study it by myself. If I cannot understand it, I will ask the teacher after school before the examination.

S7: I never ask as I will not understand his explanation. I will rather ask my classmates. Anyway, I have to figure it out by myself.

S8: I will never ask as I cannot understand what he says. It is time-consuming to ask him.

(*Teacher B*'s 1D student interview)

#### 5.4.5.3 *Seatwork*

During the short seatwork time, the teacher would walk around and check whether students had started the work or were stuck on the problem. While this was a good chance for the teacher to cater for student diversity, because of the limited time he could not really check student's progress or understanding.

I would normally select some video-clips at the seatwork time when students asked the teacher questions, but with *Teacher B* the seatwork time was very short and I could not capture a clip that showed students asking him questions. When this was mentioned to the teacher, he responded that usually only one or two students would ask questions. The next video clip, also from 1D, showed a student raising his hand and asking the teacher privately. The teacher remembered that the student only told him that he could not work out the next step and said he gave him a hint to refer to the textbook example which had a similar problem. It was not easy to find another clip where the students were asking questions, since 1D students were not used to doing so. During the short seatwork time, the teacher tried to walk around checking progress, giving hints or telling students directly how to work out the problem.

Although the interviewed students reflected that they would ask questions during the seatwork without any hesitation, they asked about procedural problems. During seatwork, *Teacher B* could only make comments such as the following:

T: Try to measure the angles to see whether they are the same or not.

T: Try to measure the lengths of those two triangles and check whether they are in ratio or not.

T: First draw the lines then measure their lengths.

T: Do you know what's going on? Yes, you have drawn the triangles. Are you feeling very tired? No, then sit straight properly.

For Class 1D which had more problem students, the teacher did not want to give students time to do seatwork as he could hardly keep an eye on all of them. Also, in this class, *Teacher B* used a microphone a lot while lecturing, which limited the help he could give because of the limited length of the microphone wire. On the quality of his help during the seatwork, the video data showed that the interaction between the teacher and students during the seatwork was not related to mathematics – he just urged students to work faster or to come out to present their answers on the blackboard.

In the second teacher interview, when I asked him about the seatwork time, *Teacher B* recalled that all the questions students asked were not concerned with mathematics, which suggested that his method of catering for student's individual differences was not effective. Approaching students to remind them to try harder or let them work on the blackboard clearly was not enough to help students of different ability levels learn the mathematics content.

He claimed that it was impossible for him to help forty-one or forty-two students in a class during the seatwork time:

> Since there are forty-one or forty-two students in a class, it is difficult for me to help. If I walk around during the seatwork and find a student who is working on a problem slowly, I will give him a hint that this problem is similar to a worked example so that he can follow it and try to continue the work. I hope this can encourage him to go on. After that, I could hardly do any follow-up for him.
>
> (*Teacher B*: second interview)

**5.4.5.4** ***Assessment***

When assessing students' classwork, *Teacher B* would let students who finished quickly work out their solutions on the blackboard. He checked the solutions together with other students and gave instant feedback. *Teacher B* obviously liked this practice very much as it could be seen in almost every videotaped lesson. In the second teacher interview, he was asked how he helped those students who still did not understand the whole concept, to which he replied:

> Because of the limited time in each lesson, when I have to give a lecture, demonstrate an example and assign the seatwork problem, the lesson is almost finished. I could only use two methods to deal with students who are behind. First, I try my best to give instant feedback to students who have problems. Also, I would invite students to work out the problem on the blackboard. That would somehow help those students who had no idea how to start the work. They could copy down the solution and think about this later. I know that the girls usually copy down the solution regardless of whether they understand it or not. When they have to work on their own to finish homework, they can refer to the copied classwork and the examples. I give hints about the odd numbered exercises and assign the even numbered ones as homework for students.
>
> (*Teacher B*: second interview)

### 5.4.6 Summary

After viewing all the videotaped lessons and the lessons specially selected for coding, overall it was clear that *Teacher B* could not discipline students effectively. Also, he seemed to be aware of the problem of student diversity. He tried to use the following methods to cater for individual differences. First, he would attempt to diagnose student differences before introducing new concepts by means of questioning, but the questions he asked were found to be too general and only one student was selected to answer. This method of diagnosis was of no use for providing him with any information about his students' needs.

The content he selected for both classes was almost the same. It was not easy to have major variation in this content, which is why *Teacher B* insisted on assigning foundation problems for all students and would not let them complete less.

Finally, *Teacher B* believed that the most effective method for catering for student diversity was helping students during the seatwork. However, I could not find evidence to support his statement. I could tell that only half of the class was kept on-task to work on the problems.

## 5.5 Teacher C

### 5.5.1 General description of Teacher C

At the time of videotaping, *Teacher C* was a student on the Diploma of Education at the Open University of Hong Kong, where she had already gained a part-time degree. Before she got the degree, she was a teaching assistant in her school, taking the Secondary 4 tutorial class after lessons for a year. Altogether she had only two years of experience as a Mathematics teacher, dealing with Secondary 1 and two elementary levels and low-ability students. Mathematics was her major teaching subject and Science her minor subject. However, her maximum qualification in learning Mathematics was at first-year university mathematics level, which she felt was not enough for teaching the subject. After her formal training, she had not taken any other in-service training because, she claimed, she was currently fully occupied in part-time study, but would join EMB classes later.

In responding to the first questionnaire (Appendix 4), *Teacher C* said that she was not keen on teaching Mathematics and, given the choice again, might not want to be a Mathematics teacher – but agreed that teaching the subject could be interesting, and was neither difficult nor time-consuming. She did not feel very confident about her teaching. Although she believed the principal appreciated her work, she could not tell whether students and their parents did so. She strongly agreed that students need clear problem statements, and time to think and talk about the problems to develop mathematical language and understanding. In her view, it was better to show students how to solve problems and give them instant feedback when they faced difficulties; and she strongly disagreed that her students could define, refine and develop problem statements and work out problem solutions on their own. In her view, students need experience with problems which have multiple/no clear answers. When introducing new concepts, *Teacher C* believed drilling was necessary for students to learn and understand the whole concepts and their relationships. She felt that, if given a broad programme to explore concepts, students might sometimes master the basic concepts and do more creative or thoughtful work – so it was worth giving them the chance to create and think in all areas of mathematics. Then student learning could happen in leaps or chunks of understanding – and those leaps might come from solving problems, especially doing so in various ways.

*Teacher C* strongly agreed that it was better to separate slower students from more advanced students while teaching. She also believed that students could learn a great deal during discussion, particularly when it was planned well before giving the answers, results or decisions. Finally, she strongly agreed on the importance of parents motivating students to help them learn.

### 5.5.2 Teacher C's attitude towards the Curriculum Guide

When talking to *Teacher C* about the Curriculum Guide, as in the case of *Teacher B*, she noted it only when I asked her about her school-based curriculum planning for teaching Secondary 1 Mathematics. She just told me that she was aware of the Curriculum Guide but had never read it seriously.

#### 5.5.2.1 *Teacher C's general beliefs about the teaching and learning of Mathematics*

In responding to the second questionnaire, after a series of videotaped lessons, *Teacher C* strongly agreed that she encouraged students to talk and ask questions, and display independent learning and thinking. She also strongly agreed that, when solving problems, she encouraged students to brainstorm on the solution methods and accepted different approaches to a problem in an effort to promote logical, analytical thinking. She agreed too that she gave lectures to the whole class and sometimes held group activities or competitions, and she also liked to use teaching aids. She indicated that she established good rapport with students in class and encouraged them to participate actively in discussion, and did not worry about trial and error mistakes caused by free association of ideas. When solving problems, she focused on the procedures and relevant concepts, and at the close of lessons she could tell what students had learned.

There were a number of questions to which *Teacher C*'s response was 'neither agree nor disagree' – for instance, on whether she prepared her lessons well; stuck closely to the textbook when teaching; used worksheets to help students to learn; employed computers in teaching; posed challenging questions; used open-ended questions; and introduced debates, projects and presentations. In response to how she used most of her time in teaching, she expressed no preference for demonstrating how to solve textbook problems, letting students solve problems independently and solving problems that related to real-life. She also responded with neither 'agree' nor 'disagree' about giving students sufficient time to think and answer questions or solve a problem. After problems had been solved, she did not let students present their solutions on the blackboard or facilitate immediate self- and peer evaluation. For other issues, such as infusing thinking strategies and skills into learning, *Teacher C* also indicated no preference.

#### 5.5.2.2 *Teacher C's specific attitudes towards catering for students' individual differences*

*Teacher C*'s attitudes towards catering for students' individual differences, and her awareness of different students' needs, were weak. She strongly disagreed about knowing students' prerequisites very well and took a neutral position on recognizing students' individual needs, potentials and strengths. She also indicated that her interaction with students was not frequent during lessons, and students did not appear to wish to ask her questions when they could not understand. In addition, she had no intention of using a variety of assessment methods. She did respond that she could ask questions of appropriate levels for students' ability, but she also gave a neutral response on whether most students could answer her questions correctly.

At the second teacher interview, I asked *Teacher C* whether she knew the Curriculum Guide's recommendations for dealing with students' individual differences. She replied me that she remembered this part, but had never tried to read it thoroughly. Then she told me her own approach for handling student diversity.

> Actually, I've never tried any special method to cater for students' diversity. For the high-ability students, I will try to let them do more problems. For the weak students, I will not force them to do more simple problems since I think these students, to certain extent, might feel it so hard to understand the lesson content as they lack enough prerequisites. Sometimes they can follow my work during the lesson … however, they totally forget it after leaving the classroom. On the other hand, they could learn much better in other subjects. So I do not force them to do well in my subject and make them feel big pressure because Mathematics is a very important subject. I prefer to release them by telling them it is fine to try their best to keep what they have learned in their minds. Then I will feel very happy if they can keep up with their limited work in Mathematics and not give up in the examination. I hope they still have confidence to learn the other subjects more by asking more interesting questions.
>
> (*Teacher C*: second interview)

Although the teacher said she had never tried out any suggestions from the Curriculum Guide, she did respond differently to low-ability students. Again, further investigation of these findings will be covered in Chapter 6.

### 5.5.3 Features of Teacher C's teaching

Once again, in the videotaped lessons for *Teacher C*, some differences were found between her questionnaire ratings on teachers' general beliefs and her classroom practice, as shown below.

*Teacher C* rated two and three in the questionnaire on knowing students' prerequisites very well and recognizing students' individual needs, potentials and strengths. However, in the former case, there was no evidence to show that her planning was unsuited to both classes. In preparing her lessons, *Teacher C* liked to use real-life examples to help students to learn and did not adhere totally to the textbook when teaching.

Also, while *Teacher C* claimed she was used to giving lecture to the whole class, it was evident from the videos that she did not do so all the time – for example, she gave pair-work activities to let the students explore problems. When solving problems, she did not focus only on the procedures but also on the relevant concepts. In the process of solving problems, she encouraged free association of ideas, and to motivate students she used teaching aids such as the overhead projector but not the computer. In the coded summary lessons table (Table 5.4), *Teacher C* was found to ask seventy-eight higher-order questions (C2) in 1D and fifty-seven in 1E in the coded lessons, which is a very high total. In terms of the overall classroom atmosphere, in both classes *Teacher C* encouraged students to talk and ask questions and to develop independent thinking and learning, so there was always a very good rapport for student learning. Surprisingly, *Teacher C* rated herself as only three in the statement about giving students sufficient time to think and answer questions or solve problems. She also rated three on the questions related to the frequency of her interactions with students and students asking questions, but many examples of the latter were found.

### 5.5.4 Data from lesson tables

**Class 1D**: According to the video data chosen for this class, in general *Teacher C* established a friendly classroom environment. Students could seek help freely or ask questions proactively and got immediate feedback. Although verbal reminders to behave were sometimes needed, overall the students concentrated on their learning tasks.

From the data from the videos and coded lesson table (Table 5.4), I could see that

*Teacher C* used some techniques to help individual students in this class. Because of the small number of students, she could easily walk round the whole class, checking each student's work. At the very beginning of lessons, she diagnosed students' needs and differences by asking simple questions about the concept of congruent triangles which are closely related to the new topic of similar triangles. After gathering information about the students' present knowledge, she tried to relate it to the new topic, and she designed a group-work activity to let students work out the basic concepts of similar triangles. In doing so, she did not introduce variation for different students as this was an introductory lesson. However, *Teacher C* designed two concrete triangles, one bigger and one smaller, and put them together to see if they were similar – which was suitable for arousing students' interest in learning. In order to sustain their interest, she then raised many real-life examples of similar objects.

**Class 1E**: For this class, *Teacher C* also established a friendly classroom environment in which students could seek help freely and get immediate feedback. In this class, more discipline was needed to monitor students since I could see that some students were very naughty and did not pay attention. *Teacher C* had to use verbal reminders to draw students' attention to make them follow her lecture or instructions. However, the overall learning spirit was fine as, although the students were of limited ability, most of them were motivated to work on the activities. Students seemed able to finish tasks by themselves although they did the work slowly.

The lesson table showed that *Teacher C* did not use as much time to introduce the basic concepts as in Class 1D. Then she moved quickly into the real-life examples. She let students work out similar figures by using alternative methods. In discussing the methods for proving similar triangles, she told students to work in groups to measure the angles of the triangles. However, some students tore the triangles into pieces to compare it with another triangle and some others used a ruler to measure the length of the sides of the two triangles. Unexpectedly, students promptly took up these methods of comparing the triangles, which motivated other students.

### 5.5.5 The similarities and differences in Teacher C's teaching of Class 1D and 1E

By referring to the coded summary table (Table 5.4), we can see *Teacher C* catering for students' individual needs during the lecture time by often diagnosing students' prerequisites for the learning task. The lessons for both classes were coded A about fourteen times, which illustrated a real concern for students' learning needs and for guiding them to relate their existing knowledge to the new knowledge. Most of students could follow her lecture, so she gained their attention at the beginning of the lesson and maintained it later for most of the time. Also, she monitored the transitions from a whole-class lecture to group work and to individual seatwork effectively by scanning and moving among students. During the seatwork, she still kept the attention of the students by providing relevant active forms of seatwork practice, during which the coded summary table showed her catering for students' individual needs about eleven times for both Class 1D and 1E.

Overall, there were no major differences observed in the way *Teacher C* responded to student diversity in the two classes. She only tuned her teaching focus according to the students' needs during the open discussion. For seatwork, she tended to give less time for Class 1E. She explained that students in that class needed her guidance more in working on problems, especially in first few lessons on a new topic. Since students in Class 1D had confidence in trying to solve new problems, she would let them explore. *Teacher C* said that her main method for helping the lower-ability students in both classes was to ask them to stay after school for further help. She suggested to these students that they should confine themselves to doing basic problems, as she would rather encourage them by praising their good work on fundamental questions.

#### 5.5.5.1 *General differences in catering for student diversity*

*Teacher C* could vary her approach and style of teaching even if the core content to be covered was the same. As the following table shows, she asked many open-ended questions in Class 1D to get students to think before letting them explore the special features of similar triangles. She mentioned the method of overlapping the triangles which she used in the topic of congruent triangles to get students to think. However, for Class 1E, she just told the students directly that the two triangles were similar and the smaller triangle was made by decreasing from the bigger triangle. She never mentioned any special features of these two triangles.

**Table 5.7** Comparison of *Teacher C*'s teaching in two classes

| **1D** | **1E** |
|---|---|
| T: Today we will discuss the topic of similar triangles. Before we discuss this new topic, we have to take a look at these two triangles first. Do you remember the special features of these two triangles? (The teacher raises one paper triangle and one plastic triangle | T: Today, I've prepared some triangles for you. If we use the visualizer that will be better to show you. Anyway, just look at these two triangles; they are well designed by the computer. I made the smaller one by decreasing it from the bigger one. You have tried to draw a figure by using the computer, |

| | |
|---|---|
| and puts the plastic triangle over the paper triangle to remind students.) These are congruent triangles, right? Do you remember those congruent triangles' figure and size are …<br><br>Ss: Same<br><br>T: They are the same. Now I'll show you another two triangles. (The teacher raises one paper triangle which is bigger in size and one plastic triangle which is smaller in size.) This is the older brother and this is younger brother. You have eight groups of two students. Each group will be given two triangles like the ones I have.<br><br>T: When you get them, please put them together by overlapping the plastic triangle over the paper one. What do you find out after overlapping them?<br><br>S1: They are not the same.<br><br>T: Yes, they are not the same but they look alike. This is what we are going to teach about similar triangles. These two triangles, the older brother and the younger brother, are similar triangles. I'm telling you they are similar triangles. However, how are they similar actually?<br><br>S2: Just look at their appearances.<br><br>T: Look at their appearances. You cannot tell they are similar or not by only looking at their appearance directly.<br><br>S3: Both of them have right angles and the hypotenuse.<br><br>T: How can you say they have right | haven't you? Have you ever used Word to make the figure?<br><br>Ss: Never!<br><br>T: Oh, you should try then. Here I have two triangles – this is the older brother and that is the younger brother. They are similar figures as the younger brother is decreased from the older brother. We are going to study the similar triangles. So triangles are not all congruent – they can be similar. You have learned the transformation before, right?<br><br>S3: Reflection.<br><br>T: Yes, reflection. However, one method will make the figure decreased or enlarged. Do you remember what it is?<br><br>S4: Enlarged or decreased?<br><br>T: What kind of change has the figure in size and shape?<br><br>S5: Larger in size only!<br><br>T: Since it is a triangle, after it is enlarged, it is still a triangle. That means the size increased and the shape remained unchanged.<br><br>S6: the same!<br><br>T: Remember this, OK? Here I have two triangles for your reference. In real life, there are a lot of examples of similar figures. Can anyone give me some examples of similar figures?<br><br>S7: For example the notice board and the classroom rules display.<br><br>T: They look like the same size! Anyway, can you make the A4-size classroom rules display |

| | |
|---|---|
| angles?<br>S3: You can look at it in this way.<br>T: Look at it in this way, then you find it has a right angle? It might be eighty-nine degrees.<br>S3: Then we need to use the protractor to measure the angle.<br>T: Yes, you'd better use the protractor to measure the angle. I have only three protractors for you. In a moment later we will use these protractors. Come back to these two triangles. How can we say they are similar? If we are not talking about the triangles, we have rectangles or rhombuses or other subjects. How can we say they are similar?<br>S4: They look alike.<br>T: How can we say they look alike? Is there anything in real life that you think looks similar?<br>T: A moment ago, I introduced the two triangles to you as the older brother and younger brother, right? So how can you tell in real life that they are similar? No? Do you remember in your school hall, when you raise your head to look, what do you see there?<br>S5: The school logo<br>T: What size is this school logo?<br>S6: It is as big as the desk. | into a A3 size?<br>S8: Use a magnifying glass!<br>S9: Use a computer!<br>T: Using a computer, we can scan it first then enlarge or decrease it. Any other method?<br>S10: Draw it by hand.<br>T: It might not be very accurate when drawing it by hand.<br>S11: Use a ruler to help!<br>S12: Photocopy it.<br>T: Yes, photocopy! Actually, when I was making these two triangles, I also used a photocopying machine to help. Originally, I wanted you to look at it closely. However, we have not got the visualizer. OK, any other method?<br>S13: Take a photo!<br>T: Good, student XXX, could you elaborate further?<br>S13: Develop the photographs into different sizes.<br>T: Yes, if you want to develop a bigger photo, you could develop it as 5R. All these different sizes like 2R, 3R, 4R are similar rectangles. All of them are similar figures. |

#### 5.5.5.2 *Differences in questioning style and techniques*

**Class 1D:** In the second interview about the video-clips, *Teacher C* was shown extracts chosen to allow detailed questions about the issue of catering for individual differences. The first video-clip was about her questioning style, to which she responded:

> I'm used to asking those weaker students to answer my questions specifically as I would like to let them know I am concerned about their learning. If they are day-dreaming and not listening, I would alert them by asking questions regardless of the difficulty level. Since the students in this class are weak and like to day-dream, I have to remind them frequently by using this method.
>
> (*Teacher* C: second interview)

On the video-clip, we saw the teacher asking one student a question. Remembering the occasion, *Teacher C* explained the purpose of asking her a question, as follows:

> This student was usually day-dreaming or writing something secretly for other classmates or talking to her neighbours. Anyway, she was just not paying attention to my lecture, so I asked her to remind her to attend to my lecture.
>
> (*Teacher* C: second interview)

Most of the time, students were unable to answer her and felt embarrassed. The function of questioning was broadened for the purpose of assessing student's level of understanding and giving appropriate help.

The next video-clip, also in 1D, showed the teacher asking the whole class a question, but no student could answer her and she had to answer it herself. *Teacher C* confessed that it was not good for her to answer questions and not give students enough time to think them through. She wanted to use questions to repeat the important points or procedures to guide students in solving problems.

In another video extract, I found a student discussing an answer openly with *Teacher C* and other students, though the sound was not clear and I could not tell what the student said. The teacher pointed out that this student was the smartest in the class and could raise other students' curiosity. When asked why this student had been assigned to this special class, the teacher explained:

> In the allocation test, he could not present the steps appropriately and get the correct answers, so his mark was low. Although he could think through

the problems quickly, he could not present them and gain marks.

(*Teacher* C: second interview)

**Class 1E**: From the data in the 1E class video-clips, it was seen that, in general, *Teacher C* could not use questions to cater for students' diversity in this class as very few students could answer her questions. In most cases, she had to answer her own questions during teaching or select a specific student to answer her. The first video extract showed her choosing a particular student to answer. Since the teacher claimed she preferred asking whole-class questions, she was asked in the second interview why she had done so. The teacher explained in the following way

> Students in 1E always fail to pay attention to the lesson. So I would like to remind the student who was doing something else to attend to the lesson by asking a question.
>
> (*Teacher* C: second interview)

The next video-clip for Class 1E showed a student raising his hand and asking the teacher a question privately. The teacher remembered that this student just wanted to clarify the problem statement. No other clip of a student asking a question could be found, since 1E students were not used to doing this. During the seatwork, for most of the time the teacher walked round giving hints or telling students directly how to work out the problem.

When comparing the video-clips on *Teacher C*'s teaching in the two classes, there were fewer examples of students answering in Class 1E than in 1D. The only possible reason *Teacher C* could think of for this was that she also taught this class Science, and they had come to know each other well. While this probably encouraged students to ask questions, the teacher felt that normally students in this class would ask questions just to clarify the problem statement.

**Class 1D**: During teaching, *Teacher C* did not use many questioning techniques to cater for different ability levels. She would ask the whole class open-ended questions first and prompt other students to answer them step-by-step. More students in 1D were involved in the discussion and thought about the properties of similar triangles. The questioning techniques she employed were to lower their level to cater for weaker students and give positive reinforcement to encourage them.

When introducing the concept of similar figures, she asked many questions which varied from high level open-end questions for capable students to closed low-level ones for less able students, as seen in Table 5.7.

**Class 1E**: In Class 1E, not many students could answer *Teacher C's* questions, possibly because of lack of motivation and limited ability. It could be seen that she sometimes had to answer the questions herself in this class. Since 1E students were not very confident in answering questions, *Teacher C* preferred asking students low-level ones, a method that seemed to work in this case. For instance, she asked 'one method will make the figure decrease or enlarge – do you remember what it is?' Since this question involved only recall, a student could give the answer.

She did not ask appropriate questions to stimulate thinking since not many students could answer such questions. She merely adjusted the approach to match the students' ability level. She preferred to ask low-level open-ended questions first, then tell students how to make similar figures by photocopying:

#### 5.5.5.3 *Students' questioning*

Students stayed calm for most of the lecture time and tried to understand what was being said. When they were stuck on the mathematical concepts, some of them felt free to ask the teacher right away – they did not mind interrupting the teacher's talk. In the student group interview data, students said it was not rare for them to ask questions during the teacher's lectures. When I asked them how they reacted if they did not understand something in a lesson, they gave the following responses:

*Class 1D students*

S1: Most of time, I will raise the question to the teacher right away.

S2: I will try to think it through at home. If I cannot figure out the problem, I will ask the teacher during the lesson.

S3: I will ask the teacher during the lecture.

S4: I will also ask the teacher by calling out right away during the lecture.

S5: If I do not understand, I will not ask as I will forget it anyway.

S6: I think I will ask during the lesson; however, I never try to ask as I have no problem.

(*Teacher C*'s 1D student interview)

*Class 1E students*

S1: I never try to ask a question.

S2: No, I will not ask.

S3: No, I will not ask also.

S4: Sometimes, I will ask the teacher a question after the lesson.

S5: If I do not understand, I will ask during the lesson.

S6: I will call out right away when I come across difficulties.

(*Teacher C*'s 1E student interview)

#### 5.5.5.4 *Seatwork*

It was not easy to find students who raised their hands to ask in video records of both classes. However, quite often students called out to ask during the lecture as well as at the seatwork time. Since the class size in both cases was small – only fifteen or sixteen students in a class – the teacher could easily walk around and check whether students had started the work or had a problem during the seatwork. In the teacher interview, *Teacher C* was asked what the differences were between these two classes in the learning atmosphere:

> 1D students are more disciplined. Some of them are off-task and not listening, but some concentrate very hard and want to write down the main points of what I was teaching. Owing to my lack of experience, I think I should learn some methods to draw the off-task students back to my lecture.
>
> 1E students cause discipline problem as most of them like to talk a lot. They are just like little kids and I prefer not to take a very firm approach to scold them. I think this would break our good relationship and have a bad effect on the learning atmosphere.
>
> (*Teacher C*: second interview)

She also claimed that 1E students asked more questions than in 1D, and explained this as follows:

> It might because I use a different teaching method in the two classes. Since 1D students are more disciplined, I am scared that if I make any jokes they might not have any reaction, so I prefer using a more serious manner to teach. Students in Class 1E are more active, so I can be more easy-going. In addition to this, I teach 1E one more subject other than Mathematics so I know them well. Students in 1E are also familiar with me and not afraid to ask me questions.
>
> (*Teacher C*: first interview)

During the seatwork, no students raised their hands to ask the teacher questions. *Teacher C* had to walk around to take a look at students' work and talk to them. *Teacher C* explained that the students were not bold enough to ask openly – but they would ask her when she stayed close to check their work. She claimed that a number of students did not want to work on the problems and would like to wait for her answers and copy them. She had to walk around and force them to try, but they did not have enough confidence to complete the work correctly and did not want the teacher to know about their progress. Although *Teacher C* believed it was not good to let them finish the classwork after lessons, she could not prevent them from doing so. She could not assess these students' learning effectively during the class.

A few students did ask her questions during this time. However, when the nature of these questions was investigated further, it was found that they did not actually involve mathematics concepts but were just about clarification (e.g. in 1D: S59: what's this? T: U'). Students did not seem to be used to asking about the concept of similar triangles. Although those who were interviewed reflected that they would ask questions during the seatwork without any hesitation, they only asked for clarification to help them continue the work. On the other hand, the less able students in Class 1E did not dare to do anything else but the task, since the teacher could keep an eye on all of them. *Teacher C* not only checked students' work closely but also identified errors right away. Her interaction with students during the seatwork is illustrated in the following excerpt:

| |
|---|
| S22: Why has this triangle no angle?<br>T: You tear off all the angles from your triangle! |
| S23: I break the triangle into pieces!<br>T: Your technique is very bad! You have only one angle left. How about the other angles? |
| S24: I have measured them already.<br>T: Really? What's the answer? |

(*Teacher C*'s teaching in Class 1 E)

In the second teacher interview, when I asked many questions about the seatwork time, *Teacher C* remembered that all the questions students asked were not related to mathematics. This showed that her method for dealing with student's individual differences was not efficient. In the video data, it was seen that, in certain circumstances, *Teacher C* approached students to give working hints, positive encouragement and support that helped students to work satisfactorily – but this was not enough to help students of different ability levels learn the Mathematics content.

#### 5.5.5.5 *Assessment*

Lastly, the teacher was asked how she catered for students who could work out the assigned problems quickly during the seatwork time. She mentioned that there were only one or two students in this category. However, she felt she should not suggest that they attempt some more difficult problem as they appeared reluctant to do so. For low-ability students, she suggested they should just learn how to do the basic problems.

### 5.5.6 Summary

After viewing all the videotaped lessons and the specially selected lessons for coding, overall *Teacher C* was shown to be a novice teacher who tried hard to cater for every student by checking their work during the seatwork in each lesson. In the main, she used the following methods to cater for students' diversity. First, she diagnosed students' differences before introducing new concepts by means of questioning. However, the questions she asked were found to be too general and only the limited number of students who raised their hands to answer was selected randomly. Nevertheless, she tried to link their previous knowledge closely with the new knowledge and checked students' prerequisites frequently in order to help them to learn.

As with the previous teachers, the variation in content was limited by the textbook and the syllabus. As it was difficult to vary the content much, *Teacher C* insisted on assigning basic problems for all students to complete.

*Teacher C* believed that helping each student during the seatwork was the most effective method she used to cater for student diversity. However, while I could tell that most students were kept on-task in working on the problems, I could not find much evidence to support her statement.

The last method for catering for student diversity which I found in the videos was group work. The students seemed to enjoy working with other students' help. The activity designed to help students explore the properties of similar triangles by manipulating the two triangles was very helpful for promoting students' understanding of the actual concept of similarity. Although the students were not of high ability, they were able to find the properties by hand in this activity. The method of grouping helped the teacher to cater for students' learning diversity by involving the students themselves.

## 5.6 Teacher D

### 5.6.1 General description of Teacher D

As *Teacher D* was my classmate when we studied in the Chinese University, I had known her for more than ten years. She enjoys teaching very much and is devoted to her career and the school. She has never thought of changing her school, although it is a band three school with very naughty and low-ability students. She is an industrious teacher who wants to learn more, and has taken many courses after school in, for example, mathematics and statistics, computing and EMB [currently named the Education Bureau (EDB)] enrichment courses. Since she is an experienced teacher, in addition to teaching many Mathematics classes, she is often assigned responsibility for leading extra-curricular activities, including civic education, and drafting the timetables.

In responding to the first questionnaire (Appendix 4), *Teacher D* indicated that she was very keen on teaching Mathematics, and would still wish to do so if she could choose again. She felt good in teaching the subject as she agreed it was interesting and rewarding and disagreed that it was difficult and time-consuming. She believed that the principal and students appreciated her teaching, but could not tell whether this applied also to the students' parents. She agreed that students need clear problem statements, and required silence to understand and work, and time to think about the problems. However, she was unable to decide whether students could talk to develop mathematical language and understanding. Also, she disagreed that her students could define, refine and develop problem statements and work out solutions by themselves. While she strongly agreed that students need experience with problems which have no single clear answer, she disagreed that students want to solve open-ended problems in different ways. *Teacher D* felt strongly that, when introducing new concepts, students had to be guided to learn and understand the whole concepts and that it was sometimes of value to give them opportunities to create and think in every part of mathematics. She also believed that student learning could occur in leaps or chunks of understanding which might come from solving problems and that students need drilling to learn new ideas introduced in a lesson.

*Teacher D* strongly agreed that it was better to separate slower students from more advanced ones while teaching. She also believed that students could learn a lot during discussion, but was uncertain about whether the discussion should be planned before showing the answers, results or decisions.

### 5.6.2 Teacher D's attitude towards the Curriculum Guide

Like the previous three teachers, *Teacher D* mentioned the Curriculum Guide only when I questioned her about her school-based curriculum planning for teaching Secondary 1 Mathematics. She just told me that she know about the Curriculum Guide, but never paid attention to it.

#### 5.6.2.1 *Teacher D's general beliefs about the teaching and learning of Mathematics*

In the second questionnaire about teaching style, *Teacher D* strongly agreed she was firm and consistent, and imaginative and creative. She also strongly agreed with allowing students to use trial and error, sometimes leading to mistakes, when they were attempting to learn and think independently. Further, she indicated that during lessons, she encouraged students to talk and ask questions, although she also liked to give lectures to the whole class. In addition, she liked to pose challenging and open-ended question to encourage free association of ideas, active participation and discussion. When reacting to how she spent most of her time in teaching, she highlighted demonstrating how to solve textbook problems and letting students solve problems independently. When solving problems, she focused on the procedures and relevant concept and gave students sufficient time to think and answer questions or solve the problems. She accepted different approaches to a problem such as brainstorming, and logical, analytical thinking, and infused thinking strategies and skills into learning. She strongly agreed to let students present their solutions to problems on the blackboard; and she also agreed to giving students responsibility and leadership. Finally, when the lesson finished, she could tell what students had learned.

There were only a limited number of questions on which *Teacher D* responded 'neither agree nor disagree' – for instance, on sticking closely to the textbook when teaching; introducing debates, projects and presentations; using most of the time to solve problems related to real-life; encouraging learning beyond the curriculum and textbooks; and facilitating immediate self- and peer evaluation. She also gave a neutral response to whether most students handed in their homework without any difficulty. The lowest ratings for *Teacher D* were disagreement with liking to use computers to teach and to holding group activities or competitions.

#### 5.6.2.2 *Teacher D's specific attitudes towards catering for students' individual differences*

*Teacher D*'s attitudes towards handling students' individual differences, and her awareness of differing student ability, were strong. She strongly agreed on recognizing students' individual needs, potentials and strengths, and agreed that she knew students' prerequisites very well. She also indicated that she interacted frequently with students during lessons and that her students wanted to ask questions when they had difficulty in understanding. She always intended to use a variety of assessment modes, and she agreed that most of the students could answer her questions correctly, possibly because she varied their level depending on student ability.

When asked in the second interview about her knowledge of the recommendations on dealing with individual differences in the Curriculum Guide, *Teacher D* replied that, while recalling this part, she had never paid attention to it. She explained her approach to this issue, as follows:

> If the ability differences between students are very big, I will choose the middle level teaching content to teach first rather than teaching the simple part or the most difficult part. It might be that some students are sacrificed.
>
> (*Teacher D*: second interview)

Following up on this question, I asked *Teacher D* how she helped low-ability students. She told me that she would ask classmates who were sitting close to them to teach them. However, she added that this did not really work well because these students are unwilling to ask anyone for help when they cannot understand how to work out the problems – they are very passive and do not want to learn. Although the teacher said she had never tried any suggestions from the Curriculum Guide, in practice she did handle these low-ability students in a different way. Again, Chapter 6 includes further investigation of the findings.

### 5.6.3 Features of Teacher D's teaching

The videotaped lessons of *Teacher D's* two classes showed that her questionnaire responses about teachers' general beliefs did not always match her practice, as indicated below.

In the summary of the teachers' questionnaire (Appendix 4), *Teacher D* rated four and five about knowing students' prerequisites very well and recognizing students' individual needs, potentials and strengths respectively. On close analysis of the videos, *Teacher D* seemed to recognize the individual needs of students in Class 1A more than in 1CD, as she was the Form teacher of 1A. There was evidence that *Teacher D* did not stick entirely to the textbook when teaching and liked to use teaching aids to help students learn.

In terms of teaching style, *Teacher D* claimed she liked to give lectures to the whole class and not to have group work activities or competitions, which was consistent with her actual practice. When solving problems, she would focus on both the procedures and the relevant concepts; and in the process, she encouraged free association of ideas. To promote student motivation, she used teaching aids such as the overhead projector but not the computer. Also, when posing challenging or open-ended questions (C2), *Teacher D* was found in the summary coded lessons in Table 5.4 to ask sixty-eight questions in Class 1A and seventy-eight in 1CD – a very high total. As regards the overall classroom atmosphere, in both classes *Teacher D* encouraged students to talk and ask questions and let them use a trial-and-error approach when answering her questions, and so there was a good rapport for learning in the class. *Teacher D* agreed that there were frequent interactions between her and students during lessons, and many examples could be found of students asking her questions when they did not understand.

### 5.6.4 Data from lesson tables

**Class 1A**: According to the video data selected on Class 1A, in general *Teacher D* established a routine but friendly classroom environment. Students could seek her help freely or ask questions and got immediate feedback from her. A few students behaved badly and the teacher frequently had to give verbal reminders. Overall the motivation for learning was not high though most students concentrated on their learning tasks.

From both the video data and the coded lesson summary table (Table 5.4), it was apparent that *Teacher D* used some techniques to help individual students in this class. She introduced the new topic of 'similar triangles' by using the textbook's real-life situation of similar objects. Then she defined 'similar' clearly. In order to check whether students really understood the meaning of 'similar', she asked them to come out to the blackboard to draw different similar figures. Then, after ensuring that students understood the meaning of 'similar', she then challenged them with a pair of triangles, one of which was turned upside down and the other positioned normally. That helped *Teacher D* to diagnose students' needs and differences by asking simple questions to the whole class about the basic concept of similar triangles. Further, she assigned a textbook problem to test whether students could work out the basic concepts and identified their strong and weak points in this small assignment. Since this was an introductory lesson, the basic concept could not be varied to cater for students' individual differences. However, *Teacher D* asked the students to copy down the key points about similar triangles in their workbooks in an effort to motivate them. When elaborating on the corresponding angles in similar triangles being equal, she also asked students to draw two concrete triangles in their workbooks. To sustain students' interest, she introduced a quick way to identify the corresponding angles and let students try this method by applying it to solve a problem.

**Class 1CD**: *Teacher D* also established a friendly classroom atmosphere for Class 1CD, again with students being able to ask for help freely and get instant feedback. In this class, students were more disciplined – I could hardly see anyone misbehaving – and therefore *Teacher D* did not need to use any verbal reminders to draw students' attention to their work. The overall learning motivation was very high and students concentrated on their learning tasks. Most of the students were capable in learning Mathematics and worked enthusiastically to finish the tasks by themselves.

From the videos the and coded lesson table, it was seen that *Teacher D* briefly introduced the basic concepts with the same method of using concrete triangle figures as in Class 1A, and then went on directly to discuss the two characteristics of similar triangles. In addition to mentioning the second characteristic of similar triangles, *Teacher D* guided students to find out the ratio relationship of corresponding sides. Besides, she let students work on a problem about the length of sides to figure out the correct method for matching corresponding sides. She not only checked students' understanding of the concepts but also let them look for the general rule for matching the corresponding sides. Since the general rule was just the same as for congruent triangles, students could find it easily.

*Teacher D* gave concrete examples to introduce the concept of similar triangles and stated clearly that the target of the task was to find out the general rule for deciding the corresponding sides of similar triangles. Although she used the same problem for the whole class, she managed to relate the new learning effectively to students' previous knowledge about congruent triangles so that they could transfer and apply the knowledge easily. She got the attention of the whole class at the beginning of the lesson and maintained it for most of the teaching time, since this was a small class. She moved easily from a whole-class lecture to individual seatwork by looking at and circulating among the students. She also kept students' attention for most of the seatwork time by providing appropriate forms of practice and moving often among the students to offer assistance and remind them to make suitable progress. For example, in the Class 1A lesson at 29:45, she said: ‘Do not stop working! We have to complete it and correct it before the lesson ends. If all of you can finish it together that will be great. Good, I think that all of you have already finished it’.

Overall, according to the videos and coded lesson table (Table 5.4), it could be seen that *Teacher D* catered for students’ individual differences mainly by: keeping on diagnosing students’ learning progress; using real-life examples to motivate them; defining the learning objectives clearly; and using special mathematical language for students. She also gave appropriate work for the classes and using methods of variation in questioning. For the less able students, she also gave clues to help them to complete the tasks.

### 5.6.5 The similarities and differences in Teacher D’s teaching of Class 1A and 1CD

Referring to the coded summary table (Table 5.4), it can be seen that *Teacher D* was catering for students’ individual needs during the lecture time by checking students’ prerequisites or progress frequently. For the classes, there were twelve and ten examples of code A (which means diagnosis of students’ needs and differences), which indicates that she was really concerned about students’ learning needs and could guide students to relate their present knowledge to new knowledge. Consequently, students paid attention to her instruction for most of the time and could follow her lecture. She was also successful in getting different students involved in open discussion, with the code for this aspect being high. She could monitor students’ learning pace from the whole-class lecture to individual seatwork by questioning, scanning and circulating.

Overall, there were no significant differences observed between the two classes in how she catered for student diversity. She only tuned her teaching focus according to the students’ needs during the open discussion. For the seatwork, *Teacher D* tended to give less time to Class 1A. She explained that these students needed her guidance more in working on problems, especially in first few lessons on a new topic. She would let Class 1CD explore as they had higher ability and more confidence in trying new problems, and so she would prepare more problems for this class – an approach which could enhance students’ learning motivation. *Teacher D* said that, as a main method for helping the less able students in both classes, she would ask them to stay after school to help them again. Also, when she found some 1CD students who were weak in their seatwork, she would invite them to do more exercises after school. For the low-ability students in Class 1A, the teacher suggested that they do basic problems only and skip the difficult ones. She would rather encourage lower-ability students by praising their good work on fundamental questions. In order to raise their confidence in doing more problems, she also would suggest that they should use the book examples as the reference by following the steps there to complete the problems.

#### 5.6.5.1 *General differences in catering for student diversity*

When I looked into the teaching content that *Teacher D* selected to teach for the two classes, I found it was different – it was not totally limited by the textbook and syllabus. There was still some room for *Teacher D* to design her own teaching to cater for student diversity. It was not easy to vary the content, which is why she insisted on assigning basic problems for all students and would not let them complete less. However, she varied the depth of understanding of certain concepts, such as 'ratio' which was discussed further in 1CD but not in 1A. She also varied the approach and the style of teaching for the two classes of students, even though the core content to be covered was the same. As the following table shows, in Class 1CD, she simply asked an application level question to check students' understanding of the corresponding angles being equal, and then moved on to the other characteristics of similar triangles.

In Class 1A, she just mentioned the method for comparing the corresponding angles and demonstrated how to compare them correctly, like the method for comparing congruent triangles, and then finished the first lesson. However, while *Teacher D* did design different learning material for the two classes to fit the students' needs, when faced with students of different ability in a class; she seemed unable to identify the differences.

**Table 5.8** Comparison of Teacher D's teaching in the two classes

| 1A | 1CD |
|---|---|
| T: If two triangles are defined as similar that means triangles ABC and XYZ have special features: the first criterion or the first characteristic is … please pay attention … that the angle A is equal to the angle X, i.e. /_ A is equal to /_ X. Please write down what I wrote on the blackboard. Secondly, then the angle B is same size as the angle Y. Thirdly, | T: The first thing is: if these two triangles are similar then the corresponding angles are equal. Like this angle A is equal to angle X, angle B is equal to angle Y. Which angle is the last angle C equal to?<br>Ss: Angle Z.<br>T: Yes, it is equal to angle Z. OK, this is the first characteristic. So up to now, you have learned that similar triangles are the |

| | |
|---|---|
| this angle C is equal to angle Z. You might find that this characteristic is equal to the properties of congruent triangles. Remember what we called this kind of angle? A student replied ‘symmetry angles’. Remember, at that time we mentioned that when two triangles are congruent; their corresponding angles are equal. What do we call this kind of angle? Student XXX still has missed something here, can anyone help?<br><br>Ss: Symmetry angles / symmetry sides’ angles.<br><br>T: Not symmetry angles – it should be corresponding angles. Good, this it the first characteristic of similar triangles. If two triangles are similar then their corresponding angles are equal. How can we get the corresponding angles correctly? We can read this by using the order of the names. How do we read this order of names? From the names, can you tell which angle corresponds to angle A?<br><br>Ss: X.<br>T: Yes, angle X. How about angle B: which angle corresponds to angle B?<br><br>Ss: Y.<br><br>T: Which angle corresponds to angle C? Yes, angle Z. OK? Today, we just learned the first characteristic. Please leave ten lines for the second characteristic, then draw these two figures. | same in their shape and the corresponding angles are equal accordingly. Angle A is equal to angle X; angle B is equal to angle Y; and angle C is equal to angle Z. The second characteristic is related to the length of the sides. What is the relationship between their sides? Let’s take a look at a concrete example with numbers. In this triangle, the lengths of the sides are 1, 2 and 3 units. If this triangle is similar to that triangle, then we will find that the triangle’s lengths of sides are 3, 6 and 9 units. What is the meaning of this? From this case, you will find this side is one and that side is three, and the other side is two and that side is six. It follows, if the side is three then the other side is nine. Can anyone tell me what kind of relationship there is between the length of sides of these triangles? Student XXX?<br><br>S2: The one is multiplied by three.<br>T: Which one’s length of sides is multiplied by three?<br>S2: Two times three.<br><br>T: two times three – where do you get the three? Would you please make it clear?<br><br>S2: I do not know.<br><br>T: Can anyone help him?<br><br>S3: The other side is also multiplied by three.<br><br>T: What do you mean by that?<br><br>S4: All of them are multiplied by three.<br><br>T: That means every side of this triangle XYZ and every side of triangle ABC has what kind of relationship? |

| | |
|---|---|
| | Ss: Times three.<br>T: Yes, three times the length of side. i.e. the length of AB times three becomes the length of XY, the length of AC times three becomes the length of XZ and the length of BC times three becomes the length of YZ. OK? |

**5.6.5.2** ***Differences in questioning style and techniques***

In the second interview, *Teacher D* was shown video extracts selected for discussion of the issue of catering for individual differences. The first video-clip was related to her questioning style. Teacher D said:

> I ask the whole class questions and let students call out the answers. Then I will pick a student who can give me the correct answer. By [offering] this chance, I can give this student more encouragement to learn. I prefer not ask a student who will give me the wrong answer as students might laugh at that student and discourage his or her learning.
>
> (*Teacher D*: second interview)

On looking at the video-clip, we found the teacher asking one student a question. The teacher explained the purpose of asking her this question:

> At that time, I found this student was doing something else and did not pay attention to my lecture, so I stopped her by asking a question. However, this student is a good student. At that time, she might have been disturbed by other students.
>
> (*Teacher D*: second interview)

**Class 1A**: The video-clips showed that, in this class, *Teacher D* liked to use questions to encourage student learning. As she knew the students were of low ability and less confident, she let them call out the answers and chose students who could give her the correct answer. Sometimes, when students were unable to answer her, she asked a student of higher ability to try. She also widened the function of her questioning to include not just assessing students’ understanding but also encouraging their interest in learning.

Here is an example which shows *Teacher D* asking many questions which varied from high-level ones for capable students and low-level ones for less able students.

| | |
|---|---|
| Teacher D | We should follow the names stated in the question. This provides us with very important information. Angle C is not a right angle, right? We do not know the number of degrees of angle C, so we have to look at it. Since the name gave us important information about angle C, it is equal to angle X, right? If you find angle X, then you can find out angle C. Could we look at the triangle ABC first? Let's find the angles one by one. This is angle A which corresponds to angle Y. That means angle Y is equal to which angle? (low-level question to the whole class) |
| Ss | A |
| Teacher D | How many degrees is angle A? (low-level question to the whole class) |
| Ss | 40 degrees. |
| Teacher D | Good, 40 degrees. That means angle A is 40 degrees. Here follows B which corresponds to angle Z. Then which angle is equal to angle Z? Student XXX. (high-level question for an able student) |
| S12 | Angle Z and angle B |
| Teacher D | So how many degrees is angle B? (low-level question to the whole class) |
| Ss | 50 degrees. |
| Teacher D | Yes, angle B is 50 degrees. C is equal to which angle? (low-level question to the whole class) |
| Ss | Angle X. |
| Teacher D | Yes, angle C is equal to angle X, so how many degrees is angle X? (low-level question to the whole class) |
| Ss | 90 degrees. |
| Teacher D | Yes, 90 degrees. So angle C is 90 degrees. Here, I would like to ask you all whether we can find this angle C by another method rather than using angle X? (high-level questions to the whole class) |
| Ss | Use 180 to minus. |
| Teacher D | Yes, we can use 180 degrees minus 40 degree and minus 50 degrees because we learned every triangle has three angles. How many is their sum? |
| Ss | 180 degrees. |

| | |
|---|---|
| Teacher D | So here it is possible for us to use either method for similar triangles' characteristics or angle sum of the triangle to find the angle C. |

(*Teacher D*'s teaching in Class 1A)

The next video-clip discussed in the second interview showed a 1A student raising his hand and asking the teacher a question. *Teacher D* recalled that the student had pointed out a fault in her writing and said that normally students in this class did not ask questions. In another video record, a student came out of his seat to ask the teacher a question. *Teacher D* explained that this was because she had called out his name for not having done corrections in his exercise book – an activity which she valued. Also, there was a case where *Teacher D* did not circulate round the class as she was holding a microphone. She explained that seatwork time was aimed at letting student do the corrections. She had already let students come out to the blackboard to work out the problems, so other students could copy down the answers as corrections. In this case, the students did not find any difficulty in copying.

**Class 1CD**: Generally, *Teacher D* liked to use questions to encourage student's learning. Although this small class had higher ability and motivation, she still wanted to encourage students by choosing ones who could give the correct answers rather than selecting any student to answer. She mentioned that this might be her own teaching style in asking students.

As can be seen by highlighting the questions in Table 5.8, she asked many questions to get students to think and varied their level:

- Can anyone can tell me what kind of relationship there is between the length of these sides? Student XXX? (open-ended question for an able student)
- Which one's length of sides is multiplied by three? (low-level questions)
- Two times three – where you get the three from? Would you please make it clear? (open-ended question)
- What do you mean by that? (open-ended question)
- That means every side of this triangle XYZ and every side of triangle ABC has what kind of relationship? (open-ended question)

The next 1CD video-clip showed students' seatwork. During this period of time, *Teacher D* walked along every row of seats to observe how students were progressing. Since she preferred to let students work on their own after the lecture, she left more time for seatwork in this class – she thought 1CD could acquire knowledge by doing exercises. In another video-clip, *Teacher D* observed a student working out a problem in the wrong way and then went out to the blackboard to remind the whole class. I did note one student who asked the teacher whether his textbook was an old version as some page numbers were different from the new one However, it was not easy to find another clip in which students asked questions as 1CD students were not used to doing so.

#### 5.6.5.3 *Students' questioning*

During direct teaching, most of the students stayed calm and pretended to be listening and understanding the lecture even when they had difficulty with the mathematical concepts. As they did not want to interrupt the teacher's lecture, they would ask her questions when they were assigned classwork after the lecture. In the student group interview data, students said that it was rare for them to ask any questions. When I asked them how they reacted if they did not understand some point in a lesson, they gave the following responses:

*Class 1A students*

S1: I will keep it to after school to ask the teacher. I am scared to ask during the lesson.

S1: Classmates would think I am stupid to ask that kind of question.

S2: I will ignore it as I do not think I will understand.

S3: I never try to ask as I do not like learning Mathematics.

S4: I do not want to ask.

S5: I also never ask.

(*Teacher D*'s 1A student interview)

*Class 1CD students*

S1: Normally, I could understand all the content.

S2: I do not want to ask during the lesson. I would ask the teacher after school.

S3: I would not ask actively during the lesson. I prefer asking classmates the question.

S4: I have nothing to ask as I normally understand all the content.

S5: I will ask the teacher during the lesson if I find something difficult.

(*Teacher D*'s 1CD student interview)

In the videotaped lessons, it was not easy to find students in either class who raised their hands to ask questions. However, during the seatwork, the teacher walked round and checked whether students had started the work or if they faced difficulty with the problems, which was a good opportunity for her to cater for students' needs and help them to learn directly. In the teacher interview, when she was asked about the types of questions students asked in these two classes, she responded:

> 1A students never try to ask me questions as the whole class atmosphere is not of this kind and the students in this class are not capable of asking questions too. They do not know how to ask actually since they are not used to doing so.
>
> Most 1CD students like to work out problems in their own way. I remind them to correct their work once I find a student has done it wrongly. I think other students might do it wrongly as well.
>
> (*Teacher D*: second interview)

**5.6.5.4** ***Seatwork***

Although *Teacher D* used the same problem from the textbook for the whole class, she gave additional support to less able students during the seatwork. Evidence of this could be found only in the lesson table for class 1CD when she said:

> You still have not yet written down the relationship between the sides! You should first write down which triangle is similar to which triangle, just as I did on the blackboard. Then you should write down which side divides which side.

For the lower-ability class 1A, *Teacher D* could only push students to work on tasks rather than helping them. However, she did hold the attention of most students at the beginning of the lesson and maintained this during most of the instruction time. During the seatwork, she still got students attention for most of time by giving them relevant seatwork practice and circulating frequently among the students to assist them and monitor their progress.

**Students' questions during the seatwork**: Most students were kept on-task to follow *Teacher D*'s teaching by copying the learning notes and working on the problems.

However, few students asked her any questions during this time. A student did ask the teacher a question in 1A – S5: 'Why is there no sign for it?' – but this did not actually involve any mathematics concept. Students seemed not to be used to asking about the concept of similar triangles. Although the students interviewed said they would not hesitate to ask questions during seatwork, they did not ask questions related to the work. On the other hand, in the large Class 1A, *Teacher D* could only glance at students' work quickly to check whether they were on-task or off-task. Along with doing that, as noted before, she would give comments such as the following:

T: Please do it first.

T: Do not stop working! We have to complete it and correct it before the lesson ends. If all of you can finish it together that will be great. Good, I believe that all of you have already finished it.

T: Anything wrong? Please take out the classwork book and draw these figures

T: Please write them down. Use the pen to write it down. Student XXX, please be quick.

The more able students in 1CD did not seem to be used to asking for help. According to the video data, the interaction between the teacher and students during the seatwork was mainly teacher-initiated. The interaction between the teacher and students was related in some way to the learning content, e.g.

T: You still have not yet written down the relationship between the sides! You should first write down which triangle is similar to which triangle, just as I did on the blackboard. Then you should write down which side divides which side.

T: I did the cross-fraction multiplication already! You do the remaining calculation part.

T: Why have you so many that unknown xs? Is that y instead? You have written the x and y messily and I cannot identify them clearly.

When asked in the second interview about seatwork time, *Teacher D* remembered that the comments she made were not really mathematics-related, which suggested that her method for handling individual differences was not effective in helping students to learn. In certain circumstances, as seen in the video data, *Teacher D* approached students to give hints, encouragement and support that helped students to work satisfactorily.

#### 5.6.5.5 *Assessment*

When assessing students' classwork, *Teacher D* would let students work out their solution in their workbooks. She then checked the solutions together with all the students and gave immediate feedback to clarify wrong representations. In line with this, according to the student questionnaire in Appendix 5, thirteen out of the twenty students (65%) in 1CD and twenty-two out of the thirty-six (61%) in 1A agreed that 'I can get instant feedback from the teacher when I come across difficulties'. Anyway, the students could copy her solutions when they found their own work was not good enough. *Teacher D* could be seen using this practice in almost every videotaped lesson. Also at the end of the lesson, she rounded up the whole session by telling students what they learned in this lesson. However, it was difficult to find a very good summary in the videotaped lesson data. For most of time, the teacher would simply repeat the main points quickly to remind students about what they had learned as time was limited. In short, *Teacher D* made no attempt to get feedback from individuals on their level of understanding.

Finally, when *Teacher D* was asked how she catered for students who could complete their work quickly, she said there were only a few instances of this, and so she never asked students to do more work as this situation was so rare. She only tried to assign challenging problems to the whole class. For the low-ability students, she again did not encourage them to do more than the basic problems.

### 5.6.6 Summary

After viewing all the videotaped lessons and specially selected lessons for coding, *Teacher D*, a very experienced teacher, could cater for some students' individual differences. In the main, she tried to cater for student diversity in the following ways. First, she attempted to diagnose students' differences before introducing new concepts by means of questioning. However, the questions she asked were too general and only the limited number of students who called out the answers were chosen. It could be that she knew the students very well and that, by asking a select few, she was able to gain a good overview of the students' needs.

During her teaching, *Teacher D* used many questioning techniques to try to cater for the different ability of the students. She raised an open-ended question to the whole class first and prompted other students to answer it step-by-step. However, not many students could answer her questions, perhaps because of the students' low ability. In Class 1A, it could be seen that she sometimes had to answer her own questions; and in one case cited earlier (Table 5.8), she ended up having to give hints about using the order of the names, which finally enabled students to give the answer ‘angle X’. Since students in 1A were not very confident in answering questions, *Teacher D* would choose students who could give the correct answer. While this approach appeared to encourage student learning in this class, it did not help the low-ability students. On the other hand, there were more students in 1CD who became involved in the discussion and thought about the characteristics of similar triangles. The questioning techniques she employed here were lowering the level of questions to cater for students of different levels and giving positive reinforcement such as ‘Good’ to encourage students.

*Teacher D* believed that the most effective method she implemented to cater for students diversity was checking each student’s progress during the whole lesson.

## 5.7 Teacher E

### 5.7.1 General description of Teacher E

When the study was taking place, *Teacher E* had around fifteen years’ experience as a Mathematics teacher and had been working in his current school since he left college. He was quite experienced in teaching Secondary 1 Mathematics, but Mathematics was his minor teaching subject as he also taught Physical Education and Integrated Science in the first few years. However, over the years he had increased the number of Mathematics classes he taught and now had three classes in Secondary 1. He admitted frankly that he had never been trained to teach Mathematics.

> I do not know what the formal training for Mathematics teaching is. However, I would use what I learned from Education College about the five areas of learning. Mathematics learning belongs to the area of rule learning, so I’ve tried to teach Mathematics by the rule learning method.
>
> (*Teacher E*: first interview)

His highest level in learning Mathematics was secondary level, which he felt was good enough for teaching. When I asked him whether he had attended any in-service training classes offered by the EMB, he claimed that he had studied other subjects but would join those classes later.

In the first questionnaire (Appendix 4), the data showed that *Teacher E* was very keen on teaching Mathematics, and that, if he could choose again, he would still want to be a Mathematics teacher. He felt good in teaching this subject as he agreed it was rewarding, and not difficult or time-consuming. He seemed not to be very confident that the principal and students' parents appreciated his teaching, but felt that his students did. He strongly agreed that students need clear problem statements, time to think about problems and instant feedback when they come across difficulties; and he also agreed that students need silence to understand and work after being shown how to solve problems. However, he disagreed that student talk would develop their mathematical language and understanding, and also felt that his students could not define, refine and develop problem statements and need clear single answers for the problems. In addition, he agreed that students could figure out solutions to problems on their own and should have experience with problems which had multiple or no clear answers; and he felt that that students wanted to solve open-ended problems in different ways. When introducing new concepts, *Teacher E* agreed that students need to be guided to learn and understand the whole concept and their learning could happen in leaps or chunks of understanding – and those leaps might come from solving problems. He responded that it was sometimes worth giving students the chance to create and think in the various areas of mathematics, and that once they had mastered basic concepts they could do more creative or thoughtful work. For him, students did not need drilling to learn new ideas introduced in a lesson but had to see the whole concept and its relationships.

*Teacher E* strongly agreed that it was better to separate slower students from more advanced students while teaching. He did not believe that teaching through discussion would help students much, except when the class discussions were well planned before giving out answers, results or decisions. Lastly, he strongly agreed that parents played an invaluable role in motivating their children to learn.

### 5.7.2 Teacher E's attitude towards the Curriculum Guide

In discussing his image of the Curriculum Guide, *Teacher E* mentioned it only when I asked him about his school-based curriculum planning for teaching Secondary 1 Mathematics. He simply told me that his school had a special Mathematics curriculum design, and that Secondary 1 students focused only on learning algebra and geometry; and that the topic congruent and similar triangles was not in the textbook *Essential Algebra*. He inserted this topic into the teaching schedule when I arranged the visit time with him. Because of my request, he copied some pages of notes to teach his students and even reversed congruent and similar triangles when teaching the topics. During the year, he said he would mainly follow the textbook to teach and forget about the Curriculum Guide.

#### 5.7.2.1 *Teacher E's general beliefs about the teaching and learning of Mathematics*

In the second questionnaire, *Teacher E* strongly agreed that he knew where to get the necessary teaching resources. He agreed that he prepared his lessons well and liked to use teaching aids to teach. Also, he strongly agreed that he liked to give lectures to the whole class and used most of the time to demonstrate how to solve textbook problems. He agreed that he posed challenging/open-ended questions to students and, when solving problems, he strongly agreed with focusing on procedures and the relevant concepts. He indicated that he established good rapport with students by encouraging active participation and discussion or trial and error. He also would give students sufficient time to think and answer questions or solve problems independently. In addition, he would definitely drill students by using textbook exercises. Lastly, he claimed that he could tell what students had learned after a lesson. For his lowest rating, *Teacher E* responded that he strongly disagreed with using computers to teach and to have group activities or competitions. Also, he had never introduced debates, projects and presentations in lessons, and also indicated that he strongly disagreed with solving problems related to real life.

There were only a few questions on which *Teacher E* gave a 'neither agree nor disagree' response, such as on encouraging free association of ideas, independent learning and thinking, learning beyond the curriculum and textbooks, and giving responsibility and leadership to students.

#### 5.7.2.2 *Teacher E's specific attitudes towards catering for students' individual differences*

*Teacher E*'s attitude towards dealing with students' individual differences, and his sense of differing ability among his students, was strong. He strongly agreed that he knew students' prerequisites very well and agreed he recognized students' individual needs, potentials and strengths. However, he disagreed that his interaction with students was frequent during lessons, with students seeming not to want to ask him questions when they failed to understand. He was not intending to adopt a variety of assessment modes or to promote immediate self- and peer-evaluation. Also, he strongly agreed that could check whether students understood concepts or not and noted that, for most of the time, they could answer his questions correctly, perhaps because he varied them according to student ability.

In the second teacher interview, I asked *Teacher E* what he knew about the Curriculum Guide, to which he responded that he was aware it existed but had never read it as his school had a special curriculum design which was quite different from it – the lower form Mathematics curriculum focused mainly on algebra and geometry but not the other areas. So when I asked him whether he knew the recommendations in the Curriculum Guide for catering for students' individual difference, he had no ideas about it. When I queried him on how he dealt with individual difference in class, he responded as follows:

> I try my best to teach the basic concepts clearly in order to make sure all students can handle this since there are only three or four lower-ability students in the class [but] the smart students who comprise one-third of the class will be bored and cause discipline problems. I have no idea how to handle their problems. Sometimes, I let them do whatever they want, like reading fiction under the table, playing electronic games with classmate and using different methods to communicate with the far away classmates [but] only when they are not disturbing the whole class. I could ask them to do some more difficult problems only when the whole class proceeds to higher-level content. However, at that time, the less able students will feel frustrated in working on those difficult problems. I have to go around the less able students to teach them one by one.
>
> (*Teacher E*: first interview)

Although the teacher was unfamiliar with the Curriculum Guide, in fact he did try to do something for those low-ability students. See Chapter 6 for further investigation of the findings.

### 5.7.3 Features of Teacher E's teaching

After looking at the series of videotaped lessons of *Teacher E* teaching the two classes, there appeared to be some differences between his questionnaire responses about teacher's general beliefs and his actual practice, as illustrated in the following discussion.

*Teacher E* rated five and four in the questionnaire about knowing students' prerequisites very well and recognizing students' individual needs, potentials and strengths. However, on studying the videos closely, it appeared that *Teacher E* did not really seem to recognize students' individual needs in these two large classes. In preparing lessons, there was evidence that *Teacher E* liked to use extra notes to help students and did not stick to the textbook or worksheets. The topic of similar triangles was not part of the school-based curriculum, so the textbook did not include this topic.

In terms of teaching style, *Teacher E* claimed that he liked to give lectures to the whole class but did not want to use computers in his teaching. It was clear that these claims were matched in his actual teaching. However, it was not easy to find him using teaching aids, for which he rated four in the questionnaire. He strongly agreed that, when solving problems, he highlighted both the procedures and the relevant concepts; and that in the problem-solving process, he would encourage free association of thoughts. In the coded summary lessons in Table 5.4, *Teacher E* was found to ask forty-five high-level questions (C2) in 1Y and thirty-six in 1S which was not low among the six teachers. In terms of the overall classroom atmosphere, *Teacher E* claimed to encourage students to talk and ask questions, and to let them use a trial-and-error approach when answering him. For the question on interaction, *Teacher E* disagreed that there were frequent interactions between him and his students during the lesson. No examples could be found of students asking him questions when they failed to understand.

### 5.7.4 Data from lesson tables

**Class 1Y**: According to the video data selected for Class 1Y, in general, *Teacher E* tried to establish a routine but friendly classroom environment, but students were not used to asking for help openly. Although some students were at points rather out-of-control (e.g. talking to a neighbour quietly or reading a book under the table), they would pay attention when *Teacher E* stared at them. The overall learning atmosphere was fine and students concentrated on their learning tasks.

From the data of video and coded lesson table, I could tell that *Teacher E* used only a few techniques to help individual students in this class. Regardless of the large number of students, *Teacher E* walked round the whole class either checking each student's work progress or searching for any student facing difficulties in handling the worksheet. At the very beginning of the lesson, he was unable to diagnose students' needs and differences by asking open-ended questions on recalling the two characteristics of similar triangles. However, by asking students how many of them had completed the drawings, he discovered that quite a number of them had not followed the homework instructions to think about the relationship between the characteristics of two similar triangles after drawing the triangles. Then he let them try to look for the answer again. He stressed the logical relationship between the two characteristics: if two triangles were given three pairs of angles which were correspondingly equal, then the lengths of their corresponding sides should be in a certain ratio. After the seatwork, he used a sequence of guided questions to help students construct the above logic, but the process was so abstract that students did not find it easy to follow. He was not able to gather students' background knowledge or link their earlier knowledge to the new knowledge as every time he asked he only picked the one student who raised his hand; and the other students who had not raised their hands might have felt frustrated. Since this was not an introductory lesson, students' basic concepts were not checked in order to cater for their individual differences. Therefore, the higher levels of learning outcomes might not be easy to achieve. As regards variation in approach, although *Teacher E* used the same worksheet for the whole class, he gave additional support to less able students during the seatwork. He got the attention of most students at the beginning of the lesson and maintained this for most of his instruction. He also monitored the transition from a whole-class lecture to individual seatwork by scanning the students and circulating among them. He kept the attention of students for most of time in seatwork giving relevant practice and often moving among the students to assist certain students and monitor progress. Overall, according to the video and coded lesson table, I could see that *Teacher E* was trying to cater for students' individual differences mainly by giving clues for tasks. Fortunately, the students were of high ability and could manage the classwork regardless of the methods used by the teacher.

**Class 1S**: Again, a friendly classroom environment was established by *Teacher E*. The students seemed to care about their learning and were very attentive to the teacher, although they never sought help from him proactively. In this class, the students were more disciplined and I could hardly see anyone misbehaving. *Teacher E* did not need to stare at any students to get them to pay attention to their work. However, the overall learning motivation was not very high as students seemed to know everything already. Most of students were very capable in learning and were able to finish any difficult task by themselves, and they were looking forward to tackling higher-level work.

The data showed that *Teacher E* did not use as much time to repeat the basic concepts of the two properties of similar triangles. He just asked how many students had not finished the drawing work and requested them to complete the work at home.

Then he began the third method of proofing similar triangles by referring to the worksheet directly. He did not ask many questions to get students to think since students could answer his questions. He preferred asking open-ended questions first then draw a conclusion directly as following segment shows:

| | |
|---|---|
| Teacher E | This pair of triangles gave two pairs of corresponding sides and a pair of corresponding angles. This angle is in between the two sides. And you are using all this information to draw the pair of triangles, right? After drawing, you should measure and find some special features. What kind of special features can you tell? XXX student? |
| S1 | Their corresponding angles are equal and the corresponding sides are equal. |
| Teacher E | What can you prove by using these two properties? XXX student? |
| S2 | Check whether they are similar or not. |
| Teacher E | Since these two triangles have these two properties that means these two triangles are …? Yes, they are similar. From this drawing, we discover that we do not need to know all the corresponding angles and sides to draw the similar triangles, right? In this case, what we need to know is two pairs of corresponding sides and an included angle. Does anyone disagree with this? |
| Teacher E | No, let's look at the notes on the left-hand corner of page 4. It states the third method to prove similar triangles. If angle A equals angle P, this is a pair of corresponding angles, and if the two corresponding sides are in equal ratio, then these two triangles are similar. We have a special name to represent this method for proving similar triangles – SAS similarity. Please note that the angle here should be included by those two corresponding sides. This angle is called the included angle. |

(*Teacher E*'s teaching in Class 1S)

Referring to the coded summary table (Table 5.4), it can be seen that *Teacher E* was catering for students' individual needs during the lecture time by frequently diagnosing students' prerequisites for the learning task. Code A was identified for both classes about six or five times, which indicates that he was concerned about students' learning needs and could guide students to relate what they already knew to the new knowledge. Therefore, as most students could follow his lectures, he gained the attention of all the students at the beginning of the lesson and maintained it during most of his instruction. Besides, he also monitored the transition from a whole-class lecture to individual seatwork by looking round the students and moving among them. During the seatwork, he could obviously cater for 1Y students' individual needs more as we coded E3 sixteen times in this class while for 1S it was coded only twelve times.

Finally, when *Teacher E* was asked how he catered for those students who could complete the assigned problems quickly, he mentioned that he would ask them to do some more problems which had the answers at the back of the textbook or worksheets. However, that did not appear to happen very often. For low-ability students, he suggested that they just do the basic problems and skip the difficult ones. He believed that students should learn how to solve all those basic problems which were in the textbook.

### 5.7.5 The similarities and differences in Teacher E's teaching of Class 1Y and 1S

*Teacher E* could vary his approach and style of teaching to cater for different classes of students, even when the core content to be covered was the same. As the following Table 5.9 shows, he asked many questions in Class 1Y to get students to think before letting them explore the logical link between the two methods for proving similar triangles. He mentioned the method of drawing the two triangles' six angles as well as measuring the lengths of the sides and then finding the ratios of each pair of corresponding sides. In 1S, he was keen to let students follow the instructions to complete the drawing work at home and he preferred to use the teaching time to work out the new concept by proving similar triangles in a practical way.

**Table 5.9 Comparison of *Teacher E*'s teaching in the two classes**

| 1Y | 1S |
|---|---|
| Let's revisit your notes page two in the right hand corner: 'the class discussion'.<br><br>T: The first one required you to draw two triangles: triangle ABC and triangle PQR by using six angles. You could design the length of those sides freely or follow the 7cm and 3.5cm in the notes. Remember it or not? When you finished, what did you find out about the sides of those two triangles? Those three pairs of sides' ratios were…? Forgotten? You drew them. Let's take out the sketch book and look at those two triangles. | The teacher stated clearly the aim of this lesson. He would like to continue last lesson's work to find out another method for proofing similar triangles. Since students had learned two methods for proofing similar triangles, they should know how to find out the other method.<br><br>T: In the last lesson, I asked you to draw two triangles, right? Has any one not finished? Only a few of you, OK? Please go home and finish this and try to find out the properties of similar triangles. For those who have drawn the figures, please |

| | |
|---|---|
| There were two triangles drawn by using six angles. Remember what I asked you to check after drawing them?<br><br>S1: Measure those sides of two triangles.<br><br>T: Yes, what should we do after measuring those sides?<br><br>S2: Measure the angles of the two triangles.<br><br>T: Why measure the angles?<br><br>S2: To compare them.<br>T: Compare what you found out about those three pairs of angles?<br><br>S3: They are the same.<br><br>T: Definitely, because the question asked you to draw those two triangles by using certain angles: angle A is 34 degrees and angle P is also 34 degrees, 101.5 degrees and 44.5 degrees to draw two triangles. So their angles are equal. What we have to do, which was mentioned by a student a minute ago, is to measure all the lengths of the six sides after drawing the triangles – and then do what next?<br><br>S4: Divide them.<br><br>T: Divide them and …? Does anyone remember? Let's look at the instructions. Question number one's instructions are:<br>(a) Construct two triangles. Done, right?<br>(b) Measure all the sides of the two triangles. So you measured them.<br>(c) Is it true that the ratios are equal? That means dividing the lengths of corresponding sides to get the ratio. Are they all equal? Have you done that part? What did you find then? Have you done | take a look at what criteria you got in drawing.<br><br>T refers to the notes page 4 and draws two triangles on the blackboard.<br><br>T: This pair of triangles gave two pairs of corresponding sides and a pair of corresponding angles. This angle is in between the two sides. And you are using all this information to draw the pairs of triangles, right? After drawing, you should measure and find some special features. What kind of special features you can tell me XXX student?<br><br>S1: Their corresponding angles are equal and corresponding sides are equal.<br><br>T: What can you prove by using these two properties? XXX student?<br><br>S2: Check whether they are similar or not.<br><br>T: Since these two triangles have these two properties, that means these two triangles are …? Yes, they are similar. From this drawing, we discover that we do not need to know all the corresponding angles and sides to draw the similar triangles, right? In this case, what we need to know is two pairs of corresponding sides and an included angle. Does anyone disagree with this? No, let's look at the notes page 4 on the left-hand corner. It states the third method to prove similar triangles. If angle A equals angle P, this is a pair of corresponding angles, and if two corresponding sides are in equal ratio, then these two triangles are similar. We have a special name to represent this |

| | |
|---|---|
| that part? Please raise your hand if you have done it. (Only three or four hands were raised.)<br><br>T: Only a few of you have done it. That's why you could not answer me. Put down your hands. Now, please tell me anyone who never drew the triangles? All of you have drawn the triangles. Then please measure all the six sides and divide those pairs of corresponding sides to find the ratios. Check them now. | method of proving similar triangles: SAS similarity. Please note that the angle here should be included by those two corresponding sides. This angle is called the included angle. |

What I see in the table above is that *Teacher E* asked many low-level questions in 1Y to guide students to think about the logic between two characteristics of similar triangles by relating the angles and lengths of sides of two concrete triangles which they had drawn. It seemed good to use their drawing to introduce the relationship between two characteristics of similarity. However, I feel that *Teacher E* should have also used the drawings to explain the properties of similarity more thoroughly.

**5.7.5.1** ***Differences in questioning style and techniques***

***Class* 1Y**: Generally, *Teacher E* could not use questions to cater for student diversity in this class as they preferred to answer questions in a whole-class form and only a few would answer him by raising their hands. For most of the time, these students would answer the most difficult or high-level questions which not many students could answer. *Teacher E* would pick these students specifically to answer him. *Teacher E* knew that most of the students in this class were of high ability and needed challenges; otherwise they felt bored and did not listen to him. He therefore preferred to ask higher-order questions and requested students to think further and explain their ideas. The students considered they could figure out the answers to most problems, but *Teacher E* found that they could not represent their thinking or solutions properly in written form. He had to highlight the representation skills in order to guide them in working out the problems formally. He commented:

> The biggest difference between Classes 1Y and 1S is the learning atmosphere. In Class 1Y, most students are of high ability and more eager to learn. However, some of them think they already know the learning content and are

> not willing to pay attention. Then they talk a lot, disturbing other students. Overall, Class 1S pays attention to the lecture, but most of them are low achievers and might not understand what I have taught although they sit properly and listen. They are actually not listening and learning. That's totally different from 1Y as the students there can catch up with the learning easily when they read the textbook again and again or ask for help from their classmates. In the final examination, 1Y students are still much better than those in 1S.
>
> (*Teacher E*: second interview)

**Class IS**: In the second interview, *Teacher E* was shown video extracts specially selected to allow in-depth questioning on the issue of catering for individual differences. The first video-clip chosen was about his questioning style. He liked to ask high-level questions to the whole class and let students think about them for a few seconds. Then he would pick a student who raised his hand to answer – and normally, the student could answer his high-level question correctly. In only a very few cases would *Teacher E* use questions to get students' attention, and in these instances, the students would ask the teacher for the question again and answer it, helped by other students. I could tell most of the students were listening to the teacher during the lesson. The primary function of questioning was to get students to think and could also serve to assess their level of understanding and provide them with appropriate help.

Normally, I would select some video-clips of students asking the teacher questions at seatwork time. However, this teacher gave limited seatwork time and I could not find a clip which illustrated this. The teacher explained that normally only one or two students would ask questions; and that the seatwork time was limited because of time constraints in covering the curriculum. During the seatwork, the teacher focused on some low-ability students and approached them purposely. He said:

> I know some students might not understand what I taught so I would approach them to ask them, and hope that teaching them once again would help them.
>
> (*Teacher E*: second interview)

He also preferred to ask the whole class to judge the answers to questions by counting the raised hands and not telling them the correct answer immediately. Then he would spot a high-ability student to explain what he thought and try to further investigate his thinking and clarify him strategically. However, *Teacher E* said that, for most of the time, he would randomly choose students to answer his questions without any hidden agenda.

Again, in this class, *Teacher E* mainly tried to use high-level and open-ended questions to challenge students and aimed to help students to think more deeply about the questions by prompting:

| | |
|---|---|
| Teacher E | What information have you got to draw these two triangles? |
| S13 | The lengths of sides, first. |
| Teacher E | Correct, the second question: after drawing the triangles, what other information have you got from the figures? |
| S13 | I found those angles of two triangles. |
| Teacher E | What special feature of these corresponding angles? |
| S13 | Triangle ABC is equal to triangle XYZ. |
| Teacher E | Those angles are …? |
| S13 | Those angles are equal. |
| Teacher E | What conclusion could you draw when you found these two properties? |
| S13 | Triangle ABC is similar to triangle XYZ. |
| Teacher E | Please sit. These two triangles are similar. The most important point is: we do not need to find out those two properties to prove they are similar. We only need to know the ratio of the corresponding sides' is equal – that's good enough. We do not need to work out if those corresponding angles are equal or not, |

(*Teacher E*'s teaching in Class 1S)

**Class 1S**: In this class, *Teacher E* could ask low-level questions which related to solving problems. Students were guided step-by-step to think of how to solve the problem. They could not only follow the stated procedure to work it out but also apply the learned concepts to explain their findings.

| | |
|---|---|
| Teacher E | The third pair of triangles, XXX student. |
| S7 | They are not equal. |
| Teacher E | Yes, they are definitely not equal. |
| S7 | They are not similar. |
| Teacher E | Why? |
| S7 | The length of B is not given. |

| | |
|---|---|
| Teacher E | Yes, one of the lengths is not given, so we need to check all the angles see whether they are correspondingly equal or not. |
| S7 | (could not hear) |
| Teacher E | So their angles are not correspondingly equal. Yes, please sit down. The third pair of triangles is not similar. The reason is: of all three pairs of corresponding angles, it has only one pair of corresponding angles which is equal while the other two pairs are not equal. So they are not similar. |

(*Teaching E*'s teaching in Class 1S)

Overall, I could tell from the coded lesson tables that *Teacher E* could not cater for students' individual differences effectively. He could not use the appropriate method for finding out students' learning progress and both classes of students seemed unwilling to show their learning problems during the lesson.

**5.7.5.2** ***Students' questioning***

**Class 1S**: During the lectures, the students appeared not to want to interrupt the teacher's lecture, so they would ask the teacher questions when they were assigned classwork later. In the group interview, students said that it was rare for them to ask any questions. When I asked Class 1S why they did not ask teacher questions during the lesson, the students' responses were as follows:

> S1: I think the teachers in our school are perfect. I cannot find any discrepancy in their lectures to attack.
>
> S2: Please do not criticize me for being too arrogant in saying that all the teacher's lectures are too simple … . For example, every time we have a worksheet, I can scan it once and I understand what it is about.
>
> S3: From the beginning of the term till now, I have asked one question only during the lesson. That means I think what the teacher teaches is very simple – just like one plus one.
>
> S4: I feel scared that if my answer is wrong, my classmates will tease me. I will not ask the teacher questions during the lesson. I prefer asking my classmates nearby.
>
> S5: I think what the teacher says in the lecture is not difficult at all. Most of the content, for example today's topic about similar triangles, I learned in the primary school. This is because my primary school's Mathematics

> teacher asked us to go back to school during the summer vacation to learn a lot of secondary Mathematics – for example, all the content about how to prove similar triangles, the reasons for similarity and the signs of similar, etc.
>
> S6: If I do not understand, I will ask the classmates near me first. We can usually solve the problem.
>
> (*Teacher E*'s 1S student interview)

The Class 1Y students' responses when asked the same question were:

> S1: I never like to be laughed at when I raise my hand to ask the teacher questions. I will only choose to ask about those really difficult problems. If the problem is not that difficult, I will find the answer from the books.
>
> S2: If I have problem, I will ask the teacher.
>
> S3: It depends. When a student asks question, other students will laugh at him and tease him as an idiot. So I'm scared to ask any questions during the lesson.
>
> S4: If I have problem, I also will ask the teacher.
>
> S5: If I have problem, I will also raise up my hand to ask the teacher.
>
> S6: If I have problem, I also will raise up my hand to ask the teacher.
>
> (*Teacher E*'s 1Y Student Interview)

It was difficult to find examples of students raising their hands to ask in the video records of both classes. Fortunately, during the seatwork, the teacher walked round the class to check whether students had started the work or was having problems. This was a good chance for him to cater for students' needs and help them to learn directly. In the teacher interview, when I asked *Teacher E* about the types of questions students in these two classes asked, he responded:

> The students would like to ask me questions during the seatwork. The problems are similar. They would ask whenever they find they cannot understand.
>
> (*Teacher E*: second interview)

#### 5.7.5.3 *Seatwork*

In the second teacher interview, when I asked about the seatwork time, *Teacher E* remembered all the questions students asked were focused on the problem-solving level – procedural knowledge only, not really concept-related – which confirmed that this method of catering for students' individual differences did not work well. The video data showed that when *Teacher E* approached students to remind them how to work on a problem, this was also very target-oriented and did not involve trying to analyse students' needs by letting them show how they worked on the problem. This was not enough to help students of different ability levels to learn the Mathematics content. During the seatwork, *Teacher E* could only provide help to certain specific students to figure out the problem directly, as in the following instance:

T: Do you know how to do this one? Is this pair of triangles similar or not? For the similar triangles, we have three methods to prove them, right? One method is looking at their three pairs of corresponding angles, checking whether they are equal or not, right? Do these two triangles give you equal angles?

S3: No!

T: No, so can we use the method of three pairs of corresponding angles equal?

S3: No

T: Then two methods remain: one is three pairs of corresponding sides are in ratio, and another is two pairs of corresponding sides are in ratio and the included angle is equal. Since it gives no angle, can we use the method of SAS?

S3: Impossible.

T: Yes, impossible. So we could only use the third method. This method is SSS similarity. Can you tell me the meaning of SSS similarity?

S3: The corresponding sides are equal.

T: No, their corresponding sides are not equal.

S3: The corresponding sides are …

T: The corresponding sides are equal in ratio. Let's look at the sides of this triangle – they are 5, 6 and 7. The other triangle's sides are 6, 7.2 and 8.4. So you can divide them accordingly to check whether they are in ratio or not. If they are equal, then these two triangles are similar. Yes or no? You try and check, OK?

(*Teacher E*'s teaching in Class 1S)

On the other hand, in Class 1Y with more high-ability students, the teacher would set higher learning outcomes and guide students to think more deeply about the logical link between the two characteristics. Also, in this class, *Teacher E* used to spend a lot of time on lectures and allocated less time to seatwork, in which students could carry out the exercises quickly. According to the video data, the interaction between the teacher and students during the seatwork was not very much related to mathematics. He only glanced at students quickly and passed by. Once I recorded him asking a student: ‘Which pair of triangles? This one right? Triangle ABC and triangle PQR’. I could hardly identify whether the teacher was ‘helping’ the student.

**Students’ questions during the seatwork**: The video-clips captured in Class 1Y showed a student raising his hand and asking the teacher privately, but the teacher remembered that the student only told him that he could not work out the answer. So *Teacher E* asked him some questions to guide him to think about the ways to solve the problem. It was not easy to find another clip about a student asking questions since 1Y students were not used to doing so.

In the lesson table for 1Y, I found a conversation initiated by students but not an example of a student raising questions, viz.

S24: I have done it.

T: You do not need to write it in a separate line. This is only the steps but not the answer. Get it?
S26: Done, it should be correct.

T: Yes, please write down your answer on the blackboard. Clean the blackboard first, OK?

(*Teacher E*’s teaching in Class 1Y)

During the short seatwork time, the teacher tried to walk around checking progress and answers, giving hints or questioning students to work out the problem indirectly. He thought students in this class normally would raise their hands to check the answers to questions but not to ask questions closely related to mathematics concepts, as they seemed to know them.

#### *5.7.5.4 Assessment*

When assessing students’ classwork, *Teacher E* would check students’ work publicly by asking them directly or letting them work out their solutions on the blackboard. *Teacher E* checked the solutions together with other students and gave instant feedback to clarify the wrong representations, and then went on with his teaching strategy. He often asked students to explain their reasons and he favoured this practice so much that it could be seen in almost every videotaped lesson. In order to be effective, the teacher had to understand and apply this thinking to give an appropriate method from his point of view. However, at the end of the lesson, *Teacher E* was not used to rounding up the whole lesson by asking students what they had learned from it. Nevertheless, according to the student questionnaire question 'After the lesson, we can tell what we learned', only twenty out of forty-two (48%) 1Y students and twenty two out of forty-two (52%) 1S students could tell what they had learned. In the second teacher interview, when *Teacher E* was asked how he helped students who were low achievers, he responded:

> In the class, there are only three or four students slower in working out the problems, so I could help them privately during the seatwork. I let the high-ability students do whatever they want when they have finished the work. The middle-level students might need more time to figure out the problems, so I let them have enough time to try and don't disturb them.
>
> (*Teacher E* : second interview)

### 5.7.6 Summary

After viewing all the video taped lessons and specially selected lessons for coding, overall *Teacher E* was found to know most of his students. He did not need to discipline students as most of them behaved well. He seemed aware of the problem of student diversity and mainly used the following methods to cater for individual differences. For example, he diagnosed students' differences before introducing new concepts by means of questioning. However, the questions he asked were found to be too difficult and only some students wished to raise their hands to answer – and finally only one student was selected to answer. This method of diagnosis was not effective and could not provide him with accurate information about his students' needs – he could only get a rough picture of his students' learning.

The teaching content for the two lessons was almost the same for both classes, with the variations limited by the textbook and the syllabus. This was understandable, however, given the Hong Kong context and was why *Teacher E* insisted on assigning the foundation problems to all students and would not let them complete less.

When reviewing the concepts of similar triangles, he highlighted the point that the properties of similar triangles were also related to corresponding angles and sides. Quickly, he again raised another example of the ratio of three corresponding sides.

Although students were guided to answer his question successfully, I could tell they still had no clear conception of how the logical link between one characteristic of equal corresponding angles could apply to the equal ratio of length of corresponding sides and vice-versa. I had doubts about whether they really understood the basic concept of the logic, since they never discussed this in detail in the lesson. In Class 1S, he guided students to explore the third characteristic only by giving a question. He never showed the characteristics clearly to students but told them directly the third method of proving triangles by similarity. Students only followed his instruction to work on the exercises and then tried out the method to prove the similarity. *Teacher E* thought students in 1S learned better by working on the exercises, since he believed in learning by doing.

Also, *Teacher E* felt that the most effective method he implemented to cater for student diversity was helping students during the seatwork. However, I could not find much evidence to support this statement – I could tell that only a small number of students benefited from individual help from the teacher. A few students did ask him questions during this time and he also went over to some students he thought needed help. However, when the nature of the interactions between the teacher and students was examined closely, it was found that they did not actually involve mathematics concepts – rather, they were about problem-solving procedures which were stressed by the teacher in order to give practical help. Students were not used to asking about problems related to the concept of similar triangles.

When looking for evidence of how *Teacher E* catered for student diversity within the lesson and across the classes in the coded summary table, it was found difficult to do a comparison because of differences in the coverage of the lessons: With Class 1Y, *Teacher E* discussed the concept of proving two similar triangles in the third and fourth lessons, while for Class 1S it was the in fifth and sixth lessons, by which time students were working on difficult problems about proving the two combined similar triangles and then finding the unknowns. The level of difficulty in the two classes was different, so that the teacher's instructions and focus were also quite different. Anyway, we can see *Teacher E* catering for students' individual needs during the lecture time by often diagnosing students' prerequisites for the learning task. In the classes, lessons involving code A occurred five or six times, which showed that he was concerned about students' learning needs and could guide students to relate the known knowledge to the new knowledge.

## 5.8 Teacher F

### 5.8.1 General description of Teacher F

At the time of videotaping, *Teacher F* was studying at the Open University of Hong Kong, having already completed a degree there. Before getting her degree, she had been teaching the lower forms in this school for a few years, but wished to teach higher forms after finishing the degree. Mathematics was her major teaching subject and she had experience in dealing with Secondary 1 and students at two elementary levels. In terms of training, she took the teaching of Mathematics as a major subject in her part-time study at the Open University, but her highest level in learning the subject was first-year university mathematics, which she did not consider was adequate for teaching. She had taken no EDB in-service training classes, arguing that she would do so later, but was currently fully occupied in her part-time studies.

Her responses to the first questionnaire (Appendix 4) indicated that *Teacher F* was very keen on teaching Mathematics and she would still want to be a Mathematics teacher if given the opportunity to choose again. She strongly agreed that she felt good in teaching this subject as it was interesting and rewarding, but felt that it was difficult and time-consuming. She showed confidence in her teaching, agreeing that the principal, students and students' parents appreciated her work. She also agreed that students need silence to understand and work and that, to develop mathematical language and further understanding, they have to have a chance to discuss problem statements, and be given time to think about problems and talk to develop mathematical language and understanding. She considered it was better to give students instant feedback when they faced difficulties and believed students were able to work out problem solution by themselves. In addition, she agreed that students need experience with problems which have multiple/no clear answers. When introducing new concepts, *Teacher F* believed that drilling was needed in guiding students to learn and understand the whole concept and its relationships. In her view, if students were given a broad programme to explore concepts, they might master basic concepts to do more creative or thoughtful work – and, therefore, students could benefit from being given opportunities to create and think in all aspects of mathematics. As a result, student learning could happen in leaps or chunks of understanding – and those leaps might come from solving problems, especially in different ways.

*Teacher F* strongly agreed that it was better to separate slower students from more advanced students for teaching. She believed that, in teaching through discussion, students could learn a lot, especially with good planning prior to showing the answers, results or decisions. Finally, she agreed that the parents' contribution was vital in motivating student learning.

### 5.8.2 Teacher F's attitude towards the Curriculum Guide

To assess *Teacher F*'s attitude to the Curriculum Guide, I focused on her general image of the guide and, as for all the other teachers, she mentioned it only when questioned about her school-based curriculum planning for teaching Secondary 1 Mathematics. She just informed me about how the teachers chose the textbook and designed the teaching content according to the Curriculum Guide at the beginning of the school term – namely that they followed the suggestions in the guide to choose the enrichment topic for the high-ability class and tailored the teaching content for those of lower ability in the split class. During the year, they would mainly follow the textbook to teach and paid no attention to the Curriculum Guide.

#### 5.8.2.1 *Teacher F's general beliefs about the teaching and learning of Mathematics*

In response to the second questionnaire on teaching style, *Teacher F* agreed that she prepared her lessons well and that during them she liked to give lectures to the whole class and use teaching aids when needed. She also showed that she liked to pose challenging, real-life problems or open-ended questions to let student think independently using trial and error or free association of ideas to solve problems. Besides, she claimed to establish good rapport with students so that they participated actively, discussed and asked questions even when she introduced debates, projects and presentations. When solving problems, she focused on the relevant concepts, accepted different approaches to a problem and infused thinking strategies and skills into learning to encourage logical and analytical thinking. She responded that she gave students sufficient time to think and answer, and then let them present their solutions on the blackboard after they had completed their work. Sometimes, she would facilitate immediate self- and peer evaluation or questions in order to check whether or not students understood a concept since she had set standards to evaluate learning outcomes. She also indicated that she could tell what students had learned after a lesson. She assigned homework after all lessons to drill students by using textbook exercises. Also, she would like to allocate responsibility and leadership to students. Overall, she agreed that she was firm, consistent, imaginative and creative.

As with the previous five teachers, there were a number of questions on which *Teacher F*'s response was 'neither agree nor disagree'. These covered the use of worksheets to help students to learn, the use of group activities or competitions, and using computers to teach. Also, when solving problems, she was not sure whether she would focus on the procedures and encourage learning beyond the curriculum and textbooks. She also gave a neutral response on whether most students could hand in their homework without any difficulty.

In her responses, she disagreed with the following statements: 'I always stick closely to the textbook when teaching' and 'I encourage brainstorming, problem solving'. She disagreed that she used the majority of time to demonstrate how to solve textbook problems and let students solve problems independently.

#### *5.8.2.2 Teacher F's specific attitudes towards catering for students' individual differences*

*Teacher F*'s attitudes towards dealing with students' individual differences, and her awareness of the differences in her students, was strong. She agreed that she knew her students' prerequisites very well and recognized their individual needs, potentials and strengths. Besides, she indicated that her interaction with students was not frequent during lessons, though students wanted to ask her questions when they faced difficulties. Also, she had no intention of using a range of assessment methods. About whether most students could answer her questions correctly, she gave a neutral response, perhaps because she did not vary them by ability.

On asking *Teacher F* in the second teacher interview whether she knew the Curriculum Guide's section on catering for students' individual differences, she replied that she had read it but could not remember the details. Also, when queried about whether she had tried to follow the suggestions for dealing with student's diversity, she said she had the impression that she was using some of the recommendations during her lessons. I then asked her how she dealt with the individual difference in her class and she replied as follows:

> For the lower form students, I hope they can grasp the foundation concepts firmly. They have to know the basic concepts anyway to learn further. So I always request students to learn the basic concepts thoroughly by solving the first-level problems. This year, I tried to divide those problems into different levels from simple to complex. I will let the low-ability know clearly how to solve the first-level problems. If they can do these problems by themselves, they will gain confidence to move on level by level. I l encourage students to try the other level problems, although the problems

> may be a little bit harder. Students are encouraged to try one or two problems in order to gain experience and find out the solution method. In this stage, some low-ability students may fail to figure out this level's problems. Then I will comment on their success in the first-level problems to make them feel positive and confident. I let the high-ability students work out more problems since they can finish the assigned problems in a short time. I will push them to complete the first-level problems quickly and move on to ones at the second or third level step by step enthusiastically and constructively.
>
> (*Teacher F*: second interview)

Since this teacher thought that she had already tried out some of the suggestions from the Curriculum Guide, she was doing something for both the high- and low-ability students. What kind of method did she claim she had used? See Chapter 6 for further investigation of the findings.

### 5.8.3 Features of Teacher F's teaching

After looking at the series of videotaped lessons of *Teacher F* teaching her two classes, some differences were found between her questionnaire responses on teachers' general beliefs and her actual practice, as noted below.

*Teacher F* rated four in the questionnaire about knowing students' prerequisites very well and recognizing students' individual needs, potentials and strengths. On the former, there was no evidence to show her planning was unsuitable for both classes. However, on the videos, it was found that *Teacher F* seemed to recognize students' individual needs more in Class 1E than in Class1A, as she was the Form teacher of 1E. There was also evidence that *Teacher F* did not stick completely to the textbook when teaching, but used teaching aids to help students learn.

Also, as regards her teaching style, *Teacher F* claimed she was neutral about giving lectures to the whole class, but it was clear from the videos that she liked to do so. When solving problems, she focused on both the procedures and the relevant concepts; and, in the process, she would encourage free association of ideas. To motivate the students, she liked to use the overhead projector but not the computer. When posing challenging or open-ended questions, *Teacher F* was found to ask sixty-six for 1A and ninety for 1E in the coded lessons, which was a very high total. In terms of the overall classroom atmosphere in both classes, *Teacher F* encouraged students to talk and ask questions and let them use a trial-and-error approach when answering her questions – and so there was always a very good rapport for student learning. Surprisingly, *Teacher F* rated herself as two in the statement about encouraging brainstorming in problem-solving with students. For the question related to her interactions, *Teacher F* agreed that there were frequent interactions between her and students during the lesson, and there were certainly many examples of students asking her questions when they did not understand.

### 5.8.4 Data from lesson tables

**Class 1A**: According to the video data selected for Class 1A, in general, *Teacher F* tried to set up a friendly classroom environment. Students could seek help freely or ask questions and received immediate feedback from her. Although some students misbehaved a little and the teacher had to give some verbal reminders, the overall learning spirit was high and students concentrated on their learning tasks.

From the videotaped lesson data and coded lesson table, I could tell *Teacher F* used only a few techniques which really worked to help individual students in this class. Regardless of the large number of students, *Teacher F* walked round the whole class either checking each student's progress or seeking out any student who had difficulty with the work. In the introducing the new topic, she motivated the students by using similar dolls. Almost the whole class was involved in open discussion. When *Teacher F* raised the problem of 'in proportion', different students contributed ideas to explain this term. Also the teacher invited a student to give an example to further elaborate the idea of 'in proportion'. This idea was incorrect and the subsequent discussion clarified the actual meaning of the term, as seen below:

| | |
|---|---|
| S21 | 'In proportion' means that one triangle's side minus one will become the other triangle's side. |
| S22 | No, it is not. |
| T | Student XXX is brave. He says, for example, there is a big square and a small square. If they are similar, the big square's side minus one will become the small square's side. Is it what you mean? |
| S21 | No, when the length of a side minus one, you should check how many percentages it deducted in this side then deduct the same amount in the width. |
| S23 | If it is a square then [there is] no need to do this, right? |
| T | Yes, if it is a square then [there is] no need to do this. But why? |

| | |
|---|---|
| S23 | A square has equal length of sides. |
| T | When their sides are equal in length, then what? |
| S24 | If you follow the same proportion in deducting the sides, then it will be correct. |
| S25 | I know how to enlarge or reduce the figure by using the computer. You only need to press the 'shift' button to do it. |
| T | Yes, you can press the 'shift' button to do it. It is fine. However, you still need to know the pattern behind the motion. Anyway, good, students raised a question about enlarge or reduce the square. Since the square has the same length of sides, then all the sides should enlarge or reduce in the same way and get the same length, right? That's good. How about we do not discuss the square, but think about the rectangle. We would like to reduce the rectangle. What constraint should we be aware of when processing the reduction? Originally, Miss Cheung asked you a question about the meaning of 'in proportion'. I would like you to know exactly the meaning of it other than knowing the term only. Can you use the number to represent the meaning? I think it is easier for you to explain, right? |
| S26 | The length of one side is the multiple of another length of side. |

(*Teacher F*'s teaching in Class 1A)

I could tell that *Teacher F* catered successfully for this student's needs. During this discussion, students were free to give different suggestions and ideas as well as questions to solve the problem. Because of the students' responses, the teacher could gather background information on their knowledge and then link this to the new knowledge. Next, she assigned students seatwork to do the task of measuring all the lengths of two triangles and calculating the fractions to prove the two triangles were similar. Overall, *Teacher F* could follow and make progress according to the students' needs.

Although *Teacher F* used the same problem for the whole class, she varied her approach by giving additional support to less able students during the discussion. For example, from the lesson table, she said: 'Yes, the three sides are proportional. That means the three pairs of sides are in equal ratio. It is not multiplication'. She gave students prompt feedback when she found it was necessary. She kept the attention of most students at the beginning of the lesson and maintained their attention for the whole lesson. Besides, she also monitored the move from a whole-class lecture to individual seatwork by scanning and circulating among the students. So, during the seatwork time, she still attracted the attention of most students by giving appropriate forms of seatwork practice. Also she moved around the students during seatwork to give assistance and check on progress.

**Class 1E**: For Class 1E, *Teacher F* established a friendly classroom environment in which the students seemed to care about their studies. They often asked for her help, without any hesitation. The students were highly motivated by the example of the similar dolls at the beginning of the new topic, and *Teacher F* managed to link the concept of similar triangles to the taught topics of rotation and reflection, as well as congruent triangles, by using open-ended questions. Then she used three examples to introduce how to find the ratio of the lengths of similar triangles by matching the corresponding sides. Almost the whole class of students was involved in an open discussion. Lastly, the teacher invited a student to discuss the concrete and scientific method for comparing the lengths by matching the shortest length of sides to another triangle's shortest length of side (see Table5.10, column 1E). This implicitly questioned the student's thinking and clarified the actual meaning of 'in proportion' – proportion involved the concept of multiplication only, not addition.

| | |
|---|---|
| S25 | [For] triangle A and triangle B, every length of side plus two will become the other triangle's length of side. |
| T | Yes, it is a fact that every length of side plus two will become the other triangle's length of side. However, what's the meaning of 'in ratio'? It involves multiplication, right? |
| S26 | It should be triangle A and triangle C. |

(*Teacher F*'s teaching in Class 1E)

For Class 1E, *Teacher F* introduced the lesson in exactly the same way as for Class 1A. For example, she used the same teaching aids to arouse students' interest. Then the concept of similarity was defined through open discussion. She catered successfully for students' needs during the interactions since students in this class were free to give different suggestions and ideas, as well as ask questions, to solve the problem. She assessed students' learning level and then related what they already knew to the new knowledge according to students' feedback. Before she assigned students work on the four triangles, she worked together with all of them to apply the learned method in an example – and, this time, students could apply the rules successfully. Overall, *Teacher F* could follow students' learning needs well and make progress according to the students' requirements.

Although *Teacher F* used the same problem for the whole class, she gave additional support to less able students during the discussion. For instance, the following lesson table showed:

| | |
|---|---|
| T | Why do you say they are angles? They are not. |
| Ss | (Could not be heard) |
| T | [You can see] they are not similar even if you just glance at them. Anyway, I'll draw it again. Ah, this one should not be like an angle. How about these triangles – are they similar? Similar, right? These two triangles are similar. How you can tell these two triangles are similar? |

(*Teacher F*'s teaching in Class 1E)

Again, she gave students prompt feedback when she found the need. She kept students' attention from the beginning of the topic and during most of the instruction. She also monitored the transition from whole-class lecturing to individual seatwork by looking round the students and circulating among them. So, during the seatwork time, she still could maintain the attention of all the students, as in Class 1A. The teaching style of *Teacher F* was consistent in both classes.

From the coded summary table (Table 5.4), it can be seen that *Teacher F* was catering for students' individual needs during the lecture time by checking students' prerequisites or progress frequently. For her classes, code A (i.e. diagnosis of students' needs and differences) was recorded five or six times, which showed that she was really concerned about students' learning needs and could guide students to correlate their known knowledge to the new knowledge. Consequently, most of the students could follow her lecture so that she gained all the students' attention at the beginning of the lesson and maintained attention during her instruction for most of time. Also, she successfully let different students become involved in the open discussion. The code for the number of students involved in the discussion was high. She monitored students' learning pace from whole-class lecture to individual seatwork by questioning, scanning and circulating.

Overall, there were no major differences observed in the way *Teacher F* catered for student diversity in the two classes. She only tuned her teaching focus according to the students' needs during the open discussion. For seatwork, *Teacher F* tended to give less time to Class 1E. She explained that students in 1E needed her guidance more in working on the problems, especially in the first few lessons on a new topic. Since Class 1A students had confidence in trying new problems, she would let them explore; and she would also prepare more challenging problems for this class – an approach which was effective in enhancing students' motivation for learning. As regards the main method she used to help students of lesser ability in both classes, *Teacher F* said she would ask these students to stay after school to help them again. Students saw this as a punishment and would take the quiz and tests seriously. Also, she explained that when she found some students who were weak in doing the seatwork, she would invite them to do more exercises after school in order to help them. She suggested to the low-ability students that they should mainly confine themselves to doing basic problems. In addition, she told all the students the level of difficulty of the textbook problems, which she mostly separated into three levels: the basic problems that all students should know how to work out; the middle-level ones that would help students to get higher marks; and the higher-level problems which were very challenging. She encouraged lower-ability students by praising their good work on basic questions; and in order to increase their confidence in trying problems at other levels, she suggested that they should try examples of middle-level problems. The students of higher ability would try to figure out challenging problems without the teacher instructing them to do so.

### 5.8.5 The similarities and differences in Teacher F's teaching of Class 1A and 1E

*Teacher F* could vary her approach and style of teaching to cater for different classes of students, even when covering the same core content. She could use open-ended questions to motivate students. They could ask questions freely and react to her questions, and she also allowed students to discuss the issues openly. For example, the following table shows episodes where 1A students were discussing the concept of 'in proportion' and 1E students were talking about how to match the corresponding sides of similar triangles. Several students joined the discussion spontaneously.

**Table 5.10 Comparison of *Teacher F*'s teaching in the two classes**

| 1A | 1E |
|---|---|
| T: They should be in proportion. You are very serious about this. However, what's the meaning of 'in proportion'?<br>T: Only knowing this term but not its actual meaning is useless. Just like when I asked you what is the height and the base of the triangle – if you cannot tell from the triangle that will be no use. Even if you know the formula about the area of a triangle, but you cannot find the right sides to insert into the formula then you still cannot figure out the area, right?<br><br>S21: 'In proportion' means that one triangle's side minus one will become the other triangle's side.<br><br>S22: No, it is not.<br><br>T: Student XXX is brave. He says, for example, there is a big square and a small square. If they are similar, the big square's side minus one will become the small square's side. Is it what you mean?<br><br>S21: No. When the length of a side minus one, you should check how many percentages it deducted in this side and then deduct the same amount in the width.<br><br>S23: If it is a square then [there's] no need to do this, right?<br>T: Yes, if it is a square then there's no need to do this. But why?<br><br>S23: A square has equal length of sides.<br><br>T: When their sides are equal in length, | T: Let's go to question number two. Please stop talking in these five seconds. Think seriously. Give time for all of us to think. Ding, ding, ding, ding, ding, good, student XXX.<br><br>S25: Triangle A and triangle B – as every length of side plus two will become the other triangle's length of side.<br><br>T: Yes, it is a fact that every length of side plus two will become the other triangle's length of side. However, what's the meaning of 'in ratio'? It involves multiplication, right?<br><br>S26: It should be triangle A and triangle C.<br><br>T: Yes, it should be triangle A and triangle C. However, which side corresponds to which side here? Can you tell? How about enlarged or decreased?<br><br>S26: Enlarge!<br><br>T: How many times is it enlarged?<br><br>Ss: 1.5 times.<br><br>T: How can you tell? Which side corresponds to which side?<br><br>Ss: Four corresponding to six.<br><br>T: Four corresponding to six and six corresponding to nine. What else? Yes, five to seven point five. I would like to know how you can match all these sides.<br><br>S27: From the figure.<br><br>T: The triangles are drawn neatly side-by-side so that you can tell easily, right? Any |

| | |
|---|---|
| then what?<br><br>S24: If you follow the same proportion in deducting the sides, then it will be correct.<br><br>S25: I know how to enlarge or deduce the figure by using the computer. You only need to press the 'shift' button to do it. | scientific method [by which] you can tell?<br><br>S28: Trial and error – to use the length of side, divide the other triangle's length of side.<br><br>T: If so, how many times do you need to try?<br><br>S29: Use four to divide six, and check whether this is the ratio or not!<br><br>T: Really, what's the meaning of 'whether this is the ratio or not'? Actually every fraction is also made by division. |

#### 5.8.5.1 *Differences in questioning style and techniques*

*Teacher F* used to ask whole-class questions first and then choose a student to answer from among those who raised their hands or ask a specific student to answer. In the first interview, she stated that the main functions of questioning are:

(1) The teacher would like to wake up the student as she finds this student might be day-dreaming.

(2) The teacher knows those students might get lost and so asks them to help them understand.

(3) The teacher checks the students' learning pace – whether they could follow or not.

(*Teacher F*: first interview)

In the second interview, the first video-clip was from the fourth lesson for **Class 1A**. *Teacher F* gave a challenging question to students about a big triangle with two small triangles inside it. The students had to separate the two triangles first in order to prove they were similar, and then calculate the unknown side. In the first few minutes of seatwork, the teacher asked a question. She commented:

> During the seatwork, I usually ask some questions to guide students so that they can get the direction on how to work. However, this problem is supposed to challenge students. I would prefer students to think thoroughly and try their best to work it out.

(*Teacher F*: second interview)

*Teacher F* would like to use questions to guide students. Reflecting on this method, she mentioned that, if she could give some time for students to talk with their neighbours, they would come up with more methods to deal with problems. A challenging problem could produce student discussion and enhance their motivation for learning too. For the videotaped lesson, *Teacher F* had to help students by separating the triangles for them so that they could read the data clearly from it. After giving this big hint, some students could finish the work and get *Teacher F* to approve it. I selected some video-clips from the time when students raised their hands. *Teacher F* remembered that those students wanted to ask her whether their solutions were correct or not – so she glanced at their work quickly and encouraged them with a smile. For those whose work was not complete, she gave them a comment like 'think about it again – still has something left'. If the students' work was correct so far, she would encourage them by saying 'Keep on, almost done'.

*Teacher F* was shown some specially selected video extracts for discussion on the issue of catering for individual differences. The first video clip captured was about her questioning style, about which she noted:

> I ask whole-class questions for various purposes. I like to check how much they have learned about this topic. And sometimes when I am introducing a new item, I want to know their basic knowledge. Students normally will call out the answer right after I ask. At that time, there will be many answers and I will summarize them to highlight the differences. Then I will continue to invite more answers of different dimensions.
>
> (*Teacher F*: second interview)

In the video-clip, we could find the teacher asking one student a question. On recalling the occasion, the teacher described the purpose of the question as follows:

> Generally, I would like to pick a student who is not paying attention to my lecture, using this chance to remind this student to concentrate on the lecture. Sometimes, I choose some weak students who I think this time may know how to answer me correctly in order to encourage or praise them. I don't choose the bright students frequently as they are too quick to make a response. I would rather let all students think about the questions seriously.
>
> (*Teacher F*: second interview)

*Teacher F* seemed to know all the students' situations very well, and could use the questions effectively to cater for students' needs. However, sometimes she made a wrong judgement and the student chosen was unable to answer her. She then used guiding questions to help the student so that he/she would not feel bad about it. The function of questioning was broadened and not only served the purpose of assessing students' level of understanding but also encouraging their interest.

In **Class 1E**, I selected a lesson in which *Teacher F* was checking the students' homework with all the students. In the first episode, she chose a specific student to answer her. She remembered that this was a weak student and wanted to encourage him by asking a question he could answer correctly. She added:

> First, I would like to check his level of understanding. Secondly, I really wanted him to get more confidence in learning Mathematics. Since these problems were taught in the last lesson, students should have learned how to do it as this involved the basic concept only.
>
> (*Teacher F*: second interview)

*Teacher F* walked around to check students' work after asking that student. During that time, she also noticed a student who had not written down the equation. After making sure all students could work out the basic problems, she then raised two problems, from which students had to select one. These two problems, which were specially selected for this class, were less challenging than the one set for Class 1A. As usual, she did not give many hints to students and let them figure it out by themselves. I captured a moment when she stood behind a student during this seatwork time and another in which she answered a student's questions. She explained:

> In the first one, I gave him a hint as he was a middle-level student. In the other one, the student asked me whether his work was correct or not. I found his presentation was not clear enough, so I reminded him. I remember that he was confused about proving and finding unknowns.
>
> (*Teacher F*: second interview)

As can be seen in Table 5.10, for Class 1A, *Teacher F* raised an appropriate open-ended and high-level question about 'in proportion' to get students thinking. As this class was of a higher ability level, they did not mind facing challenging questions and raising different dimensions of thinking. Here is an example showing how students interpreted the concept of 'in proportion'.

Also, from the same table, it can be seen that almost all the students in Class 1E were involved in an open discussion. When *Teacher F* raised the problem of which lengths should be used to do the comparison that were 'in proportion', several students gave their ideas on how to get similar triangles:

**5.8.5.2 *Students' questioning***

In order to invite students to feel free to answer her questions, she would ask an open-ended question first. From the videotaped lesson, it was clear that students were actively giving their responses to the teacher. However, from the students' questionnaire, more than half the students in each class indicated that they disagreed or strongly disagreed to answer the teacher's questions. Their responses were:

*For 1A students*

S1: I have nothing to ask since I have no problems.

S2: I also have no questions at all.

S3: Sometimes, I will think of the problem by myself first then ask my neighbours. Then I will ask Miss.

S4: I will ask only when I am totally stuck or I was absent from the lesson .

S5: I will not ask.

S6: I will ask only during the lunch time or after school.

(*Teacher F*'s 1A student interview)

*For 1E students*

S1: I will not ask questions as I think I will delay the learning progress. I am also scared teacher will blame me for not listening to her carefully during the lecture. If I really want to ask, I will ask the teacher privately.

S2: I will try my best to figure it out by myself.

S3: I prefer not asking as I miss the lesson because of day-dreaming.

S4: If I ask questions, my classmates might think I am stupid.

S5: I will ask those students who get higher marks first.

S6: I think the teacher will repeat what she teaches once again to me, so I prefer not asking her.

(*Teacher F*'s 1E student interview)

During the lecture, students were busy giving their responses to the teacher. They were concentrating on listening and understanding the content. It was not easy to find any student who was off-task. Some students were so involved in the lecture that they asked questions frequently during the lesson. In the group interview, when students were asked whether they would answer the teacher's questions, the Class 1A students' responses were:

S1: There are mainly some students who will answer the teacher's questions actively but not the others. Other students will not give the teacher any response.

R: How many of you will respond when the teacher asks you actually?

S2: Only two of us will answer. .

S3: Yes, I will let them answer her as they are eager to do so.

S4: I prefer to sit and listen to other students' answers in order to learn more.

S5: I do not know how to answer so I will not raise hand to answer.

S6: If my answer is wrong that will be very embarrassing so I prefer not answering.

(*Teacher F*'s 1A student interview)

When I asked Class 1E students whether they would like to raise their hands to answer the teacher's questions, the responses were:

S1: I think it is great to answer the teacher's question.

S2: I will try my best to answer. If the answer is wrong, I will pay more attention to the teacher's lecture. Then I will learn more and understand more.

S3: I think at the time the teacher asks questions, I am day-dreaming.

S4: I will neither ask questions nor answer question by raising my hand. Actually, I will call out the answer promptly right after she raises the question.

S5: I also would like to answer to check whether my answer is correct or not. If I am wrong, the teacher will correct me.

S6: Boys will think it is embarrassing if they give the wrong answer.

(*Teacher F*'s 1E student interview)

Although students claimed they did not want to ask questions during the lesson, I still captured many moments when students did so.

When I asked *Teacher F* why students appeared to like to respond and ask questions spontaneously during the lesson, she replied that she would think of some tricks to enhance students' participation by using more real-life material in order to maintain the friendly atmosphere – but she always asked students to give serious thought. She liked to probe further by asking 'why' students gave a particular answer, which made them explain their thinking and how they got the answer. This prevented students from just copying other students' answers when they could not answer themselves.

After the normal assessment, *Teacher F* liked to raise challenging questions for students in order to enhance their learning. Students of higher ability could answer the questions easily in a limited amount of time. When *Teacher F* was asked how she helped lower-ability students who might not understand the whole concept, she responded as follows:

> In the first term, for both classes, once students could not hand in the homework assignment, they were asked to stay after school to do the work for me. In the second term, I could only do the follow-up remedial work by using the results of a quiz to find those falling behind. When students failed in the quiz, they were asked to stay after school to let me help them
>
> (*Teacher F*: first interview)

In the last video clip, *Teacher F* talked to a student privately. When asked what she had said, she noted that she had asked him questions in order to guide him. She preferred not to tell students directly how to answer, and instead she would ask questions. Those questions were: 'What are the methods for proving two similar triangles and what information do you require in those three methods?' Overall, during the seatwork time, she gave enough time for students to work out the problems. Also, she could cater for student diversity during this time. Finally, when teacher was asked how she catered for students who could not figure out challenging problems, she mentioned there were some students sitting and waiting for the answer only. Even when she gave them many hints, those students still felt frustrated. She could help them only after school.

#### 5.8.5.3 *Seatwork*

*Teacher F* believed the method she implemented which could cater for student diversity was helping them during the seatwork. However, I could not find much evidence to support her statement. I could tell that the whole class was kept on-task to work on the problems, and some students did ask her questions during this time. I could not capture exactly what students asked, but *Teacher F*'s answers involved Mathematics concepts as seen below with Class 1A:

| |
|---|
| T: Yes, the three sides are proportional. That means three pairs of sides are in equal ratio. It is not the multiplication.<br>S62: How can we know the reason is 'given'?<br>T: You can make your own judgement, right?" |

(*Teacher F*'s teaching in Class 1A)

Students seemed used to asking about the learning content. Although the students who were interviewed reflected that they would not ask questions during the seatwork, in fact they asked when they were stuck on a problem. During the seatwork, *Teacher F* could only glance at students' work quickly to check whether they were on-task or off-task. Along with that, she would give students' comment such as:

| |
|---|
| T: Prove them similar or not! The problem statement is 'In the figure, are these two triangles similar?' |
| T: Please do not ask me again, I already told the whole class three times. Student XXX, you should draw the figure in your class workbook. I do not think this is funny! |
| T: Do you want to discuss the work with your neighbours? Take a look at your classmates' work? |
| T: You have still not yet finished drawing the figure! |

(*Teacher F*'s teaching in Class 1A)

On the other hand, for Class 1E, with more low-ability students, the teacher did not want to give students a lot of time to do the seatwork as she would like to guide them step-by-step to follow her presentation. According to the video data, the interactions between the teacher and students during the seatwork were mathematical, e.g.

| |
|---|
| T: Can you see, student XXX? It's a little bit difficult but you still can read it, right? Next year, I will make it bigger. |
| T: Ah! You have found it! You are so happy! OK, which two triangles? Do they really exist? Have you really found it? Please tell me privately. |

(*Teacher F*'s teaching in Class 1E)

**Students' questions during the seatwork**: During the short seatwork time, the teacher would walk around and check students' progress, which was a good chance for her to cater for student diversity. Although she could not spend long because of limited time, she still targeted the students with problems to give appropriate feedback. For example, in Class 1A, she said:

> T: What is the reason? Because this angle is equal to angle A, right? But why are they equal? Are you guessing it? Or do you just think it's like that?
> T: Yes, so this is equal to what? Good, write it here 'so this is equal to …'
> T: This one is correct 'so it is equal to…'. You have calculated it correctly 'so the angle A is equal to …'. Don't rub it off! What is it equal to? Write it in the next line, what is it equal to? Yes, that's why you have this sentence. OK, what's follows?

(*Teacher F*'s teaching in Class 1A)

#### 5.8.5.4 *Assessment*

When assessing students' classwork, *Teacher F* would let students work out their solution on the blackboard once she had made sure they could solve the problem. She checked the solutions together with other students and gave instant feedback to clarify any wrong representations, and then went on with her teaching strategy. This practice could be seen almost in every videotaped lesson. *Teacher F* said that at the end of a lesson she would ask students what they had learned, but in the videotaped lessons data, it was not easy to see students answering this question directly: the teacher would repeat the main points to remind them, but not ask for responses. However, in response to the student questionnaire question 'My teacher always checks whether we understand the concept or not by asking us questions', only one out of forty-one (6%) 1A students and one out of thirty-nine (6.57%) 1E students disagreed with the statement. This indicates that the teacher's ongoing questioning could evaluate students' learning efficiency.

Actually, *Teacher F* liked to pose challenging problems that related to the real world in her lesson. She not only used textbook problems but also prepared other ones beyond what was learned during the lesson. She had the intention of developing students' skills in problem-solving as she did not show students how to solve the problem with typical solution methods. She believed that students could learn to think critically from using a variety of solution methods and see the advantages and disadvantages of each in the process. Students could also learn how to distinguish between a correct and incorrect solution by going back and checking their answers. It was found that *Teacher F* selected different levels of problems for her two classes in order to cater for their needs.

### 5.8.6 Summary

After viewing all the videotaped lessons and those specially selected for coding, *Teacher F* was found to know her students very well. She could motivate them effectively by asking them questions of different levels when teaching. Also, she seemed aware of student diversity and used several methods for handling individual differences. First, she would diagnosis students' differences before introducing new concepts by means of testing and questioning. She used open-ended questions to motivate students, and they could ask questions freely and react to her questions. She also let students discuss the issues openly. In addition, during the lesson, *Teacher F* used different levels of questions well to check on students' progress.

Second, the teaching content *Teacher F* selected for the two classes was quite different. Although content variation was bounded by the textbook and syllabus, *Teacher F* focused on different main points according to the ability of the students in these classes. As shown in lesson Table 5.10 above, in Class 1A, the teacher found that students were confused about the mathematical term 'in proportion', while Class 1E seemed to already know how to apply the ratio of two similar triangles. In the latter case, the teacher addressed the strategy of matching the corresponding sides of similar triangles. However, in Class 1E I found that a student (S25) gave a non-proportional relationship between two triangles' lengths – but the teacher did not explain in detail what the student's misconception was. She simply asked the question 'What is the meaning of "in ratio"'? It involves multiplication, right?', and continued the discussion. The other students could follow up the question and answer it again.

Third, although *Teacher F* believed that the method of helping each student during the seatwork was not sufficient for her to cater for student diversity; I could find evidence to question her statement. I could tell that the students were kept on-task to work on the problems and some students did ask her questions that involved mathematics concepts.

In the second teacher interview, when I asked about the seatwork time, *Teacher F* remembered that all the questions students asked were related to mathematics but, because the seatwork time was short, it was not very effective in catering for students' individual differences. In certain cases, as seen in the video data, *Teacher F* approached students to remind them to try or gave them positive encouragement by letting them work on the blackboard, though this was not enough to help students of different ability to learn the mathematics content. When she found students were having problems in doing their homework or in a quiz, *Teacher F* preferred to ask them to stay on after school to help them.

## 5.9 Summary of the chapter

The schools' profiles are first introduced, and then the two classes in each school which were videotaped are described briefly. This is followed by a detailed description of the six teachers involved, including their attitudes towards the Curriculum Guide, their beliefs about the teaching and learning of Mathematics, and their specific attitudes towards catering for students' individual differences. After that, the features of the teachers' teaching, with data support from lesson tables, are elaborated. Also, the similarities and differences in each teacher's teaching of his/her classes are compared, covering questioning style and techniques, and students' questioning habits during both lecture and seatwork time.

The extensive information gathered here about the teachers' schools, their beliefs and attitudes, and their normal teaching practice lays a very firm basis for analysing the specific research questions posed in this thesis.

# CHAPTER 6
# A CROSS-CASE ANALYSIS

## 6.1 Scope of the chapter

This chapter presents a cross-case analysis of the actual practices of the six teachers in the research. For this purpose, the features of each teacher's practice are compared directly with the recommendations in the Curriculum Guide (CDC, 2002). For a further comparison of the cases, I draw on both the interview data and the coded data about classroom practice presented in Chapter 5. The Curriculum Guide recommends certain strategies for teachers when designing classroom activities and these are used in the present study as indicators for checking whether the teachers catered for students' individual differences. Wong et al. (1999) reported that teachers seldom referred to the curriculum documents for help in catering for students' diversity, preferring to handle individual differences by adjusting the teaching themselves – but using the recommended strategies to check teachers' classroom practice could show the real situation. Also, Leung (1992) described a typical lesson in Hong Kong as including five parts: (1) reminding students about what they had learned, which has same function as code A – diagnosing students' needs and differences; (2) explaining new content with examples, which is discussed in code D about variation in approaches when introducing concepts and code B about variation in the level of difficulty and content covered; (3) asking students questions which is covered by code C on variation in questioning techniques; (4) assigning students to do classwork, checking students' work and assigning homework, which is similar to code E in variation in peer learning. In short, these strategies include:

1 diagnosis of students' needs and differences (code A);

2 variation in the level of difficulty and content covered (code B);

3 variation in questioning techniques (code C);

4 variation in approaches when introducing concepts by using concrete examples or symbolic language (code D); and

5 variation in peer learning (code E).

Based on these coded strategies, I look at the six teachers together and then provide a general discussion on the extent to which they were able to meet each of the criteria. Since these five areas are the basis for the cross-case analysis, they are discussed in detail in section 6.3. A full summary of the findings is included at the end of this chapter in Table 6.8 which summarizes the teachers' different approaches on the five strategies/codes above. This table compares the following:

Code A: Understanding of students in different classes; variations in stimulating learning motivation; variation in approaches to introducing concepts

Code B: Variation in the level of difficulty and content covered

Code C: The functions of questioning; questioning style; variation in questioning techniques; the differences in questioning techniques between each of the teachers' two classes; students' questioning habits in the two classes; students' questions during the seatwork

Code D: Variation in approaches when introducing concepts; variation in clues provided in tasks

Code E: Variation in peer learning.

The aim is to engage in an in-depth analysis of how the teachers cater for students' individual differences during Mathematics lessons. In the context of this overriding objective, the study is designed to examine the perspectives of Mathematics teachers and students on the teaching and learning of the subject. A further objective of the case studies, as noted above, is to analyse teachers' attitudes towards Mathematics teaching in general, and to explore how far they understand the guidance in the Curriculum Guide on catering for individual differences, including the principles behind it. How do teachers approach their classroom teaching, specifically in relation to providing for individual differences both within and between classes? What is their rationale for doing so, and what is the relationship between the teachers' perceptions of how they are implementing the curriculum guidance and their classroom practice, both within a class and between classes?

## 6.2 Overview of the teachers' perceptions of students' individual differences and understanding of the Curriculum Guide

Of the schools in which the six teachers worked, only those of *Teacher B* and *Teacher E* did not set students by their ability level. According to the second-round teacher interview, only *Teacher B* responded in a neutral way to the practice of setting. All the other teachers (*C, D, E* and *F*) 'strongly agreed' with setting, except *Teacher A* who only 'agreed'.

In the same round of interviews, the teachers were asked about how they perceived catering for individual differences. Both *Teacher A* and *Teacher B* held views which were different from those in the Curriculum Guide. *Teacher A* thought that only 'inclusive' students with special needs – such as those with low IQs or short-sightedness – would require special help in the classroom; and he therefore felt that low-ability students did not need any special treatment in class. Also, *Teacher B* considered that handling student diversity related only to tests or examinations, not classwork or during the teaching process. Their misconceptions about handling student diversity directly may have hindered their provision of help to individual students in normal class teaching.

It was also found that none of the teachers followed the specific suggestions in the Curriculum Guide on how to cater for learning diversity. Although all six teachers said they had read the guide, only five of them had noticed the relevant part – and even they claimed they had never tried to use any of the proposals there, for various reasons. For instance, *Teacher B* told me frankly that failure to implement the suggestions was due to his heavy workload and tight teaching schedule. *Teacher C* confessed that she had never tried to read this part thoroughly, and *Teacher E* also had no clear impression about this section of the guide. Only *Teacher F* reflected that she had already used some of the recommendations during her lessons. However, although most of the teachers mentioned that they had never attempted to implement any of the suggestions in the Curriculum Guide, there seemed to be discrepancies between their perceptions and actual practices. They actually did take some action in response to the needs of low-ability students, but the rationale of all six teachers in catering for student diversity was based mainly on their own teaching experience, not the Curriculum Guide. The implications of these findings are discussed further in the next chapter.

## 6.3 The extent of implementation for all teachers

Since this is a case study, the data collected are only snapshots of certain teachers and topics, and cannot be generalized as the normal practice of all Hong Kong teachers. However, the findings still have some significance for policy makers, as all the teachers knew of the existence of the guide but only *Teacher F* had tried to follow what it recommended.

All six teachers were conscious of the ability range of their whole classes but not of their students' individual differences. Observations suggested that most teachers just followed their normal practice in teaching, but their usual practice adopted ideas from the Curriculum Guide to some degree.

**The table of coding**: Table 6.1 presents a summary of the codes for the most significant recommendations in the Curriculum Guide for handling student diversity. The letters A to E represent the coding of the actions taken by the teachers during the lessons. However, it should be stressed that the quantitative data presented in the later Tables 6.2 to 6.6 just refer to the number of times the researcher saw examples of the approach in the lessons selected for observation. It is not implied that these lessons are indicative of all the lessons these teachers taught during the academic year in which the research was carried out, though it is believed that they would not have behaved entirely differently in other lessons or when teaching other topics.

**Table 6.1** The summary of all codes

| Codes | Description |
|---|---|
| **A** | Diagnosis of students' needs and differences |
| **B** | Variation in levels of difficulty and content covered<br>B1: Simple task<br>B2: Challenging task |
| **C** | Variation in questioning techniques<br>C1: Low-level question<br>C2: High-level question |
| **D** | Variation in approach<br>D1: Concrete examples<br>D2: Symbolic language |
| **E** | Peer learning<br>E1: Whole-class learning<br>E2: Group learning<br>E3: Individual learning |

Discussed separately below are the teaching approaches which related specifically to catering for individual differences both within and between classes, and the six teachers' rationales for acting as they did.

### 6.3.1 Diagnosis of students' needs and differences (code A)

It was found that the teachers liked to use questions for diagnosing students' prior knowledge and remind them about what they had previously told the students which linked to the new knowledge. These questions and reminders were coded as code A. In the observations, it was noted that, while the six teachers all made use of diagnostic questions at the start of their lessons to assess what students knew already, only *Teacher B* addressed the questions directly to specific individuals. Also, most of the teachers asked only one to three simple, general questions about the concept of congruent triangles, and selected randomly from the limited number of students who responded by raising their hands. (Since not many students had their hands up, it was difficult for the teachers to ask a range of students.) This method of diagnosis was not very effective as it could not provide teachers with an accurate picture of their students' needs or previous knowledge since feedback was gathered from only a small fraction of the class: in asking only volunteers, teachers are getting only a limited picture of the pupils' understanding. This scenario – attempting to check students' prior knowledge, but only with a small number of students – echoes the finding of Morris et al. (1996) (see Chapter 3, 3.2.4) that the teachers 'were unable (or unwilling) to make due adjustments to the depth of treatment of individual topics to cope with the different abilities of pupils'. It would have been better to give all students a short quiz and check the answers immediately afterwards by letting them work in pairs to make the necessary corrections. The teacher could then collect the answers to the quiz after counting quickly how many questions students had missed – a process which would have involved a more careful and specific checking of the students' overall prior knowledge.

Code A is also concerned with linking prior knowledge and new knowledge. It was found that *Teacher C* and *Teacher D* reminded students frequently about the skills or prior knowledge which would help them to figure out the problems (see the number of times code A appears for these two teachers in Table 6.8 at the end of the chapter). Since these classes were of lower ability, such reminders seemed to help them to apply their previous knowledge to the new content. For example, *Teacher C* let students measure the angles using a protractor after reminding them how to do so correctly, an approach which, in this researcher's view, would have been helpful for the other classes too. While teaching, it is better for teachers to be sensitive to students' progress and find out which points might be hindering them. Giving more reminders and varying the approach according to students' needs might enhance their learning considerably.

**Table 6.2** Diagnosis of students' needs and differences

| Special code | Ab (b,u) | Ad (s,m) | Ba (b,m) | Bd (b,m) | Cd (s,l) | Ce (s,l) | Da (b,l) | Dcd (s,u) | Ey (b,u) | Es (b,u) | Fa (b,u) | Fe (b,m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code A | 3 | 2 | 3 | 5 | 14 | 14 | 12 | 10 | 6 | 5 | 6 | 5 |

**Note**: As an example of the special codes used above, take Ab(b,u). In this case, the capital letter A represents *Teacher A*; the second letter b represents the class name 1B; inside the brackets, the first lower letter 'b' indicates a big class (N=30+ students), while 's' is small class(N=<20); and the second lower letter 'u' refers to high ability, 'm' to middle ability and 'l' to low-ability. The ability levels were defined by using schools' bands and their setting criteria. As further illustrations, So Ce(s,l) represents *Teacher C*'s Class 1E which is a small class with students of low ability; and Fe(b,m) represents *Teacher F*'s Class 1E which is a big class with middle-level ability. This coding system is used in the later tables.

### 6.3.2 Variation in the level of difficulty and content covered (code B)

Code B captured the difficulty level of the tasks the teachers gave to students during lectures or seatwork, with B1 being simple tasks and B2 more challenging ones. All the tasks were selected from the textbook only, but the teachers chose the appropriate content for their students. The teachers could probably identify the average ability level of their classes accurately through the whole-class discussion focusing on a specific theme. They tended to change the difficulty level of the tasks according to interaction with the students. However, for the individual students who were left behind, the teachers were again unable (or unwilling) to make the necessary adjustments for them. When coding the tasks, only those which students actually worked on were included: if a teacher raised a very challenging problem which no student could solve, it was not coded. It was expected that teachers would present more challenging tasks to more able classes and simpler ones to less able classes but, surprisingly, they did not adopt this approach.

In the observations, it was discovered that the teachers tended to use a number of challenging tasks, followed by simple tasks to guide students. The number of tasks asked for depended on the students' ability levels with, as expected, more tasks being given for both middle- and high-ability classes. The total number of tasks for the five high-ability classes ranged from ten to eighteen, and for the four middle-ability classes from six to fourteen. For the three classes with students of the lowest ability, six tasks were given. There was no definite number of tasks for students. This depended entirely on the teacher's teaching style and planning, and also on the nature of the tasks for different topics. The number of tasks at different levels somehow reflects teachers' understanding of their students and the appropriateness of their expectations. If the teacher expects that students can handle all the challenging questions, he or she might not need to use guided simple tasks. For example, with the more able students, in Class Ab(b,h) *Teacher A* assigned six simple tasks after giving four challenging ones; *Teacher D* in Class Dcd(s,h) gave two simple tasks after five challenging ones; and *Teacher F* in Class Fa(b,h) used seven simple tasks after four challenging ones. Where the number of challenging tasks was greater than the number of simple ones, this reflected that the teacher did not need to give any hints to guide students. The difficulty level of the challenging tasks might not really be a challenge for the class of students, and teachers could set the learning goals higher for these high-ability classes. A further review of the practices of the teachers who taught higher-ability classes, such as *Teacher E* in both Ey(b,h) and Es(b,h), showed that they tended to use very challenging tasks to enhance students' learning, which involved how to prove two similar triangles; and students could understand this kind of task once the teachers lowered the difficulty level or gave them appropriate hints. From the class observations and the lesson table, it was seen that for Class Ey(b,h), *Teacher E* asked six challenging tasks with eight lower-level ones to help students. The teacher's expectation that this would enable students to catch up with what he was teaching seemed appropriate.

For the less able classes, teachers had to guide students in working out the challenging tasks by breaking them down into many simple tasks. So, in these cases, the teachers also raised challenging tasks but then used more simple ones to help students solve them. Far fewer challenging tasks than simple ones were used in these classes. For example, *Teacher A* in Class Ad(s,m) raised two challenging tasks and eight simple tasks to guide students; and *Teacher B* in Class Bd(b,m), *Teacher C* in Class Cd(s,l) and *Teacher D* in Class Da(b,l) also gave two challenging tasks, followed by four simple ones. Looking only at the number of challenging tasks teachers prepared for classes at different levels, it was obvious that most teachers – the exception being *Teacher F* – used one or two simple tasks after a challenging task according to students' progress.

Table 6.3 below shows how the teachers varied the number of simple and challenging tasks for classes of different ability levels. For instance, in Classes Ba(b,m) and Fe(b,m), *Teachers B* and *F* gave equal numbers of B1 and B2 tasks to students. However, as can be seen in the table, with Class Ce(s,l), *Teacher C* used six simple tasks only. On further analysis of her lessons, it was found that *Teacher C* worked on the whole problem by herself and then let students work on the simple tasks embedded in the problem, such as measuring the angles or lengths. In this special case, it was understandable that this approach was adopted as the students involved were of low ability and very passive in learning.

**Table 6.3** Levels of student tasks

| Special code | Ab (b,u) | Ad (s,m) | Ba (b,m) | Bd (b,m) | Cd (s,l) | Ce (s,l) | Dcd (s,u) | Da (b,l) | Ey (b,u) | Es (b,u) | Fa (b,u) | Fe (b,m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code B1 | 4 | 8 | 8 | 4 | 4 | 6 | 2 | 4 | 8 | 9 | 4 | 7 |
| Code B2 | 6 | 2 | 8 | 2 | 2 | 0 | 5 | 2 | 6 | 9 | 7 | 7 |
| Total | 10 | 10 | 16 | 6 | 6 | 6 | 7 | 6 | 14 | 18 | 11 | 14 |

### 6.3.3 Variation in questioning techniques (code C)

Code C monitored the number of questions teachers asked during a lesson, with high or low levels identified. Those at a low level included factual recall and 'Yes/No' questions, and the other questions were coded as 'high level'. The frequency of the type of question asked, leading to a student response, is coded in Table 6.4. This time, the table is organized by different ability classes from high to low for easy comparison. If a teacher kept asking questions but no student could answer them, these questions were not counted.

**Table 6.4** Levels of questions

| Special code | Ab (b,u) | Dcd (s,u) | Ey (b,u) | Es (b,u) | Fa (b,u) | Ad (s,m) | Ba (b,m) | Bd (b,m) | Fe (b,m) | Cd (s,l) | Ce (s,l) | Da (b,l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code C1 | 52 | 69 | 45 | 36 | 53 | 67 | 12 | 13 | 93 | 65 | 44 | 75 |
| Code C2 | 53 | 78 | 31 | 41 | 66 | 45 | 16 | 10 | 90 | 78 | 57 | 68 |
| Total | 105 | 147 | 76 | 77 | 119 | 112 | 28 | 23 | 183 | 143 | 101 | 143 |

When catering for students' individual differences, one might expect teachers to know how to use questions to check their progress in learning. However, in examining their practice, all six teachers seemed to be using questions primarily to guide student learning or remind them to pay attention. As regards their questioning style, the teachers could ask questions at different levels, but did not know about the students' learning progress. I could not tell how they checked students' understanding when most of the students answered correctly. There was only one clear case in which a teacher – *Teacher B* – asked many questions without any correct answers from students; and he had to lower the difficulty level of his questions.

The functions of the questions used by the six teachers was limited – they did not use them to check students' progress in learning. When the teachers were asked about the purpose of their questioning in the second interview, they answered explicitly as follows:

A: Guiding questions to help student understanding of the content

B: Reminding students to pay attention and to check understanding

C: Guiding questions to help students follow her instructions and remind them to pay attention; and also to check the level of students' understanding

D: Encourage students by letting those who call out the correct answer make their responses

E: Ask high-level questions and let students show off; and remind students to pay attention

F: Three functions: (a) checking understanding; (b) reminding students to pay attention; and (c) encouraging weak students.

While the teachers used questions for various purposes, as regards catering for students' individual differences, most of them did not give appropriate feedback which promoted learning or identified discrepancies in learning. Hattie and Timperley (2007) stressed the power of teachers' feedback for enhancing student learning: if teachers give instant feedback to help students clarify misconceptions, or vary their ways of teaching to further explain or scaffold the important concepts, this can remove student misunderstanding. Unfortunately, I could not find any example of this approach. Although the teachers asked questions at different levels, they did not know about the students' learning progress and were unable to vary the focus to help students learn. As Leung (2005) found, it may be characteristic of Mathematics classrooms in Hong Kong that teachers dominate the talk and students do not talk much in class. On the other hand, when students gave correct answers, it was good to see that some teachers (*Teachers C*, *D* and *F*) gave very positive feedback or encouragement to them; and they also claimed they liked to choose weak students to answer questions in order to give supportive comments as they found this to be very useful for promoting the learning of less confident students and enhancing the learning atmosphere in the whole class.

In considering individual teachers in different classes, it was expected that they would use the same questioning skills in both classes and that the total number of questions they asked would be similar. However, *Teacher C* and *Teacher F* exhibited a large difference in the number of questions they asked in their two classes. In Class Cd(s,l), *Teacher C* asked 143 questions but only 101 in Class Ce(s,l); and in Class Fa(b,u), *Teacher F* posed 119 questions but 183 in Class Fe(b,m). By observation and *Teacher C's* information, Class Cd(s,l) was somewhat higher in ability than Class Ce(s,l), and so students could answer more questions. However, the situation in *Teacher F*'s classes was different. For Class Fa(b,u), *Teacher F* wanted students to work on more problems and reduce the lecturing time while, for the middle-ability Class Fe(b,m), she preferred to guide students to work out the problems by using more questions. *Teacher F* showed her understanding of both classes and taught them in ways she considered appropriate for them.

There was an interesting finding when classes of different ability levels were compared. For the high-ability classes, most teachers – the exception being *Teacher E* in Class Ey(b,u) – used more high-level questions. However, for the middle-ability classes, most teachers asked more low-level questions, except in the case of *Teacher B* in Class Ba(b,m). In contrast, for the low-ability classes, except *Teacher D* in Da(b,l), the teachers used more high-level questions. This result indicates that there was no definite pattern of levels of question. The teachers' use of more low-level questions with middle-ability classes implies that the teachers found it difficult to understand the needs of these students and raise appropriate high-level questions.

**6.3.3.1 The differences in questioning style between the two classes**

Normally, five of the teachers (except *Teacher B*) liked to ask whole-class questions first and then pick students to answer. As can be seen in Table 6.8, only *Teacher B* identified a student first before asking the question. The teachers had quite different approaches to choosing students to answer: *Teacher F* liked to select a student who was day-dreaming to remind him/her to pay attention, while *Teacher C* chose a student to show her concern. In contrast, *Teacher D* picked a student who could call out the correct answer in order to encourage his/her learning progress: this teacher preferred not to choose students who would give wrong answer to prevent other students from teasing and discouraging them. On the other hand, *Teacher E* only selected students who raised their hands to show off how intelligent they were. Since the main purpose of asking questions is to check students' prerequisites or level of understanding, teachers should use questions to assess students. Unfortunately, among the six teachers, only *Teacher F* mentioned checking students' learning pace by questioning.

All the teachers showed their concern about whether or not students were paying attention to their teaching. However, as students were easily distracted, the quality of interaction between the teacher and students was very important for maintaining their attention. If the teacher could ask appropriate questions to stimulate students' thinking and let them feel free to raise ideas without any adverse consequences, students would be more likely to be involved in learning. Asking only one student a question and leaving the others to idle away their time allows students to cause trouble in the classroom.

### 6.3.3.2 The differences between the two classes in questioning techniques

As Table 6.8 shows, several of the teachers (e.g. *Teachers A*, *D* and *F*) taught classes of different ability, while others (e.g. *Teacher B* and *Teacher E*) were teaching similar mixed-ability students in two large classes. However, they all claimed that one of the classes was a little better in its learning atmosphere. Both of *Teacher C*'s classes involved low-ability students, though neither had more than twenty students. In these very different situations, teachers used varied questioning techniques. As seen in the coded summary Table 6.4, *Teachers A, D and F* asked many questions which varied from high-level open-ended questions or reasoning questions (C2) for capable students to closed-ended low-level 'Yes/No' questions (C1) for less able students. Interestingly, *Teacher E* always raised high-level open-ended questions to challenge his students. Apart from the difficulty level of the questions, the most important issue teachers had to consider was the students' responses. If a student did not want to answer, or showed no interest in doing so, the teacher could only show the facts and, in this case, the students could not learn as they were not actively engaged in the lesson. Students' level of interest, ability and prerequisites need to be considered carefully by the teacher to ensure they could react to questions appropriately. Furthermore, as in the following teaching segment of *Teacher F*, it was good practice to let students think about the question seriously for a short time so that they could give a quality and organized answer. If a student gives a short answer, the teacher can ask him/her to explain the reason. However, not many students like to give teachers responses by raising their hands – they answer only when the teacher chooses them.

T: In question number two, are there any similar triangles? Five, four, three, two, one 'Ting', student XXX, try to answer. Any answer? (The teacher gave five seconds for the student to think)

T: I would like to ask you first. Can we randomly choose the sides to find the proportion?

Ss: No. We should do all the sides.

T: Good, we should do all the sides, but how? You still need to decide which side to compare to the other triangle's side, right? OK, before answering me, which triangles here are similar? Please think about my question about how to find the sides accordingly to find the proportion quickly – and how to make the decision

| |
|---|
| about which side compares to which side? (The teacher asked students to expand on their answer.)<br>S33: Choose the longest to compare with the other triangle's longest side.<br>T: Good, the longest one compared to the longest side, then what next?<br>S33: The shortest to compare to the other triangle's shortest side. |

(*Teacher F*'s teaching in Class 1E)

#### 6.3.3.3 Students' questioning in the two classes

In this research, there was a student interview for every class. Those selected were of different ability levels and had varying levels of interest in learning mathematics. The teachers recommended these students to the researcher according to these two criteria. Altogether, among the seventy-one students interviewed, forty-two said they would not ask the teacher any question during a lesson, some of them commenting that they were scared other students would laugh at them if they asked a silly question. Some students therefore preferred to ask their classmates first or ask the teacher privately after the lesson. Traditionally, secondary school students in Hong Kong are not used to asking questions, as they might not like to let others know they have any problems. It was not easy to find examples of students asking questions in the videotaped lessons, especially during the lecture time – and when they did ask a question, they often wanted to clarify the problem statement or the working requirements. When comparing the two classes which were taught by the same teacher, students were seen to behave differently. Generally, the less able students did not want to ask any question, and their motivation for learning was low.

#### 6.3.3.4 Students' questions during the seatwork

For assessing learning, the best practice is for the teacher to check students' work and give them instant feedback if they are having difficulty with a problem. Also, if the teacher can identify any misconceptions which are preventing a student from solving a problem, he/she can then help the student to clarify the concept. However, from all the selected videotapes, there was only one snapshot of Teacher C doing so. Also, it was found that for both classes of Teacher A, Teacher B's Class 1A and Teacher C's Class 1D, students liked to ask questions but only about working procedures or for clarification of problem statements; and for Teacher D's two classes and Teacher E's Class 1Y, students asked no questions. Strangely, Teacher F's Class 1A, in which students could respond spontaneously to the teacher during the lecture time, also did not like to ask any questions during the seatwork time.

### 6.3.4 Variation in approach when introducing concepts by using concrete examples or symbolic language (code D)

Code D checks how teachers vary their approach when introducing concepts by using either concrete examples (D1) or symbolic language (D2) during lessons. The frequency with which teachers used concrete models, such as triangle models, was coded as D1, and the frequency with which they used symbolic language in their lectures or questions as D2. The following table lists the ‘concrete’ materials teachers used during their lessons:

**Table 6.5** Teacher use of concrete examples

| Special code | Ab (b,u) | Ad (s,m) | Ba (b,m) | Bd (b,m) | Cd (s,l) | Ce (s,l) | Da (b,l) | Dcd (s,u) | Ey (b,u) | Es (b,u) | Fa (b,u) | Fe (b,m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concrete models | Transparency of triangle models | | Asked students to draw similar triangles by using a triangular ruler | | Triangle models | | Real-life objects from the textbook | | Asked students to draw the similar triangles | | Used dolls | |
| Worksheets | Y | Y | Y | Y | / | / | / | / | / | / | / | / |

According to Table 6.5 above, *Teachers D* and *F* used concrete examples such as real-life objects to indicate similarity and then used figures to introduce similar triangles. But *Teachers A* and *C* adopted concrete triangle models to demonstrate how two triangles were similar and let students manipulate them to find out the characteristics of similar triangles. *Teacher A* chose students to compare the angles of triangles while *Teacher C* prepared a lot of triangles and let two students in a group measure their angles and lengths. It was obvious that students in *Teacher C*’s classes liked to do this task very much as they were observed to be engaged in their learning – I could tell that *Teacher C* had designed a suitable task to get students involved. Introducing the concept of similarity by using real-life objects, such as photos, was good practice: it allowed students to first grasp the concept of similarity with the same shape but different size; and then narrow the learning to triangles only to show two similar triangle models and let students explore how they were similar. In Ab(b,h), Ad(s,m), Ba(b,m), Cd(s,l) and Ce(s,l), it was evident that giving hints about measuring triangles’ angles or the length of their sides was helpful for students as, otherwise, they might spend a long time to explore the issue.

On the other hand, *Teachers B* and *E* let students draw similar triangles on a worksheet and then compare their properties. *Teacher B* used figures on worksheets for students to measure similar triangles' angles or lengths. In class Ba(b,m), he even brought some triangular rulers for students to draw the two similar triangles and then measure their angles and lengths. It was easy for students to use the triangular rulers to draw a big and small triangle, and these students seemed to be engaged in the task during the seatwork. For his other class, Bd(b,m), *Teacher B* used a different method to teach as he thought there was not enough time for those students to work on the activity. Unfortunately, this class behaved badly as they had no interest in the activity. *Teacher B* also thought he could not control discipline in this class if he let them work on the activity, and so he used a different teaching approach.

*Teacher E* required students to draw similar triangles at home and find out the properties they shared. He assumed all students could follow the instructions and draw the triangles successfully, but it was difficult to know whether students had drawn the figures or not as he never asked them to show their work. *Teacher E* used a lot of symbolic language to link his teaching with students' drawing experience in Es(b,u). For example, he asked students 'What kind of special features can you tell?', and 'What can you prove by using these two properties?'; or he summarized the learning as 'The first one is corresponding angles are equal, i.e. AAA similarity. The second method is corresponding sides are equal in ratio, i.e. SSS similarity. The third one that we already discussed is SAS similarity. It is two pairs of sides in equal ratio and the corresponding included angles are equal'. I was uncertain how helpful it was to use more symbolic language to teach, but the class seemed to understand this use of abstract mathematical language. In reviewing the learning in both Dcd(s,u) and Es(b,u), the students appeared to be able to follow the teachers' instruction very well.

Teachers can vary their approach and teaching style to cater for different classes of students even if the core content to be covered is the same. For the classes with more able students (shown in bold in Table 6.6), only *Teacher D* in Class Dcd (s,u) used more symbolic language (coded as D2) than concrete examples (coded as D1), to promote student thinking before letting them explore the methods for proving similar triangles. The data in this table also showed an interesting result for the teachers who taught both high- and low-ability classes. For instance, more symbolic language was used when teaching Cd(s,l), Ce(s,l), Dcd(s,u) and Es(b,u) – perhaps because of these teachers' teaching style. For example, *Teachers A*, *B* and *F* did not use much symbolic language during lessons, but *Teacher C* used both concrete examples and symbolic language to teach; and *Teacher D* and *Teacher E* changed their teaching approach for different classes.

**Table 6.6** Concrete examples vs symbolic language

| Special code | Ab (b,u) | Ad (s,m) | Ba (b,m) | Bd (b,m) | Cd (s,l) | Ce (s,l) | Dcd (s,u) | Da (b,l) | Ey (b,u) | Es (b,u) | Fa (b,u) | Fe (b,m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code D1 | **4** | 2 | 4 | 1 | 25 | 18 | **6** | 5 | **14** | **8** | **8** | 17 |
| Code D2 | **2** | 1 | 4 | 3 | 13 | 16 | **13** | 1 | **6** | **12** | **5** | 7 |
| Total | **6** | 3 | 8 | 4 | 38 | 34 | **19** | 6 | **20** | **20** | **13** | 24 |

### 6.3.5 Variation in teaching approach (code E)

Code E aims to measure the number of changes in teachers' teaching mode. This code includes three kinds of teaching: E1 when the teacher gives a lecture to the whole class; E2 when the teacher groups students in pairs to work with other classmates to discuss problems; and E3 when he/she lets students work alone in their seats and helps individual students during this time. The Curriculum Guide recommends that, in their daily class teaching, teachers should adopt various teaching styles, such as whole-class teaching and group work, as well as individual teaching. Group work provides an opportunity for students of varying ability to cooperate with and learn from each other. Also, while tackling tasks or activities during individual work, less able students should be provided with more cues. However, as shown in Table 6.7, the teachers seemed to be using the same teaching mode in both of their classes. The code E1 ranged from three to twenty-five times and for code E2 the range was from zero to four. Apparently, Teachers B, D, E and F did not like to let students work in groups – a finding which matches that of Mok and Lopez-Real (2006) who noted little use of group work in the lessons of Hong Kong secondary school teachers. In looking closely at how students worked in pairs in Ab(b,u), Cd(s,l) and Ce(s,l), it was found that, while they talked to each other in the group-work time, not all of their discussion was related to the issue for consideration. The teachers involved did not appear to be able to teach students how to focus effectively in discussing problems. Also, the interaction between students was not monitored by the teachers during and after group work, which might make students discuss issues less seriously and therefore reduce the quality of group work. If teachers can give more guidance to students on how to discuss issues and let them present their outcomes to the whole class, group work is likely to be more fruitful.

**Table 6.7** Variation in teachers' teaching mode

| Special code | Ab (b,u) | Ad (s,m) | Ba (b,m) | Bd (b,m) | Cd (s,l) | Ce (s,l) | Dcd (s,u) | Da (b,l) | Ey (b,u) | Es (b,u) | Fa (b,u) | Fe (b,m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code E1 | 25 | 23 | 5 | 3 | 4 | 3 | 10 | 10 | 8 | 6 | 5 | 3 |
| Code E2 | 1 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code E3 | 53 | 53 | 10 | 1 | 11 | 11 | 14 | 17 | 16 | 12 | 8 | 4 |
| No. of E3/ no. of students | 53/38 =1.39 | 53/19 =2.79 | 10/41 =0.24 | 1/42 =0.023 | 11/16 =0.69 | 11/16 =0.69 | 14/20 =0.70 | 17/36 =0.47 | 16/42 =0.38 | 12/42 =0.29 | 8/40 =0.2 | 4/39 =0.103 |
| Total | 79 | 76 | 15 | 4 | 19 | 16 | 24 | 27 | 24 | 18 | 13 | 7 |

Two teachers, *Teacher B* and *Teacher E*, had a negative attitude to discussion, and so it was understandable that they did not let students have group work and construct knowledge from discussion. However, although *Teachers D* and *F* claimed they held positive attitudes to discussion, they also did not like to allow students to work in groups as they thought this would be a waste of teaching time and that students could not learn much from group work. Certainly, the value of cooperative learning among groups of students should not be taken for granted. It requires teachers to establish a good learning environment when training students to work and learn together, which may take a long time and involve designing suitable tasks and instructions for students from the beginning of the term.

The incidence of code E3 ranged from fifty-three times to only once in a class. However, when comparing the time teachers spent on each student, it seemed better to adopt the average frequency. The average frequency of teachers catering for individual students was highest (2.79) for *Teacher A*'s Class Ad(s,m). Although most teachers claimed they could cater for individual students' needs during the seatwork time, Table 6.7 indicates that the average number of times teachers approached students was low. The teachers explained this by saying that the time for teaching the curriculum content was very tight, and they had to finish the topics as planned in the schedule without delay. For example, *Teacher B* explained as follows why he could not let students have seatwork time during the lesson:

> Because of the limited time in each lesson, when I have to give a lecture, demonstrate an example and assign the seatwork problem, the lesson is almost finished.
>
> (*Teacher B*: second interview)

For the quality of help given to individual students, refer to Chapter 5 sections 5.3.5.4, 5.4.5.3, 5.5.5.4, 5.6.5.4, 5.7.5.3, 5.8.5.3 about seatwork time and students' questions during the seatwork. I found that students did not know how to ask questions. In most cases, the teachers approached the weak students to help them. However, most teachers were only concerned with students' progress in their work but could not identify students' misconceptions or hindrances in working on the problems – which is again a finding similar to Morris et al. (1996) who noted that, in most of the lessons observed, 'class work sessions were arranged but not used the best effect'. Sometimes, they disregarded the less able students during a lesson in order to finish their teaching, though these students might have a different kind of remedial class given by the class teacher or another tutor after school. In some ways, this matches Wong et al's (1999) finding that teachers thought remedial group teaching could be effective in helping individual students. However, the teachers could not guarantee that this kind of help would cater for individual students' needs, as the students would view this as a punishment. As a result, most students tried their best to meet the minimum requirements and avoid having to stay behind after the lesson, but this reinforced the tendency for students to hide their weak points from the teacher.

#### 6.3.5.1 Variation in peer learning

When considering the teaching mode to cater for students' individual differences, teachers must know how to create a classroom environment in which students can open their minds and express their learning needs. Letting students work in pairs can allow them to help each other during discussion, and teachers should value the time spent listening to them. Sometimes students may get lost when discussing, and the teacher may prepare questions to help them focus on the task. However much time it takes, training students to work in groups is helpful for ensuring they are on-task and have fruitful results. White and Frederiksen (1998) noted that giving time for students to talk about what would count as quality work, and how their work was likely to be evaluated, reduced the achievement gap between students of different ability levels. Presentations after group work should also be considered, with the teacher selecting some groups to show their results; and during the presentation time, the teacher should also encourage other students to ask questions about the content being presented in order to promote interaction among students. The quality of student exchanges can be enhanced if teachers encourage them to express their viewpoints freely. In this way, catering for student variation in learning no longer depends on the teacher alone as students can help each other during group work or presentations.

#### 6.3.5.2 Seatwork

Normally, the teachers gave seatwork time to students to work on problems in the textbook or a worksheet. The time involved ranged from a few minutes in a single lesson to more than ten minutes in double lessons. *Teacher B* gave little seatwork time for both his classes and *Teacher F* preferred to give less seatwork time for the less able Class 1E. The reason *Teacher B* gave for limited seatwork time was the tight teaching schedule; while *Teacher F* said she wanted to guide the less able students to work on the problems with her help. The number of problems given for students to work on also varied, ranging from two to five. In this period of time, students of different ability worked on the problems at their own pace. Among the classes studied, it was clear that the teachers – for example, *Teacher B*, *E* and *F* – had more difficulty in catering for students' individual differences during seatwork time for their mixed-ability classes. Some students could finish the seatwork tasks quickly while some others were either unwilling to work during seatwork or did not know how to start. When I asked the teachers how they handled the differences, *Teachers A*, *C*, *D* and *E* said that there were a few students who could work very fast and were left with a lot of time. Only *Teacher A* privately suggested to his 1B students that they should try to solve some more difficult problems if they wished. *Teacher C* never asked those students to tackle more work as they would not like to do so. *Teacher D* would rather assign challenging problems for the whole class in 1CD. In contrast, *Teacher E* would let the students do whatever they wanted if they completed the problems quickly. However, for the slow learners who might not finish the problems during the seatwork time, *Teachers A*, *C*, *D* and *F* insisted on letting these students finish, as the problems assigned to them were basic and students should know how to work them out. A better practice was employed by *Teacher F* who told students explicitly that there were three different levels of problem, and all students should know how to solve the basic and middle-level problems. If they wanted to get higher marks, they were encouraged to know how to deal with the middle-level and higher-level problems.

#### 6.3.5.3 Assessment

For the assessment arrangements, five of the six teachers got some students to work out their solutions on the blackboard, the exception being *Teacher C*. These five teachers checked the solutions together with the rest of the class and gave immediate feedback to clarify any wrong presentations. All the teachers seemed to take the formal presentation of solutions very seriously, and would get other students to follow the format after checking, which reflects Mok, Cai and Fung's (2005) finding that teachers led students on a predetermined solution pathway rather than allowing more open investigation and exploration of mathematical ideas. *Teacher F* chose students who had already worked out the right solution in their books to work on the blackboard. However, *Teacher E* selected a student to work out the solution directly on the blackboard. Only *Teacher C* did not let students show their work publicly. This teacher had to demonstrate again and again how to work out the solution properly as her classes did not have enough confidence to complete the seatwork. Students in this class copied the model answers into their exercise books.

## 6.4 Summary and reconciliation

Overall, we can conclude that teachers' perceptions of catering for individual differences affect directly their practical approaches to helping individual students. The teachers had the whole class in mind – not individual students – and it is impossible to change teachers' mindsets to focus on individual students if they care only about whole-class teaching. Chan, Chang and Westwood (2002) found that teachers made relatively few adaptations to accommodate differences among their students. As in the literature review on how Hong Kong teachers take care of students who are identified as having special needs, this study also found that frontline teachers are not prepared to plan to meet their students' needs in advance before teaching. The teachers preferred to manage student problems once they emerged during interaction. They responded to students' individual needs mainly by the way they conducted and managed the lessons. These results are consistent with similar studies in other countries (e.g. Ellet, 1993; Weston et al., 1998). The quality of feedback was not a concern of the teachers.

It seemed that, in certain circumstances, the teachers could alter their teaching in line with students' needs. However, the quality of the work still left considerable room for improvement by school advisors or other teachers, as discussed in the following chapter on the implications of the findings. However, regardless of the teachers' lack of awareness of the suggestions in the Curriculum Guide on catering for students' individual differences, they were able to use many of them to advance their students' learning. In general, the teachers involved: (1) attempted to check students' prior knowledge, but only a small number of students were involved; (2) asked questions at different levels, but did not know about the students' learning progress; (3) chose content which was most likely to follow the textbook; (4) were unable to vary the focus to help students learn; and (5) could not identify what was hindering students in working out problems during seatwork.

**Table 6.8** Summary of the six teachers' teaching

| **Teachers** | **Teacher A** | | **Teacher B** | | **Teacher C** | | **Teacher D** | | **Teacher E** | | **Teacher F** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two classes | Ab(b,u) | Ad(s,l) | Ba(b,m) | Bd(b.m) | Cd(s,l) | Ce(s,l) | Da(b,l) | Dcd(s,u) | Ey(b,u) | Es(b,u) | Fa(b,u) | Fe(b,m) |
| No. of video-taped lessons | 5 | 5 | 5 | 5 | 6 | 6 | 5 | 4 | 6 | 6 | 4 | 4 |
| Under-standing of students in different classes (Code A) | Fair | | Not good | | Fair | | Very good (class teacher) | Very good | Fair | | Very good | Excellent (class teacher) |
| Variations in arousing learning motivation (Code A) | Uses a transparency as a teaching aid to compare two similar triangles | | Uses a triangular ruler to draw triangles of different sizes, then measure the length of sides and angles | Introduces the concept with real-life textbook objects | Uses the teaching aids of concrete triangles and real- life objects to introduce the concept of similarity | Uses a worksheet activity to let students cut the triangles and measure the length of sides and number of degrees of three angles | Uses real-life examples | | Asks about students' experiences of constructing triangles to find methods of proving similar triangles, then measure | Students required to prove two similar triangles | Teaching aids (dolls) | |
| Variation in approaches to introducing concepts (Code A) | Teacher asked many open-ended questions to get students to think before letting them explore the methods to prove similar triangles. He mentioned the method of comparing the angles as well as measuring the lengths of sides, and then found the ratios of each pair of corresponding sides. | Teacher was keen to tell students how to follow the instructions to complete the work, and then show them the way to prove similar triangles. | Teacher gave students a work- sheet to find out the characteristics of similar triangles. | Teacher used real-life objects to introduce the idea of similarity. | Teacher asked many open-ended questions to arouse students' thinking before letting them explore the special features of similar triangles. | Teacher only told students directly that the two triangles were similar and the smaller triangle was made by decreasing from the bigger one. She never mentioned any special features of these two triangles. | Teacher just mentioned the method of comparing the correspondin g angles and demonstrated how to compare them correctly as in the method for comparing congruent triangles. | Teacher asked an application-level question to check students' understanding of the corresponding angles being equal and then moved on to the other characteristics of similar triangles. | Teacher asked many questions to arouse students' thinking before letting them explore the logical link between two methods for proving similar triangles. | Teacher let students follow the instructions to complete the drawing work at home and liked to use the teaching time to work out the new concept by proving similar triangles practically. | Teacher used open-ended questions to motivate students. Students could ask questions freely and react to her questions when discussing the concept of 'in proportion'. | Teacher used open-ended questions to motivate students. Students could ask questions freely and react to her questions when discussing how to match the correspondin g sides of similar triangles. |

| **Teachers** | **Teacher A** | | **Teacher B** | | **Teacher C** | | **Teacher D** | | **Teacher E** | | **Teacher F** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two classes | Ab(b,u) | Ad(s,l) | Ba(b,m) | Bd(b.m) | Cd(s,l) | Ce(s,l) | Da(b,l) | Dcd(s,u) | Ey(b,u) | Es(b,u) | Fa(b,u) | Fe(b,m) |
| Variation of the level of difficulty and content covered (Code B) | Teaches the two characteristics of similar triangles at the same time using worksheet's concrete triangles | | Teaches the two features of similar triangles at the same time | Teaches the features of similar triangles one-by-one | Guides students to find different ways to check whether two triangles are similar or not | Guides students to think how to prove two triangles are similar | Teaches the features of similar triangles one-by- one | Teaches both the features of similar triangles at the same time and introduces the concept of 'in ratio' and the techniques of cross-fraction multiplying | Teaches the methods for proving similar triangles | Teaches the proof and finding unknowns after proving two triangles are similar | Teaches the features of similar triangles; focuses on the concept of 'in proportion' first | Teaches the features of similar triangles; focuses on matching the correspond-ing sides first. |
| Function of questioning (Code C) | Guiding questions to help student understanding of the content | | - Reminds students to pay attention and<br>- checks understanding | | - Guiding questions to help students follow her instruction and<br>- reminds students to pay attention; also<br>- checks students' level of understanding | | Encourages students by letting those who call out the correct answer to make their responses | | - Asks high-level questions and lets students show off;<br>- reminds students to pay attention | | Three functions:<br>- checking understanding,<br>- remind students to pay attention,<br>- encouraging weak students | |
| Questioning style (Code C) | - liked to use questions to draw students' attention<br>- asked the whole class a question first, then picked a student to answer | | - liked to use questions to draw students' attention<br>- mainly asked a specific student to answer his question | | - liked to use questions to draw student's attention<br>- asked the whole class a question first, then picked a student to answer question<br>- sometimes asked a specific student to show her concern about learning | | - asked the whole class a question first and let students call out the answer, and then picked a student who is correct to answer in order to encourage the student in learning<br>- prefers not to ask a student who will give a wrong answer as students might laugh at that student and discourage him/her from learning | | - ask the whole class a question first and let students think for a few seconds – and then pick a student who raises his/her hand to answer<br>- very few cases of asking a specific student to draw his/her attention | | - Teacher would like to wake the student up as she finds this student might be day-dreaming.<br>- Teacher knew those students might get lost and so asked them to help them understand. | |
| Variation in questioning techniques (Code C) | More low level | | More high level | More low level | More high level | | More low level | More high level | More low level | More high level | Less low level | Half high and low |

| Teachers | Teacher A | | Teacher B | | Teacher C | | Teacher D | | Teacher E | | Teacher F | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two classes | Ab(b,u) | Ad(s,l) | Ba(b,m) | Bd(b.m) | Cd(s,l) | Ce(s,l) | Da(b,l) | Dcd(s,u) | Ey(b,u) | Es(b,u) | Fa(b,u) | Fe(b,m) |
| The differences between the two classes in questioning techniques (Code C) | Teacher asked many questions which varied from high- level open-ended questions for capable students to closed low-level questions for less able students. | Teacher asked students low-level open-ended questions first, then told them how to deal with the problem directly and let them follow his method in order to solve the problem | Teacher kept asking high-level questions as students could give him short answers. He never asked students how they got the answers. | Teacher asked mostly low-level questions to draw students' attention, but students could still not answer him. | Teacher raised open-ended questions to the whole class first and prompted other students to answer them step-by-step, and also lowered the level of questions to cater for different levels of students and gave positive reinforce-ment to encourage students | Teacher asked students low-level and open-ended questions | Teacher asked many questions which varied from high-level questions for capable students to low-level questions for less able students using methods of variation in questioning techniques | Teacher preferred to ask students high-level open-ended questions first and then guide them to deal with the problem directly and let them discover the method in order to solve the problem. | Teacher mainly tried to use high-level and open-ended questions to challenge students to think. He tried to help students think more deeply about the questions by prompting | Teacher asked low-level questions related to problem-solving. Students were guided step-by -step to think of how to solve the problem. They also had to work out the problem by applying concepts learned to explain their findings. | Teacher could raise an appropriate open-ended and high-level question to arouse students' thinking. Students did not mind having challenging questions and raised different dimensions of thinking. | Teacher raised an appropriate question and middle- level question to arouse students' thinking. Different students gave their ideas of how to get similar triangles. |

| Teachers | Teacher A | | Teacher B | | Teacher C | | Teacher D | | Teacher E | | Teacher F | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two classes | Ab(b,u) | Ad(s,l) | Ba(b,m) | Bd(b.m) | Cd(s,l) | Ce(s,l) | Da(b,l) | Dcd(s,u) | Ey(b,u) | Es(b,u) | Fa(b,u) | Fe(b,m) |
| Students' questioning habits in two classes (Code C) | Among the five students interviewed, only two of them would like to ask the teacher promptly during the lesson. | All the five students interviewed did not want to ask the teacher any questions, even when they did not understand the content. | Among the seven students interviewed, six of them would like to ask the teacher questions if they did not understand. | Among the eight students interviewed, five of them would not like to ask the teacher questions. | Among the six students interviewed, five of them would like to ask the teacher questions right away if they did not understand. | Among the six students interviewed, three would not like to ask, one would ask after the lesson and two would ask right away during the lesson. | All five students interviewed would not like to ask the teacher questions as they were scared to ask as their classmates would laugh at them. | Among the five students interviewed, only one would ask during the lesson, one would ask after the lesson and one would ask the classmates only. | Among the six students interviewed, only two would not ask questions during the lesson | Among the six students interviewed, five of them did not think the content of learning was so difficult that they had to ask. Only one student would like to ask classmates questions, if he did not understand. | Among the six students interviewed, two found no question to ask; one would ask only if missed the class; one would ask after the lesson; one would ask classmates first and then the teacher; and only one would not ask. | Among the six students interviewed: three would not ask; one would ask classmates first; one would try to solve it by himself; one said the teacher would repeat, and so did not need to ask. |
| Students' questions during the seatwork (Code C) | Students asked about procedural problems only. | Students asked questions related to the working procedures. | Students asked about the procedural problems only. | Teacher could not walk to students' seats because of the short microphone wire. | Students asked something related to clarification only. | Teacher not only checked students' work closely but also identified errors right away. | Students seemed not used to asking questions. | Students seemed not used to asking questions. | Students seemed not used to asking questions. They just showed they finished the work very quickly. | Teacher could only provide help to certain specific students to figure out the problem directly. | Students seemed not used to asking questions, so teacher targeted the weaker students to give feedback appropriately | Teacher did not want to give students a lot of time to do seatwork as she would like to guide them step-by- step to follow her presentation. |

| Teachers | Teacher A | | Teacher B | | Teacher C | | Teacher D | | Teacher E | | Teacher F | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two classes | Ab(b,u) | Ad(s,l) | Ba(b,m) | Bd(b.m) | Cd(s,l) | Ce(s,l) | Da(b,l) | Dcd(s,u) | Ey(b,u) | Es(b,u) | Fa(b,u) | Fe(b,m) |
| Variation in approaches when introducing concepts (Code D) | Asks many open-ended questions to arouse student thinking before letting them explore the methods to prove similar triangles. | Keen to tell students how to follow the instructions to complete the work; then shows them how to prove similar triangles | Uses drawing and measuring; gives out a worksheet to do an experiment to find out the features of similar triangles | Uses real-life objects in the textbook to introduce the idea of similarity | Asks many open-ended questions to arouse student thinking before letting them use concrete triangles to explore the special features of similar triangles | Tells students directly that those triangles are similar and the smaller triangle is made by decreasing from the bigger one; then guides students to measure the concrete triangles to find the special features of similar triangles | Just mentions the method of comparing correspondin g angles and demonstrates how to compare them correctly as in the method of comparing congruent triangles | Lets students discover the main concepts by asking an application question to check they understand the correspond-ing angles are equal; then moves on to the other features of similar triangles | Asks students to construct similar triangles and then explore the criteria for proving similar triangles and the logical link between methods of proving similar triangles | Lets students follow the instructions to complete the drawing work at home and discusses the new concept by proving similar triangles practically on their own, then finding unknowns | Guides students to find the concepts by using open questions to motivate them; students could ask questions freely and react to her questions when discussing the concept of ‘in proportion’ | Guides students to work on the problems to know more concepts; students could ask questions freely and react to her when discussing how to match similar triangles’ correspond-ing sides. |
| Variation in clues provided in tasks (Code D) | Less individual help during the seatwork time | Much more individual help during the seatwork time | Guides students step-by-step | Tells students how to do it directly | Lets students work on their own after clear instructions | | Guides students step-by-step | Lets students work on their own | Let students work on their own | | Lets students work on their own | Guides students step-by- step |
| Variations in peer learning (Code E) | Yes, with groups | No | No | | Yes, with groups | | No | | No | | No | |

| **Teachers** | **Teacher A** | | **Teacher B** | | **Teacher C** | | **Teacher D** | | **Teacher E** | | **Teacher F** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two classes | Ab(b,u) | Ad(s,l) | Ba(b,m) | Bd(b.m) | Cd(s,l) | Ce(s,l) | Da(b,l) | Dcd(s,u) | Ey(b,u) | Es(b,u) | Fa(b,u) | Fe(b,m) |
| Seatwork (Code E) | Two or three students could finish the work fast and left a lot of time. Teacher would privately suggest that they try to solve some more difficult problems since they didn't seem to mind working on more problems. | For low-ability students, teacher never suggested they do more than the basic problems. Teacher believed students should learn how to solve those basic problems. | Not much seatwork time because of the limited time to check students' progress or understanding | Very short seatwork time, because of the limited time to check students' progress or understanding | Only one or two students could finish the work. However, the teacher did not suggest they try some more difficult problem since they seemed reluctant to work on more problems. | For low-ability students, the teacher would privately suggest they did the basic problems only and skip the difficult problems. The problems were basic, so all students in this class should learn how to work them out. | For this class, teacher would privately suggest they do the basic problems only and skip the difficult problems. Teacher felt the problems assigned were basic problems, so all students in this class should learn how to work them out. | Only one or two students could finish the work quickly. However, teacher had never suggested they should do more as this situation was rare. She only tried to assign challenging problems to the whole class. | Only three or four students slower in finishing the work, so the teacher helped them during the seatwork. Smarter students could do what they wanted when they had finished. The teacher let middle-level students have enough time to try and did not disturb them. | Teacher would prepare more challenging problems for this class as the students were more confident in solving problems. | Teacher would prepare more challenging problems for this class as the students were more confident in solving problems. | Teacher tended to give less seatwork time in this class. She suggested that low-ability only do basic problems and skip the difficult ones. Teacher still encouraged students to work on the middle-level problems to get more marks. |
| Assessment (Code E) | Teacher let students work out their solutions on the blackboard. Then teacher checked the solutions together with other students and gave instant feedback to clarify the wrong presentations. | | Teacher let students who could finish quickly work out their solutions on the blackboard. He checked the solutions together with other students and gave instant feedback. | | A number of students did not want to work on the problems and would like to wait for teacher's answer and copy it. She had to walk around and force them to try. They did not have enough confidence to complete the work correctly and did not want the teacher to know about their learning progress. | | Teacher would let students work out their solutions in their workbook. Teacher checked the solutions together with all students and gave instant feedback to clarify wrong presentations. Students could copy her solution when they found their own work was not good enough. | | Teacher would check students' work publicly by asking them directly or letting them work out their solutions on the blackboard. He checked the solutions together with other students and gave instant feedback to clarify the wrong presentations. He liked to ask students to explain the reasons. | | Teacher would let students work out their solutions on the blackboard once she had made sure that students could figure out the problem. Teacher checked the solutions together with other students and gave instant feedback to clarify the wrong presentations. | |

# CHAPTER 7

# TEACHERS' ATTITUDES TOWARDS THE CURRICULUM GUIDE AND THE IMPLEMENTATION OF THE CURRICULUM GUIDE

## 7.1 Scope of the chapter

This chapter presents the findings on the first four research questions (see Chapter 1, section 1.4):

1 What are the teachers' attitudes towards Mathematics teaching in general?

2 What is their understanding of the recommendations in the Mathematics Curriculum Guide on the issue of catering for individual differences, and to what extent do they understand the principles behind this guidance?

3 How do these teachers approach their teaching in the classroom, specifically related to catering for individual differences both within a class and between classes, and what is their rationale for doing so?

4 What is the relationship between the recommendations of the Curriculum Guide related to catering for individual differences and teachers' actual practice in implementing them, both within a class and between classes?

This chapter covers the following areas: teachers' general beliefs about teaching and learning Mathematics; their understanding of the Curriculum Guide; and their specific attitudes towards the Curriculum Guide's suggestions about how to provide for students' individual differences both within a class and between classes. The fifth and final research question dealing with the implications for teachers, advisors and policy makers, is discussed in Chapter 8.

## 7.2 Teachers' general beliefs about the teaching and learning of Mathematics (Q. 1)

There is considerable confusion in the literature regarding both the labels and definitions used to describe teacher beliefs. Pajares, in his 1992 review, labelled teacher beliefs a 'messy construct', noting that 'the difficulty in studying teachers' beliefs has been caused by definitional problems, poor conceptualizations, and differing understandings of beliefs and belief structures' (p. 307). According to Calderhead (1996), teacher beliefs, as well as teacher knowledge and teacher thinking, comprise the broader concept of teacher cognition. Yet, Kagan (1990) noted that the term 'teacher cognition' is 'somewhat ambiguous, because researchers invoke the term to refer to different products, including teachers' interactive thoughts during instruction; thoughts during lesson planning; implicit beliefs about students, classrooms, and learning; [and] reflections about their own teaching performance …' (p. 420). Part of the difficulty in defining teacher beliefs centres on determining if, and how, they differ from knowledge. In this review, I accept the distinction suggested by Calderhead (1996): whereas beliefs generally refer to 'suppositions, commitments, and ideologies', knowledge refers to 'factual propositions and understandings' (p. 715). Therefore, after gaining knowledge of a proposition, we are still free to accept it as being either true or false (i.e. to believe it or not). Despite the difficulties related to sorting out this 'messy construct', Pajares (1992) proposed that, 'All teachers hold beliefs, however defined and labeled, about their work, their students, their subject matter, and their roles and responsibilities …' (p. 314). Because 'humans have beliefs about everything' (p. 315), Pajares recommended that researchers make a distinction between teachers' broader, general belief systems and their educational beliefs. In addition, he suggested that educational beliefs be narrowed further to specify what those beliefs are about.

Beliefs about teaching and learning (and all beliefs for that matter) tend to be embedded within a larger, 'loosely-bounded' belief system, which Rokeach (1968) defined as 'having represented within it, in some organized psychological but not necessarily logical form, each and every one of a person's countless beliefs about physical and social reality' (p. 2). According to Nespor (1987), belief systems, unlike knowledge systems, do not require group consensus, and thus may be quite idiosyncratic. This may explain why two teachers who know the same things about individual differences might have different beliefs about how to deal with it (e.g. one seeing it as a blessing; the other as a curse). In fact, as has been noted earlier, even individual beliefs within the system do not necessarily have to be consistent with each other. Bearing all these points in mind, I now try to present the general picture of the participant teachers' attitudes towards Mathematics teaching and their understanding of the proposals in the Curriculum Guide on catering for individual differences.

*Research question 1*: What are the teachers' attitudes towards Mathematics teaching in general?

According to the data from the second questionnaire (see Appendix 4), the teachers in the study have rather different perceptions of their teaching characteristics and style. On the one hand, all six teachers agreed that they knew where to find the teaching resources and prepared their lessons well, and they also claimed that they liked to use teaching aids and give lectures to the whole class. In addition, they felt they could establish good rapport with students and liked to pose challenging/open-ended questions and encourage student free association of ideas to tackle these kinds of problem. They also said they encouraged students' independent learning and thinking and let them talk and ask questions to allow trial and error, and even mistakes; and they also promoted students' active participation and discussion, and gave them enough time to think and answer questions or solve problems. As regards thinking strategies, they agreed they infused thinking strategies and skills into learning.

During problem-solving, all six teachers agreed or strongly agreed that they would use most of the time to demonstrate how to solve the textbook problems by pinpointing the procedure and relevant concepts or let students solve problems independently. Besides, they agreed to encouraging learning beyond the curriculum and textbooks by developing logical, analytical thinking. They also always checked whether students understand concepts by asking them questions; and so they could tell what students had learned to evaluate learning outcomes as they had set learning standards before the lesson. After lessons, teachers would assign homework to drill students by using textbook exercises; they would like to empower students with responsibility and leadership; and they all agreed that their teaching style was to be firm, consistent, imaginative and creative.

However, there were some statements to which teachers adopted different approaches. For instance, three of them indicated that they did not like to hold group activities or competitions during teaching. Also, three teachers indicated that they did not like to use computers for teaching. Finally, concerning the submission of homework, there were also three teachers who felt that their students had problems in handing it in.

## 7.3 Teachers' attitudes towards the Curriculum Guide's suggestions on how to cater for students' individual differences (Q. 2)

*Research question 2*: What is their understanding of the recommendations in the Curriculum Guide on catering for individual differences, and to what extent do they understand the principles behind this guidance?

The data on this research question are summarized in the table below. In terms of the attitudes of the six teachers towards the Curriculum Guide, only *Teacher F* showed a positive orientation towards it in the interview data. Four of the other five teachers had never read it thoroughly and appeared to feel that it includes no important guidance. The other two teachers claimed they knew the Curriculum Guide, but they both interpreted the idea of catering for individual differences in an incorrect way. Because of these responses, it was impossible to go any further to discuss understanding of the principles behind the guidance on handling individual differences.

**Table 7.1** Summary of teachers' attitudes to and understanding of the Curriculum Guide

| **Teachers** | ***Teacher A* (LMC)** | ***Teacher B* (StB )** | ***Teacher C* (LFH)** | ***Teacher D* (LKY)** | ***Teacher E* (WY)** | ***Teacher F* (BWL)** |
|---|---|---|---|---|---|---|
| Attitude towards the guide | Neutral | Neutral | Negative | Negative | Negative | Positive |
| Understanding of the guide on catering for student diversity | Not, thinks only about special needs' students | Not, thinks about exam levels | Not, has never read it carefully | Not, never pays attention to it | Not, never read it | Yes, thinks already using it |
| Understanding of the principles behind the guide | Not | Not | Not | Not | Not | Not |

## 7.4 Teachers' approaches to their teaching in the classroom, specifically related to catering for individual differences both within a class and between classes (Q. 3)

In Chapters 5 and 6, I discussed the strategies which teachers used to try to cater for individual learning differences within their classes. The data were drawn from twenty-five of the sixty-one lessons videotaped. The lessons chosen best illustrate the teachers' general approaches and provide an easy comparison with their other classes; and they indicate a number of strategies for handling student learning diversity.

It has been suggested that there were some significant differences between the approaches of these six teachers, and of the practices in their schools. None of the strategies observed was explicitly designed to tailor learning to all students' individual needs as teachers chose content which was most likely to follow the textbook. The general strategies used for this purpose were less direct, such as the use of individual questioning to check students' level of understanding or helping individuals during seatwork time. However, although the teachers asked questions at different levels, they did not know about the students' progress in learning and they could not identify the difficulties students were facing in working out problems during seatwork. This placed relatively few demands on the teachers in terms of preparation or classroom management. In practice, teachers are most likely to adopt strategies that best suit their teaching philosophy, their stage of personal professional development, and their school and class context.

On the surface, the teachers seemed to teach their two classes in much the same way. However, close analysis of the coding data showed some differences. The teachers seemed alert to the ability level of the class and, where appropriate, would give simpler tasks, lower-level questions and concrete examples, to show the relevant concepts. During the seatwork, teachers also helped individual students privately. Only one teacher (*Teacher D*), who taught two classes which were very different in size and ability level, used much more symbolic language in teaching the higher-level small class, and also posed more high-level questions in this class; and for the lower ability class, she would cater for students' learning needs when they were working alone at the seatwork time. In addition, she planned the learning content quite differently in terms of difficulty level for the two classes.

When exploring the teachers' rationale for teaching, it was clear that all the teachers were using their own usual practice without mentioning any special theoretical base or references for guidance. This was similar to Clarke and Clarke's (2008) finding that teachers had a tendency to tackle individual differences themselves and were not inclined to use more systematic ways. They handled the issue themselves by adjusting their teaching and seldom viewed the curriculum documents or seminars as a source of help. The teachers responded to students' individual needs mainly by the way they conducted and managed their lessons; and, as mentioned in Chapter 3, the most commonly applied strategies needed no planning or preparation in advance of a lesson.

Generally, when the teachers taught more able students, they liked to use open-ended questions to promote motivation and thinking. For example, as can be seen in Table 7.2 at the end of the chapter, *Teacher A* in the more able Class 1B, and *Teacher C* in the mixed-ability class with a better learning atmosphere, used open-ended questions to introduce the concepts. Both *Teacher A* and *C* discussed with students how to explore the characteristics of similar triangles first before letting them try to do problems. These teachers guided students to think about the special features of similar triangles' angles and the lengths of their sides; and they made sure that students knew how to measure the length of the sides and the number of degrees of angles before they let them explore the relationship between the triangles. Since the techniques for measuring the length of the sides and the number of degrees of angles were easy for Secondary 1 students, the less able ones could still work them out. Only *Teacher F* insisted on using open-ended questions with less able students in both Class 1A (an able class) and 1E (a middle-ability class). The other teachers – such as *Teacher A* in 1D (a middle-ability class) and *Teacher C* in 1E (a low-ability class) – all used direct instruction to guide less able students to complete the tasks. Actually, the measuring work was not so significant in learning about similar triangles – the most important concept was how to find out the relationship by looking at the collected data between two triangles once they were similar.

For measuring the angles, it was obvious that the corresponding angles of similar triangles were equal. Students could tell when they remembered the properties of congruent triangles. The ratio of the length of the sides was the most difficult part for the students to understand, particularly for some students who had not studied this concept in primary school, and so the teachers had to introduce this new concept thoroughly. Also, when working on the fractions, students had to know how to do fraction cancellation, which they had learned in Primary 4 but this might have been forgotten by less able students. So, after the activity, the teachers still had to do a lot of work to ensure that students understood the whole concept of ratio. Although the six teachers varied in the way they introduced the new concept, they went into the significant issue of ratio without considering students' learning background at all – as was seen in Chapter 6 , the teachers attempted to check students' prior knowledge but were not successful in identifying key issues, such as their difficulty in dealing with ratio. Most of the teachers just told students how to work on the ratio by using the lengths of sides to make the fraction, and were not aware that some students were confused in getting the corresponding sides correct.

It was pleasing to find that the teachers did think of different approaches for teaching students according to their ability level in their two classes. These tasks included completing worksheets by comparing the corresponding angles which demonstrated how to match angles accordingly, as in the method of comparing congruent triangles. In their teaching, *Teacher B* in 1A, *Teacher D* in 1A and *Teacher E* in 1Y let students explore the characteristics of similarity freely but did not focus on the significant learning point to ensure students had a thorough understanding of the properties of similar triangles. The teachers were also not very sensitive to students' needs even when they gave wrong answers or could not respond: as was noted in Chapter 6, the teachers asked questions at different levels, but did not know about the students' learning progress and were unable to vary the focus to help them to learn. Also, the teachers did not seem to be able to really identify the significant learning points that hindered student learning.

## 7.5 What is the relationship between the recommendations of the Curriculum Guide related to catering for individual differences and teachers' actual practice in implementing them, both within a class and between classes? (Q4)

Teachers' level of understanding of the Curriculum Guide's recommendations on catering for learning diversity is summarized in Table 7.2. It was clear that, although five teachers (*Teachers A*, *B*, *C*, *D* and *F*) had read the guide, none of the six teachers in the study followed the suggestions made there. In practice, it appeared that the teachers did not feel the need to refer to the Curriculum Guide as they believed fully in the value of the textbook and followed it. They had read the guide only when they were taking a teacher education course. While they were alerted to new initiatives such as catering for learning diversity in seminars they attended, they did not seem to have a clear understanding of individual differences and the rationale behind the related suggestions in the Curriculum Guide. Their different interpretations of the concept of individual differences had a direct effect on their handling of student diversity in their daily teaching. Of the six teachers, only *Teacher F*, who was studying a degree course in education, had a positive attitude to the Curriculum Guide and considered that her teaching somehow matched the suggestions there. However, when the researcher asked more about what she did to match the suggestions, she mentioned only the level of exercises, which indicated that her understanding of the rationale behind the Curriculum Guide was incomplete; and she did not seem to pay any attention to its suggestions for classroom practice.

As noted before, for dealing with learner diversity, most of the teachers were using their own personal methods to help students rather than adopting the suggestions in the Curriculum Guide. All the teachers taught consistently in their own style (see Table 7.2), but there were some differences in how they handled their two classes. For code A, it was found that all six teachers asked questions to check students' prior knowledge, but they focused on students who already knew the answers and ignored those who gave no response. As mentioned in Chapter 6, the teachers did attempt to check students' prior knowledge, but only a small number of students were involved. For code B, the teachers mainly followed the textbook to choose teaching content for their classes of students. They used challenging tasks first and then broke them down into many simple tasks in order to guide students to solve the problems – but they did vary the number of simple tasks depending on students' responses, which meant that fewer simple questions were raised with classes of higher ability. However, with middle-ability classes, the teachers tended to use more low-level questions, which suggested they were not fully aware of the ability of these students. For code C, all the teachers asked questions at different levels, but were unable to identify the students' progress by using them. Similarly, for code D, it was found that the teachers who taught both high- and low-ability classes used more symbolic language in their teaching. Concrete examples were preferred when teaching middle-level classes. As regards the mode of teaching (code E), there was a general lack of familiarity with using group-work settings and doubts about the value of students constructing knowledge from working and discussing together; and those who did use group work found it difficult to get students to work together successfully. Also, during the seatwork time, the quality of catering for individual students was in doubt. Teachers could not identify what was hindering students in working out problems and so were not able to help them effectively.

Other than the findings from the codes, the researcher also discovered that teachers varied the focus of their teaching and the learning outcomes according to students' ability levels, as can be seen for *Teachers B*, *D* and *F* in Table 6.8 in Chapter 6. For example, *Teacher B* allowed Class 1A to use triangular rulers to draw similar triangles, and measure the angles and lengths of the sides to explore the properties of such triangles. Also, *Teacher D* varied the learning focus in different classes by, for instance, stressing the concept of 'in ratio' and the techniques of cross-fraction multiplication in the more able Class 1CD. *Teacher F* also altered the learning focus slightly for her two classes: for the more able Class 1A, she highlighted proportion while for her other class with more students of mixed ability she concentrated on matching the corresponding sides of similar triangles. Some other aspects on which teachers varied their approach when teaching their two classes are summarized in Table 6.8, such as variations in questioning techniques, ways of introducing concepts, providing clues in tasks and peer learning.

Overall, it seemed that, in certain circumstances, teachers could alter their teaching in line with students' needs. However, the quality of the work still left considerable room for enhancement by school advisors or other teachers, as described in the following chapter on the implications of the findings. However, regardless of the teachers' lack of awareness of the suggestions in the Curriculum Guide on catering for students' individual differences, they were able to use many of them to advance their students' learning. In general, the teachers involved: (1) attempted to check students' prior knowledge, but only a small number of students were involved; (2) asked questions at different levels, but did not know about the students' learning progress; (3) chose content which was most likely to follow the textbook; (4) were unable to vary the focus to help students learn; and (5) could not identify what was hindering students in working out problems during seatwork.

**Table 7.2** Summary of the six teachers' perceptions of the Curriculum Guide and their implementation in the observed lessons

| Teachers | Teacher A | Teacher B | Teacher C | Teacher D | Teacher E | Teacher F |
|---|---|---|---|---|---|---|
| School type | Middle level | Low level | Low level | Low level | High level | Middle level |
| Attitude to setting as good | Agree | Neutral | Strongly agree | Strongly agree | Strongly agree | Strongly agree |
| School's own setting | Yes | No | Yes | Yes | No | Yes |
| Attitude to discussion | Agree | Hesitate | Agree | Agree | Disagree | Agree |
| Attitude to the Curriculum Guide | Neutral | Neutral | Neutral | Negative | Negative | Positive |
| Level of understanding of the Curriculum Guide | Read, but thinks not practical | Read but never try the suggested methods | Knows about, but never read the content | Read, but never paid attention to the content | Never read and no impression of the content | Read and thinks already doing it |
| Perception of students' individual differences | Not, thinks special needs students only | Not, think the examination levels | Not, never read it thoroughly | Not, never paid attention to it | Not, never read it | Yes, thinks already using |
| Understanding of the principles behind the guide | Not | Not | Not | Not | Not | Not |
| The degree of implementation of methods for catering for student diversity recommended in the Curriculum Guide | Only usual practice | Cannot do it as the Curriculum is too tight | Only usual practice and depends on students' learning progress | Only usual practice, but enhanced the learning of the better class | Only usual practice and thinks there's no need to cater for student diversity | Already using some methods from the Curriculum Guide |

| Teachers | Teacher A | Teacher B | Teacher C | Teacher D | Teacher E | Teacher F |
|---|---|---|---|---|---|---|
| Special features of teaching in both classes | Lets students have a long seatwork time and approached individual students during this time | Cannot control the class students, always choose one specific student to answer his low level questions | Asks a lot of questions to help students; lets students group together to work on hands-on activities | Traditional classroom practice; requires students to copy the main points throughout the lesson | Traditional classroom practice; a lot of lecture time and often asks one student | Gets many students involved in open discussion |
| The main differences between the teaching in the two classes | No differences in teaching content; less seatwork time in better class | Let better class do the hands on work by delivering students the triangular ruler | No differences in teaching content | Special design of the content between the two classes | No differences in teaching content | Different focus in two classes when teaching the same content; more challenging questions for the better class |

## 7.6 Summary

This chapter mainly addresses the first four research questions on (a) teachers' general beliefs about the teaching and learning of Mathematics; (b) their specific attitudes towards the Curriculum Guide's suggestions on how to cater for students' individual differences; (c) teachers' approaches to their teaching in the classroom, specifically related to catering for individual differences both within a class and between classes; and (d) the relationship between the recommendations of the Curriculum Guide related to catering for individual differences and teachers' actual practice in implementing them, both within a class and between classes. In this process, the features of teachers' practice are compared directly with recommendations in the Curriculum Guide (CDC, 2002). It was found that almost all the teachers had very positive attitudes towards Mathematics teaching. However, most of them showed only a very elementary level of understanding of the methods suggested in the Curriculum Guide for handling student diversity, although they were already implementing them to some extent in their lessons.

# CHAPTER 8
# SUMMARY AND RECOMMENDATIONS

## 8.1 Scope of the chapter

This chapter begins by outlining the good classroom practices observed on catering for students' individual differences. This is followed by discussion of a number of significant issues which emerged from the study. First, in order to answer the final research question, some implications for teachers, advisors and policy makers are elaborated by reflecting on the data collected. Second, new educational initiatives are critiqued in the light of the current research. Third, the cultural appropriateness of the notion of handling individual differences for the Hong Kong context is discussed. The chapter ends with a short summary.

## 8.2 Good classroom practices and limitations identified in catering for students' individual differences

Analysis of the classroom practices in the six schools identified a number of examples of ways in which individual differences were catered for effectively and efficiently, and also other instances in which improvements could be made. These are categorized into three main areas – whole-school practices, individual teacher's practices and pedagogical awareness – and several issues are addressed under each category.

### 8.2.1 Whole-school practices

#### 8.2.1.1 *A good grouping system* (from *Teacher D*'s school)

In this school, students who were capable in Mathematics only were strategically grouped into a small class. These students were very proud of their ability in the subject and so were highly motivated in studying it. This allowed the teachers to teach topics in more depth and raise students' expectations about their achievement. This setting method enhanced the learning of certain students who were weak in language subjects but more able in Mathematics.

#### 8.2.1.2 *A school-based Mathematics curriculum* (from *Teacher E*'s school)

Only one school had its own Mathematics curriculum which was totally separated from the normal textbook and specially designed by its teachers. The teachers could prepare the material freely to cater for students' needs, which helped the less able ones to learn at their own pace. However, teachers in most schools might not wish to follow this approach for various reasons, such as: lack of time because of the heavy teaching load for public examinations; the large variation in student ability in a single form; lack of administrative and specialist support; parents' views; and the involvement of the whole school in designing the Mathematics curriculum. Such teachers would prefer to mainly follow the textbook and the Curriculum Guide to make limited curriculum tailoring for less able students only. Certainly, such a school-based curriculum needs to be discussed at the school policy level, not just the teacher level. However, in their ongoing collaboration meetings, school advisors may let teachers make their own professional judgements on tailoring the curriculum across different levels to cater for students' needs; and the Mathematics panel then coordinates the curriculum design for each ability level according to teachers' suggestions. Such flexibility in curriculum design can reduce the burden on teachers and promote a cooperative atmosphere among them.

#### 8.2.1.3 *An after-school remedial programme* (from *Teacher F*'s school)

A number of the schools had remedial programmes for the weaker students. However, they identified these students only once a year, for example at the beginning of the term. The students were labelled as 'weak' and had no chance to appeal against the decision. In Teacher *F*'s school, however, only students who failed in the formal test were selected to join the remedial class and they could leave it when they had attained a certain level of competence in mathematics. Every remedial class had only eight to ten students, who were taught by other Mathematics teachers. This seemed to be a good practice for these students as they received other types of teaching to help them learn the subject, perhaps in different ways.

### 8.2.2 The practices of individual teachers

#### 8.2.2.1 *The need for a good learning environment*

Over the last 30 years, a number of research projects have been conducted on the classroom learning environment, among which the Harvard Project Physics (Welch and Walberg, 1972) in the USA and studies by Fraser (1981, 1986) in Australia are particularly noteworthy. Interest in studying learning environments became more prominent when evidence was found that learning outcomes and student attitudes to learning were closely linked to the classroom environment. The importance of the classroom environment for learning was also indicated in the International Studies in

Educational Achievement (IEA) (Anderson, Ryan and Shapiro, 1989).

After observing the six teachers' lessons, it was found that all of them put a considerable emphasis on lecturing and procedural learning aimed at examinations. Also, in most cases, the teachers were not close to the students as they were not the form teachers of the classes they taught – of the twelve classes studied, only Classes Da(b,l) and Fe(b,m) were taught by the class master teacher. The relationship between the form teachers and the students was closer as they took care of them through the whole school year, whereas subject teachers had difficulties in establishing a positive learning environment for students as this required a considerable time, especially with students of different ability levels. In fact, even the form teachers found it challenging to establish good relationships with students. Of the six teachers (see Chapter 6, sections 6.8.2 and 6.8.3), only *Teacher F* created a learning environment for her classes in which students could feel free to answer and question. The other teachers seemed to have only a limited knowledge of their students and their abilities – they did not know each student's name. During the second interview, when I asked each teacher to describe a student who had really impressed them during the teaching year, only three teachers (*Teachers D*, *E* and *F*) could mention a name and give details about the students, which indicated that the form teachers knew more about the students in their classes.

#### 8.2.2.2 *Collaborative group work*

From my observations, it was clear that most teachers did not want to use group work as they did not believe that students could learn from each other with this approach; and they were also afraid that grouping them in this way would cause discipline problems. However, it is important to note that these teachers had not had enough practical training (as shown in the Table 5.1) on how to teach through group work. In cases where group work was adopted – by *Teachers A* and *C* – it was not very effective. Students were just told to discuss an issue with their classmates, but they did not know how to do this successfully as the teachers did not give them guidance. Some students found collaborative work difficult and could not help each other during discussion; and, while others enjoyed talking to each other, they did not focus on the task and felt free to do anything during group work. However, based on the theory of radical constructivism (see Chapter 4), students can enhance their learning through collaborating with each other in groups. Social processes play an important role in learning as they support an individual's cognitive activity.

#### 8.2.2.3 *Good use of class workbooks* (*Teacher D*) or worksheets (*Teachers A* and *B*)

Letting students note the important learning content or work in class workbooks or worksheets is a good method for engaging lower-ability students and those who find it difficult to concentrate as this reduces the chances of their being off-task. When *Teachers A*, *B* and *D* used this approach, the students seemed very involved in learning – at least they were following the teacher's instruction and recording this in their class workbooks/worksheets. This technique also allowed the teachers to identify easily students who were off-task.

#### 8.2.2.4 *Giving a short quiz during a lesson to get feedback on pupils' understanding* (*Teacher F*)

Asking students to do a paper-and-pencil quiz was an efficient method for finding out more about student's prior knowledge, especially just before the teacher introduced a new topic. In the lessons observed where this approach was used, the teachers also used a quiz to further elaborate on the key concepts of congruent triangles which were closely related to the new topic. *Teacher F* asked students which questions they found difficult to answer and told them how to work them out right away. Although she could not mark the quiz at that time, she got a clear picture of which concepts students still found confusing, and she clarified them promptly and effectively.

### 8.2.3 Pedagogical awareness

#### 8.2.3.1 *Using different teaching approaches with classes of different ability (with variation theory)* (*Teacher D)*

Although all six teachers taught two classes, only *Teacher D* planned different teaching material for the classes as the students were of very different ability levels. Although it is sensible for a teacher to reflect on the best approach for a specific class before starting a lesson, the other teachers thought they could tune their teaching focus or procedure to cater for students during the classroom interactions. In addition, in my view, these teachers did not display a good sense of pedagogical awareness – they did not recognize the variations in students' knowledge and understanding of the topic being learned. For the topic of 'Similar triangles', the obstacles that hinder student learning are the properties of similarity, including the equal angles and the proportional relationship of the lengths of corresponding sides. Learning about congruent triangles just before the topic of similar triangles would be likely to confuse students when dealing with the property of corresponding angles being equal. It was also found that most of the teachers assumed that students had learned the concept of ratio in primary school and already knew how to match the corresponding sides of similar triangles, but in fact the students did not know or had forgotten what they had learned about ratio. As an observer in the classroom, I could read what students wrote on their worksheets or exercise books, and could see that they were stuck on the issue of ratio. I also found that the teachers were not aware that some students were confused in identifying the corresponding sides correctly.

*Teacher D* asked her Class 1CD about the concept of ratio and found that she had to teach the whole concept again Fortunately, she had prepared for student diversity and helped them to understand this critical issue through her teaching, and she extended it by also teaching this class how to calculate the cross-multiplication of fractions when finding the unknown length of sides by using a ratio which was not a whole number. However, for Class 1A, *Teacher D* just told students directly the simple meaning of ratio by using only whole numbers and they grasped the meaning easily from multiplying the whole number of the shorter length and getting the longer length. This variation in the teaching focus helped to cater for students of different ability levels. Also, in teaching students how to calculate the length of sides by using the ratio, she used the fraction ratio for the high-ability students and the whole number ratio for those of low ability. In my opinion, this kind of pedagogical awareness cannot be developed in teachers by simply attending a seminar on the topic.

**8.2.3.2** ***Use of teaching aids*** (*Teacher F* – dolls and overhead projector; *Teacher C* – real-life objects, concrete triangles and overhead projector; and *Teacher A* – concrete triangles and overhead projector)

For these twelve-year-old students, the use of model figures is highly recommended as a way of motivating them. For example, real-life objects should be used to introduce the abstract concept of similarity. Most of the teachers introduced the concept of ‘similar’ first using real-life examples, and then narrowed it down to triangles. It was found to be useful to let students manipulate two concrete triangles to explore their features of similarity. Even less able students could measure the angles of two triangles and the lengths of each side and, by comparing them, could find that those similar triangles had corresponding angles which were equal. It was also easy for them to compare the lengths of sides if the teacher made a one-to-two (1:2) ratio of the lengths. In this way, students could understand the basic idea of similar triangles.

#### 8.2.3.3 *Tailoring the exercises for students of different levels* (*Teacher F*)

*Teacher F* told all the students about the level of difficulty of the textbook problems, which she separated into three levels: the basic problems that all students should know how to work out; and the middle- and high-level problems that would help them to get higher marks. However, the high-level problems were very challenging. She encouraged lower-ability students by praising their good work on the fundamental questions and she also suggested they should work on the middle-level problems to increase their confidence in handling more than just the basic ones. The higher-ability students tried to figure out the most challenging problems automatically without being asked to do so by the teacher.

#### 8.2.3.4 *Students presenting answers on the blackboard* (*Teachers A*, *B*, *E* and *F)*

Four of the six teachers let students come out to the blackboard to show their work to the class and then checked the solutions together with the other students. These teachers – *Teacher*s *A*, *B*, *E* and *F* – considered students' presentation of their methods of working to be very valuable as it offered them a good opportunity to give quality feedback to those who presented their work on the blackboard. This was felt to be useful for the other students also, as they could learn from this practice for when they had to present their solutions. In addition, these teachers asked the lower-ability students who could not work out the solution to copy down the correct version and learn from it.

## 8.3 Implications for teachers, advisors and policy makers (research sub-question 5)

The level of academic segregation between schools in Hong Kong still remains high, despite the reform of the Secondary School Places Allocation System (SSPA) – specifically, the reduction of the allocation bands from five to three for secondary schools. Improving teacher-student ratios, reallocating lesson time for conducting action research such as lesson studies and peer learning, and providing training are useful measures for catering for individual learning differences. Reflecting on the good practices shown in the previous section, the implications for teachers, advisors and policy makers are outlined below.

### 8.3.1 Implications for teachers

Reflecting on good practices in classroom management and discipline, as well as pedagogical awareness, the six secondary teachers in this study were clearly trying to help students but more needs to be done to improve their methods for catering for individual differences. This includes taking the initiative to acquire more knowledge about this area to enhance their normal teaching skills. As regards classroom management and discipline, my recommendations are outlined below.

#### 8.3.1.1 *Creating a good learning environment for students and asking questions*

As noted earlier, students' approaches to learning have been found to have a close relationship with the classroom environment (Hattie and Watkins, 1988). It has also been shown (Fraser and Fisher, 1983a, 1983b; Rentoul and Fraser, 1980) that cognitive outcomes can be predicted by congruence with students' preferred learning environment; that is, students tend to achieve better in a learning environment closer to that they prefer. If students are not enjoying lessons, they will not engage in learning; and if they have no questions to ask or do not want to answer a teacher's questions, teachers do not know how they perceive the learning material. Teachers' knowledge can clearly be enhanced through the good practice of teacher-student interaction, including efforts to grasp the students' level of understanding of mathematics through observation and communication.

#### 8.3.1.2 *Good use of collaborative group work*

In general, in the six teachers' lessons, Mathematics was taught at a uniform pace and level, and whole-class teaching predominated, with only two classes showing evidence of separate group work. Discussion with the teachers on the pedagogical approaches they employed indicated that they experienced several challenges in teaching mixed-ability classes. For example, because of the wide range of students' mathematical skills, they found it difficult to control the teaching and learning climate. However, cooperative learning is a well-established methodology which has been demonstrated to be successful for handling student diversity in a mixed-ability class. Collaborative work can help to achieve the desired educational outcomes, and in the process students develop a greater understanding and respect for individual differences. This approach embraces all forms of diversity within the learning environment (Felder and Brent, 2001; Freeman, 1993) and small-group work makes it easier to monitor student mastery of educational concepts, and accommodate individual learning needs (McMillion, 1994); and it also facilitates remediation and direct instruction.

#### 8.3.1.3 *Good questioning techniques*

Good questions, effectively delivered, can promote student learning and thinking as they serve to motivate and focus their attention and provide opportunities for practice – and they allow teachers to assess how well students are mastering content (Dillon, 1988). However, in general, these basic conceptions about questioning did not appear to be well understood by the six teachers. In Chapter 6, it was found that most teachers (*Teachers A*, *B*, *C* and *F*) used questions to simply draw students' attention to themselves. *Teachers C* and *D*, who had a better understanding of the individual students in their classes, showed their concern for some less able students by letting them answer questions in order to encourage them. Only *Teacher F* checked students' pace of learning by asking questions of different levels which were appropriate for promoting students' thinking and getting them to participate successfully in discussion. In *Teacher F*'s case, the learning atmosphere in the whole class was so good that students appeared to feel comfortable in giving their opinions. She also invited more students to contribute their ideas when a student raised a problem. The interactions between this teacher and her students, and between the students, were of high quality, which gave her a clear picture of how the students were proceeding in their learning. The learning atmosphere in the other teachers' classes was much less good, with students being unwilling to answer questions – and this tended to lead the teachers to lower the level of the questions or answer them themselves. Overall, these teachers were unable to find out the students' learning situation by questioning, and had to assess students by other means, such as seatwork.

Table 7.4 in Chapter 7 showed that the teachers involved in this study asked higher-level questions. However, the waiting- time after the questions was not long enough for students to think thoroughly about the answers. The overall impression of these six teachers was that they required students to respond almost instantaneously to questions, and if no students raised their hands to answer, they answered the question themselves. Teacher *B* frequently named a student to answer a question before posing it, but naming a student after asking a question would make it more likely that all the students would attend to the question and prepare a covert response in preparation for being called upon to answer (Gall, 1984; Ornstein, 1988).

Questioning is a core function of both learning and teaching. Questions can stimulate students to think at higher cognitive levels (Dillon, 1988); and when they are afforded opportunities to do so, they can demonstrate an ability to analyse, synthesize and evaluate, and also score better on tests measuring recall and understanding of content (Redfield and Rousseau, 1981).

Regarding waiting-time, if teachers wait for three to five seconds after the initial response, students may be able to: answer more completely and correctly; exhibit more speculative and inferential thinking; ask more questions; increase interactions with other students; and demonstrate more confidence in their responses (Garigliano, 1972; Gooding, Swift and Swift, 1983; Rowe, 1974). Also, teachers may redirect questions to the whole class again when no one responds, so that the whole class feels more of a responsibility to answer and, hence, the interaction among and between students increases (Ornstein, 1988; Riley, 1981). Last but not least, it was found that the teachers liked to ask students to repeat their answers again to the whole class, which indirectly encourages students not to pay attention to the student who is answering the question. On the other hand, if the teacher never repeats a student's answer, other students may be more likely to listen carefully to their classmate's answer.

#### 8.3.1.4 *Good use of seatwork time to help each student by giving instant, high-quality feedback on how to improve his/her learning*

While the quality of the six teachers' feedback was not investigated in this research, it was clear that their feedback during seatwork was not as good as it could have been. Feedback should identify what has been done well and what still needs to be improved, and should give specific guidance on how to make such improvements.

Giving instant and high-quality feedback to students during both whole-class interactions and during seatwork can enhance student learning. Hattie (2002), in his presentation at the New Zealand Principal's Federation Conference in June 2002 claimed:

> If there is one systematic thing that we can do in schools that makes a difference to kids' learning, it's this notion of feedback. It is the most significant thing we can do that singularly changes achievement.

Teacher's feedback should involve a discussion about the next steps in a student's learning. Hill and Hawk (2000, p. 7) simply said that feedback should be 'directly related to and should build on the feedback that has been given'. In teaching Mathematics, more feedback is needed on the nature and quality of the mathematical thinking and less on task completion and behaviour.

In the feedback process, there are clear expectations about student learning and performance, an explanation of the specific criteria for judging the students' achievement, steps to improve performance and a shared understanding of 'quality'. Feedback can be effective if it empowers students with strategically useful information. It might inherently be about helping students to learn more effectively, rather than just getting them to do specific problems more successfully. In order to help them in giving feedback to each of their students, teachers can train students to check each other's work immediately after they complete it, a practice which is beneficial for both teachers and students as the learning outcomes are stated explicitly. Whenever students require help in problem solutions, teachers could make them aware of the success criteria, so that students bear these in mind and use the same standard when checking others' work. Of course, it will take a considerable time to train students to do this effectively and some students may 'correct' others' work wrongly, so it is better for teachers to collect the work to double-check students' marking and identify any errors.

#### 8.3.1.5 *Understanding students' learning needs*

There are a range of methods for checking the progress of students of varied ability levels, such as using paper-and-pencil or computerized short quizzes at the beginning of a lesson or asking different levels of questions. In addition, collecting information from students need not just be through questioning. For instance, as mentioned earlier, to ensure that all the students are concentrating on learning, teachers can ask them to write down the answers to questions in their class workbooks and then check the answers, which prevents the weaker students from 'hiding' information about their progress. Whole-class discussions may also be viewed as learning activities with both content and process-related goals and teachers can adjust the content and process of student learning when interacting with their students during a lesson. Students should collaborate and share their thinking in order to learn with understanding, and teachers need to provide opportunities for them to work together on meaningful problems and share their views in a safe and supportive environment. Once the teacher has identified student progress through discussion, he/she can then differentiate the learning goals by step-wise instruction. Differentiated instruction provides options related to the process, product and content utilized for learning (Tomlinson, 1999). This practice allows all students equal access to the curriculum while maintaining high expectations for them. Differentiated instruction requires teachers to respond to the individual needs of all learners within the regular education environment (Kulik and Kulik, 1992).

**8.3.1.6** ***Using different teaching approaches for classes of different ability***

From the findings, in the main, the teachers did not appear to know how to vary their teaching to help students understand the intended topic, and they also lacked knowledge of how to present the content of 'Similar triangles' in a variety of ways. They did not focus on students' common misconceptions of 'ratio' or 'corresponding sides' by analysing students' work and helping them to clarify their misconceptions. Representing concepts in a variety of ways provides a vehicle for all students to grasp them and make connections to previous learning. As argued by various writers (e.g. Bidell and Fischer, 1992; Dufour-Janvier, Bednarz and Belanger, 1987), teachers' use of multiple representations can supply a rich repertoire of access points for accommodating the different ways students have been found to learn, provided that such representations are already familiar to students. Multiple representations for certain concepts have been linked with greater flexibility in student thinking (Ohlsson, 1987, cited in Leinhardt et al. 1991).

**8.3.1.7** ***Tailoring exercise for students of different levels***

Teaching should not be directed only by textbooks or taken as the school curriculum. There is no need to cover all the contents in textbooks but, in general, the teachers observed had a fixed mindset – to finish the entire textbook content regardless of the ability of the students. They considered it their responsibility to do so as all the students, whatever their abilities, had to sit the same examination paper, which included all the textbook content. Since the curriculum is examination-driven and modern Chinese parents place a great emphasis on their children's achievement (Ho, 1986), it may be difficult for teachers to skip some elements in the textbook. However, if they can classify the teaching content into core and non-core aspects according to the teaching objectives and ability level of students, then students can learn the appropriate content successfully. Core learning aspects require in-depth studies and application, whereas the non-core or advanced learning aspects may be streamlined or selected for teaching. While asking teachers to use their own judgement, the Education Bureau can help by making suggestions on what should be included in the core and non-core parts of the curriculum.

#### 8.3.1.8 *Obstacles for teachers*

Since all the methods suggested above are not new to teachers, they should not be afraid of change. They are encouraged to enhance their skills by more lesson observations or collaboration meetings with other teachers. One of the main challenges for teachers is to change their mindsets to believe that all students can learn, though in different ways and at different rates. Teachers could allow some students to progress at a slower pace and treat every student as an individual, no longer viewing the whole class as a single unit; and they could also have high expectations for individual students by monitoring their progress carefully. In general, teachers could link their teaching more closely with students' learning, and so it is better for them to keep checking the status of student learning by adopting on-going assessment, perhaps by letting students work alone or in groups on a computer program. In addition, as noted before, teachers could train students to assess each other by giving them information on what is expected. Being fully aware of the progress of individual students enables the teacher to make appropriate decisions on how to proceed to help them learn. Overall, teachers need to let the rate of student progress, rather than any limits adopted in advance, determine how far the class can proceed; and they could also provide individual assistance where it is necessary, and challenge and stimulate students rather than protecting them from failure or embarrassment.

Another major challenge for teachers is to keep an open mind. They could try to set aside their original professional experiences and allow other professionals from external agencies, such as the Education Bureau or a university, to join their teaching collaboration meetings. The Education Bureau offers various kinds of support services, such as the School Based Curriculum Development (Secondary) which helps schools with the professional development of teachers; and it can create educational committees to improve a school's curriculum design to cater for students' individual differences or just to improve the teaching-learning process for subject teachers. Schools can apply for the different kinds of support once a year and, if the request is approved, the service is normally maintained for three years. Lastly, during such support, teachers are required to collect their students' work to illustrate the progress made. By analysing this work, those providing the support and the teachers involved can find out more about the quality of teaching and try to reflect on their own practices.

### 8.3.2 Implications for advisors

Some good practices related to teacher professional development and pedagogical awareness, including the use of technology, are discussed here as having implications for advisors. In addition, for good practice, it is necessary to discuss school management, holistic school practices and remedial programmes. I believe advisors could improve the situation by using their authority. However, before moving to detailed discussion, it should be noted that this study has the limitation that the researcher has never met any of the six schools' advisors. Therefore, the implications for the six schools are just discussed at a general level.

#### 8.3.2.1 *Teacher professional development*

Advisors should be clear about the purposes of the Curriculum Guide's initiatives as they apply to all schools and students. At the same time, schools and teachers need to reflect on their own situation in adopting the initiatives to enhance their teaching and learning. Advisors and the administrators, namely the school principals, could encourage teachers to continue to develop teaching and technology-based skills. When there is a need for secondary school teachers to attend courses on any new initiatives, they could be allowed to do so. It is recommended that teachers be asked frequently if they feel the need to attend any courses (e.g. on catering for individual differences). This feedback must be considered seriously by the Education Bureau; and the administrators also need to be open-minded on teachers' suggestions and act accordingly. However, most teachers in this study lacked any interest in joining in-service training as they viewed the training seminars are not practical and useful enough for their daily work. It is suggested that a follow-up session – consisting perhaps of a meeting or a written report – could be offered after the training to explore the circumstances in which teachers could try out the suggestions. Stigler and Hiebert (1997) also focused on the need for teachers to have the time to plan effective lessons collaboratively. Also, in order to enhance teacher professional development, school advisors could encourage teachers to hold collaboration meetings once a month for every subject they teach, at which they could exchange their teaching experiences. Allowing teachers to share their questions, struggles and emerging findings fosters the development of a learning community, an essential ingredient in any kind of lasting reform.

#### 8.3.2.2 *The use of technology*

The Curriculum Guide claims that using technology to cater for student diversity is a powerful method. However, in this study, only *Teacher B* used a computer to teach during the lessons, and even then it only involved showing a page of an e-book. In addition, *Teacher A* used an overhead projector and *Teacher* C a visualizer to show how to compare the models of similar triangles. According to various authors (e.g. Bransford, et al, 1996; Schoenfeld, 1982, 1992; Silver, 1987), empowering teachers through the use of technology in mathematics exploration, open-ended problem solving, interpreting mathematics, developing conceptual understandings and communicating about mathematics is at the heart of professional development and teacher education. Advisors appear convinced that knowledge of computer technology is essential if individual students are to be prepared well to face the challenges of the borderless world. It is undeniable that computers have become a potent tool and offer exciting approaches to cater for students' learning needs. For example, when teaching the topic of similar triangles, teachers can show the whole process of comparison clearly and easily by using computers; and students can capture the main properties by visualizing the comparison procedure. In addition, the computer can be used together with models to let students get a concrete impression of similarity. Students can be impressed by the computer program even if they have no chance to manipulate the triangle models. However, the teacher may let slower learners try out the program at home by providing the website address, thus giving them an opportunity to learn about the properties individually by manipulating the whole procedure themselves.

If such technology is used extensively, and in a proper manner, it could lead to a radical improvement in education. School administrators must lead the way in encouraging teachers and students to familiarize themselves with technological developments. Software and hardware could be updated frequently and a resource bank with different levels of resources and programs for each topic could be produced. When necessary, teachers are able to call on technicians to support them when using programs in their teaching.

#### 8.3.2.3 *A good setting system*

School advisors could consider adopting a strategic and flexible setting system to help student learning. Most schools use an all-year system in which students are separated according to their overall results, but this policy can have a serious harmful effect on the attitudes to learning of some students for a whole year. A better practice is to separate students based on their subject scores and let them try their best to meet certain attainable targets. If they are allocated to a less able class and have to stay there until the next year, they are labelled as weak in learning. Moveable group setting gives students a chance to overcome their difficulties and make more progress and flexible grouping can also be a positive learning strategy if it is not overused. While there is not complete consensus on this issue, there is some evidence that homogeneous grouping by skill level can be effective for instruction in the areas of mathematics and reading (Marzano, Pickering and Pollack, 2001). Three key features of flexible grouping are that it should be used sparingly, student progress should be monitored closely, and continual remixing of assigned groups should be allowed, thus letting students move between smaller homogenous skill-based groups and larger heterogeneous groups for creative and problem-solving activities. Flexible grouping by student skills and across-age grouping allow students performing at various levels to share their combined areas of knowledge and strength (Marzano, Pickering and Pollock, 2001). If utilized effectively and in a sensitive manner, the method of flexible grouping does not have to carry a negative stigma for the learner (Tieso, 2003).

However, for mathematics instruction, within-class ability grouping has been shown to be effective only for mathematics computations, with no differences found in concept attainment and application. On analysing within-class ability grouping, Slavin (1987, p. 336) suggested the following:

1 Students should be assigned to heterogeneous classes for most of the day and be regrouped by ability only in subjects where there is a benefit to instructional pacing, material selection, and content organization.

2 Grouping plans should be based on subject specific criteria, not general IQ or standardized test scores.

3 Grouping plans should be flexible and allow student movement between groups.

4 Teachers should vary the level of material, pace, and content of instruction to correspond to students' levels of readiness, learning rate, and interest.

5 Groups should be kept small and should be regrouped often to meet instructional goals.

On the other hand, some school advisors like to assign young and inexperienced teachers to teach less able classes and let expert teachers teach the high-ability classes as they think expert teachers can enhance the performance of high-ability students. Actually, school advisors could encourage expert teachers to help less able students to clarify their misconceptions and improve their learning step-by-step, thus enhancing their confidence in making progress. Students with high attainment are easily motivated by any teachers who could recommend they explore extending their knowledge in different topics. Also, such students would like to carry out self-learning without any limitations from teachers.

#### 8.3.2.4 *A school-based Mathematics curriculum*

The idea of encouraging school-based curriculum development reflects calls for more active and direct school autonomy and participation in educational innovation. Curriculum modification is a procedure for removing repetitive, unnecessary and unchallenging content, and/or enhancing existing curricular materials with higher-level questioning, critical thinking components, independent thinking, transferring skills and insights into new contexts (e.g. Halpern, 1996). A centrally planned curriculum does not consider the specific characteristics of different schools. School advisors could encourage their teachers to design their own curriculum to help student learning and, especially for the less able students, it could be designed somewhat differently, to offer what is most suitable for them. A scaffolding approach should be utilized to match the curriculum with the student's learning needs. Opportunities must also be provided for both guided and independent practice related to student learning activities and high expectations should be maintained for all learning tasks (Tomlinson, 1999). Judgements about the appropriate content for students of different ability could be considered by teachers, using their experience and pedagogical knowledge. Advisors could allow teachers enough space and support to use a trial-and-error approach in developing their own school-based curriculum. With support from the Education Bureau, teachers can consult specialists from, for example, the School based Support Service (Secondary) whenever they need help.

#### 8.3.2.5 *After-school remedial programmes which involve different teachers*

School advisors could emphasize that the purpose of a remedial programme is to improve the basic mathematics skills of students who fail to master the required minimum objectives for a certain topic. Students could be screened for their mathematical ability on a test or examination and, based on the result; they could be assigned to a remedial programme for weekly instruction in Mathematics. Once their mathematical weaknesses have been diagnosed, individualized teaching needs to be implemented for each student in the programme. Students may be moved in or out of the programme according to their performance, with teachers keeping a close watch on students' progress for this purpose. Teachers might benefit from using remedial programmes – a modest illustration was provided in section 8.2.1.3, where Teacher *F*'s success with an after-school remedial programme was discussed. However, since this kind of after-school remedial programme puts considerable pressure on teachers, school advisors need to check with them how effective it is and, when students begin to meet the basic requirements, they could decrease the scale of the programme.

### 8.3.3 Implications for policy makers

The main implication of this study for policy makers is that they need to take practical issues into consideration when planning any educational change. As the success of any educational change depends to a large extent on the reactions of classroom teachers, teacher development should be a central focus (Wedell, 2009). Overall, the findings of this research centre on teachers' need for continuing professional growth and their active participation in the curriculum change process.

One of the recommendations of the current research is that teachers' needs and voices must be considered seriously when educational policies are introduced. It is important to learn more about their practical needs, rather than just providing theoretical seminars which are not down-to-earth and are difficult for them to implement. As regards the issue of catering for student diversity, this study indicates that teachers are using their own methods to try to solve this problem, but the approaches they employ are not of a high enough quality to help students – and policy makers should therefore build on the teachers' experiences to enhance their abilities.

This project reports the reality of how the methods suggested in the Curriculum Guide for catering for individual differences were implemented inside the classroom. In general, the teachers involved:

- attempted to check students' prior knowledge, but only a small number of students were involved;

- asked questions at different levels, but did not know about the students' learning progress;

- chose content which most likely followed the textbook;
- were unable to vary the focus to help student learning; and
- could not identify what was hindering students in working out problems during seatwork.

Teachers need practical ideas and professional support on the pedagogical issues that arise. On the whole, policy makers should not only change curriculum materials and syllabuses but also support the professional development of school Mathematics teachers in a practical way.

The discrepancies between the recommendations and the findings on dealing with individual differences suggest that policy makers have not taken enough account of the teachers' actual classroom practice. In addition, the learning environment which teachers need to establish for students to demonstrate their learning should also be considered. Policy makers could commit to ensuring that, wherever possible, policies are developed on the basis of publicly available research evidence, and encompass clear and independent evaluation strategies. Such a policy-level commitment could feed through to practice, where more evidence-based decision-making could be encouraged where appropriate. It is also recommended, therefore, that communication channels are established among teachers, school advisors, educational authorities and curriculum policy makers, not only in the form of official documents – which, as been found here, can easily be ignored by teachers – but also through collaborative development. Furthermore, policy makers could encourage the revision of the textbooks and Teachers' Guides in order to keep up with changes in the curriculum. Since teachers often follow the textbook in their teaching, it would be very helpful if the materials have tailored learning content or exercises at different levels.

## 8.4 Reflections on the effectiveness of educational initiatives

At this stage, let us step back and consider the problems associated with the new initiative on catering for individual differences among those studied in this research. There are certain conditions in secondary schools which make innovative approaches to teaching and learning more difficult to introduce. The most crucial ones appear to be:

- large class sizes;

- inappropriate setting for students;
- the poor motivation of some teachers who underestimate their role in students' learning progress and have low expectations for their students; and
- an inflexible, centralized curriculum aimed at examinations.

Also, there are pedagogical problems related to:

- lack of appropriate in-service training or support for professional development;
- lack of knowledge and skills in terms of content, methods of teaching and the development of teaching aids;
- teachers being unable to manage large classes due to poor skills in classroom organization or management; and
- teachers' heavy workload.

Finally, problems related to new curriculum initiatives include:

- new curricula being introduced which are not yet ready to be used effectively in practice;
- teachers not being consulted about curriculum development;
- overcrowded curricula with too much content to cover; and
- textbooks and Teachers' Guides which do not keep up with changes in the curriculum and technology.

The current study did not aim to provide explicit support on implementation but the six teachers perceived some beneficial side-effects of my providing a point of contact. While I was particularly careful to avoid contaminating the interview data, I was willing to give occasional advice after the whole of the lesson observations, for example about language usage in mathematics, information on how other schools were tackling the same individual difference problems or suggestions on the informants' own further academic studies. The six teachers also commented that the experience of observation was beneficial to them in terms of either developing confidence in being observed or in providing a challenge for further improvement.
Such positive implications for teachers' involvement in research are corroborated by Morris, Lo and Adamson (2000), who found that:

> Those teachers that worked in close collaboration with university researchers and other professionals tended to exhibit more professional development and growth. This is probably because such teachers receive feedback on and endorsement of their work, which helped them to raise their professional consciousness and in turn helped them to improve their analytical awareness (p. 12).

Although the support described above is less focused and specific than coaching and support strategies, I believe it had some positive effects on the teachers.

## 8.5 Implications for cultural appropriateness

How culturally appropriate is the notion of catering for individual differences in the Hong Kong context? In the traditional Hong Kong classroom, handling individual learner differences has not been emphasized. As noted in Chapter 2, Cheng and Wong (1996) stated that 'Individualised teaching, where teachers work towards diverse targets at different paces, is almost inconceivable in East Asian societies' (p. 44). Teachers are used to teaching whole classes, not individual students; and all the teachers in this research thought it was very difficult to cater for individual students.

However, there is some evidence of Chinese cultural traditions which support individualization in teaching and learning. For example, the highly influential philosopher and scholar, Confucius, adjusted his teaching methods according to the individual capacities and personalities of his students (Chen, 1993). Also, although there are potential cultural barriers to catering for individual learner differences, none of the six teachers in the study viewed this as culturally inappropriate, even when questioned closely on the subject. Their reservations about handling individual differences were confined to the difficulties of individualized learning when faced with large class sizes, and limited time and resources. The teachers thought they could help individual students with low test scores or poor homework only during the lunch break or after school. However, this kind of help is not practical because of their heavy workload.

## 8.6 Summary

In order to help teachers cater for students' individual differences successfully during lessons, it is recommended that policy makers, school advisors and teachers introduce certain changes. For example, policy makers could visit classrooms to look at the practical issues frontline teachers face daily and consult them when designing new initiatives. Also, school advisors could establish a whole-school approach to face the problem of dealing with individual differences, such as a good setting system to allow students to move to different levels during the term. They also need to tailor the Curriculum Guide to fit students of different levels and help teachers by grouping remedial classes after school. Finally, teachers also need to enhance their professional knowledge in the working context. It is clear that the achievement of instructional outcomes is enhanced when teachers: know the prior skills students do/do not have; personalize goal-setting; and get feedback on individual students' performance and progress toward specific standards or classroom objectives. Also, they could: establish a safe learning environment to encourage students' talk; try to ask questions at different levels to check student progress; use more group work to let students construct knowledge through social communication; and, finally, vary their teaching methods in accordance with students' needs. Given that changing teachers' classroom practice is notoriously difficult and classrooms are extremely complex environments, it is acknowledged that achieving these changes will not be easy – it would be understandable that teachers might try to change, but in vain. As Feiman-Nemser and Loden (1986, p. 516) argued:

> … Those who criticise teachers for maintaining this 'practicality ethic' may underestimate the added complications that flow from attempts to alter established practice and the degree to which current practices are highly adaptive to classroom realities.

# CHAPTER 9
# CONCLUSION

## 9.1 Scope of the chapter

This chapter outlines the significance of the study, and examines its main strengths and limitations. Next, several suggestions are made for further research. Finally, there are some concluding comments on the project as a whole.

## 9.2 Significance of the study

The main significance of the study lies in its contribution to three areas, viz.

- The general variation of teaching
- Insights into constructive learning and perspectives on catering for individual learner differences
- Discussion of the implications for teachers, advisors and policy makers.

By focusing on both the recommendations of the Curriculum Guide (CDC, 2002) and the teachers' practice in the classroom, the study meets Fullan's (1999) suggestion that theories of change and theories of education need to be harnessed together. In other words, the study has something to say about both the management of change related to the Curriculum Guide and also innovation in the classroom with respect to catering for individual learner differences.

### 9.2.1 Contribution to the general variation of teaching

As regards the theory and practice of classroom teaching, the study contains both descriptive and analytic data on the teaching and learning process. It has extended knowledge about how teachers are catering for students' individual differences in their actual practice of Mathematics teaching. General variations are measured by way of codes to capture different areas of classroom teaching, this dimension offers a new way of looking at lessons together with qualitative observations. Combining the qualitative observations of the video record with these codes gives a more in-depth understanding of how teachers cater for student diversity.

### 9.2.2 Insights into constructive learning and perspectives on catering for individual learner differences

An understanding of how individual learner differences are handled in relation to implementing the curriculum guidance emerged from the classroom observations and the interview data. These data provided a number of insights into the teaching and learning of Mathematics in the Hong Kong secondary classroom, with reference to the Curriculum Guide and its principal features and how this practice relates to the principal features of the Curriculum Guide. Some good practices of classroom implementation were identified and discussed in Chapter 8 (section 8.2). In Chapter 6, the methods which the six teachers involved were actually using to cater for individual learner differences in their normal practice were analysed, although the strategies were found not to be very effective. The next section discusses the implications of the teaching approach which was observed.

### 9.2.3 Discussion of the implications for teachers, advisors and policy makers

As indicated in Chapter 8 (section 8.3), school advisors and policy makers need to take more account of teachers' professional development during educational reform, so that schools can build on the past when attempting further improvement. This research also provides empirical data for exploring the factors which facilitate and inhibit the management of the new initiatives for handling student diversity (see Chapter 6, section 6.4). In this case, the data support the centrality of teacher-related factors in the management of change.

After the cross-case analysis, it appeared that teachers, advisors and policy makers should pay more attention to the following five issues derived from the data.

1 *Concern about students' prior knowledge*: The teachers found it difficult to get enough information from all the students. This is an area where advisors might work with frontline teachers to identify effective strategies, and these teachers could be involved in disseminating the approaches via in-service courses.

2 *Teachers' questioning skills to identify students' learning progress promptly*: It seems that this issue is related to teachers' beliefs. The teachers were very familiar with asking questions in their lessons, but they were only used to check what students understood, not to identify what they misunderstood. This situation may be remedied by creating a cooperative learning circle among Mathematics teachers working at the same level. By observing others' lessons and learning

from each other, they could modify their own practices. Advisors and policy makers should give teachers more space and time to facilitate professional dialogue and promote a learning community inside a school or between schools.

3 *Creating appropriate content*: Developing suitable content from different textbooks to form a school-based curriculum usually raises difficulties between teachers, advisors and policy makers. Apart from the issue of teachers' workload, it involves deciding how to deal with students' parents and textbook developers; and it also relates to cross-school curriculum consistency. Policy makers should give schools more freedom to construct their own school-based curricula, but then monitor closely the quality of the content, so that parents can be assured that the curriculum aligns with that of other schools.

4 *Varying the focus to help students learn*: As with issue (2) above, this is concerned with the teachers' teaching skills, as the data suggests that they are unable to vary the focus to promote students' learning. Their pedagogical awareness did not appear to be sensitive enough when it came to dealing with individual students. The training they had received for catering for every student was not effective in the real classroom situations which teachers face day-by-day. Middle management in schools could identify capable teachers and encourage them to demonstrate or introduce effective strategies to their colleagues; and sometimes, it may be possible to arrange for them to co-teach with other teachers, which would have the potential for enhancing very significantly every teacher's teaching quality.

5 *Seatwork time*: The teachers considered that they were able to cater for individual students during this time, but it was noted that they were unable to identify what was hindering students in working out problems during seatwork. The reasons for this might relate to the tight curriculum, too many students experiencing problems with the work and the short seatwork time. The teachers just wanted to make sure every student was engaged in the seatwork and was working properly. They found it impossible to check carefully how students worked on the problems and why they could not solve them correctly. Advisors and policy makers should place more emphasis on assessment before the end of lessons and perhaps provide teachers more training on how to assess an individual students level of understanding as they circulate during seatwork time.

## 9.3 Strengths of the study

### 9.3.1 Classroom observation

With respect to classroom observation, I highlighted the limited research on the classroom implementation of innovations. However the current study provides data on how an innovation was actually carried out in the classroom. A further positive aspect of the research is that classes were observed during the course of a week and across different periods of time, which reduces the possibility of observing one-off lessons which may be different from the teachers' normal practice. And the longitudinal aspect enhances the validity of the study. One of the challenges presented by the classroom observation was that it generated a large amount of data which had to be reduced and summarized. For example, the need for selectivity in the choice of lessons for transcription was an issue for the internal validity of the study. One of the strengths of the classroom observation schedule was that it permitted the collection of both quantitative and qualitative data. Also, the schedule proved to be practical and user-friendly for the purpose for which it was designed.

### 9.3.2 Multiple case study research

As discussed in Chapter 4 (section 4.3.3) a multiple case study approach was used in order to facilitate an in-depth analysis of a small sample of teachers. As an alternative, a larger number of cases could have been studied, but this would have necessitated some sacrifice in the depth of data collection: analysing additional cases would have required a reduction in the number of lessons observed which may not have been desirable. In fact, the sequence of five or six lesson observations served mainly to confirm the findings, which supports the argument that it is reasonable to make recommendations on the basis of this research. This confirmation function is in itself particularly useful for the validation of findings. It also relates to the longitudinal aspects of the study, which are worth reviewing. The main data collection for the study was concentrated over a period of twenty months within two academic years, which enabled me to see one topic being tackled by the teachers at different times in the school year.

### 9.3.3 Quantitative and qualitative data

As noted above, this research sought to use both quantitative and qualitative data to provide a full, complementary and triangulated picture of the implementation of curriculum guidance in the case study classes. In practice, this generated a mass of classroom data which could be analysed quantitatively, qualitatively or through a mixture of both methods. Within the word limit for a doctoral thesis, it was not possible to report all the data that were collected. During the course of writing this thesis, I became more convinced of the trustworthiness of the qualitative data with the support of the quantitative data, and hence the eventual emphasis was on the qualitative aspects.

## 9.4 Limitations of the study

While this research has strengths, it also has several limitations, viz.

- First, due to limited finance and time, a total of sixty-one lessons conducted by six teachers from different schools in Hong Kong were studied; and only twelve videotaped lessons were coded for further investigation. The six teachers in this study are clearly not representative of Hong Kong teachers, despite the effort put into selecting the sample. However, as the teachers involved were more likely than the average teacher to be aware of the Curriculum Guide, this suggests that the findings on problems in implementing the guide's recommendations are likely to be widespread. Also, as pointed out in Chapter 4, it is up to the readers to assess whether the results are applicable in their settings. Moreover, the slight disparity in terms of the sample lessons, including the teachers' and school backgrounds (see Chapter 5), should be taken into account when interpreting the differences between these teachers. However, the intention of this study was to provide a more thorough understanding of what really happened in some Mathematics classrooms in Hong Kong.

- Second, the one-year time-gap between the data collection from some teachers could have distorted the comparability of the data. However, no major reforms were introduced during the period of data collection; and so the comparability of the data is still acceptable as a reflection of the usual situation in Hong Kong.

- Third, my experience and theoretical perspective could have affected the objectivity of analysis and interpretation in the current work since all the lessons were observed by the researcher and involved some teachers who were friends or ex-students; and, in some cases, I had a limited amount of contact with these teachers outside the context of the study. However, I was very aware of the need to avoid influencing the teachers' teaching in any way. Also, on the positive side, my knowledge of these teachers gave me a more sensitive understanding of them and their teaching rationale. As regards the other schools' teachers, the researcher was an outsider and is unlikely to have influenced the participants before videotaping the lessons. To reduce any disparity in understanding the classroom teaching in those schools, I discussed the findings with many experts, such as officers from the Education Bureau of the Hong Kong SAR.

The study focused explicitly on the teacher perspective and actual practice in catering for students' individual differences. The students are, of course, the other crucial element but the effect of the curriculum guidance on them was not a primary focus of the study and, therefore, has not been discussed in any detail (see also below).

## 9.5 Suggestions for further research

Finally, I would like to outline some issues which arise from the current study (or were not its central focus) and so point the way for further research. In the light of the present research, the following research questions require further investigation:

1 The optimum strategies for improving the ways in which teachers handle individual differences and their effects on learners' attitudes and academic progress

2 To explore students' perceptions of different strategies aimed at catering for individual differences

3 The strategies adopted by primary school teachers for handling individual differences.

It is hoped that the following outcomes may be achieved as a result of research and intervention in these areas:

1 The formation of self-supporting groups of teachers and trainers working collaboratively, with the capacity to adapt and develop curricula, within the framework of educational policy, which focus on catering for individual differences

2 The creation and adoption by schools and training organizations of strategies which support and enable the process of handling student diversity

3 The production of readily adaptable, sustainable resources on innovative methods and materials for training, teaching and learning, which are shared and disseminated through networks of teachers.

## 9.6 Conclusion

The results of this study suggest that there are problems with the management of new initiatives imposed by policy makers, as frontline teachers do not fully understand the rationale for the changes and how to implement them. I am sure educational reforms never work successfully when teachers do not understand them, care about them or have no commitment to them. Sudden, even small changes, without prior and parallel attention to building relationships of trust and collaboration in teachers' and students' cultures are unlikely to succeed. Therefore, before the delivery of curriculum change, such as giving recommendations on catering for students' individual differences, it would be sensible for the frontline teachers to be consulted. Also, it would be helpful if policy makers would consider the methods used in other parts of the world for handling student diversity and work more closely with teachers to carry out the recommendations in the classroom. Professional learning grounded in experience and action, not just planning and talk, is much more likely to lead to the effective implementation of change.

Also, the problem of dealing with students' individual differences should be dealt with at the level of the whole school system rather than just the classroom. But if we need better structures to care for students and to support teachers, improving them by administrative mandate is, in my view, not the best way to go about it. As mentioned in the previous chapter, schools advisors should consider the holistic school plans for students of different ability by designing a school-based setting system with a typical 'go in, go out' policy, a flexible curriculum design and after-school remedial programmes to cater for students' needs. The establishment of a professional learning community as a means to renew both teachers and schools is a common recommendation in the professional development literature (Grant, 1996; Guskey, 1995; Little, 1993). Collaborative work cultures create and sustain trust, risk-taking, openness, opportunities to learn, a shared language and common experiences that make educational changes less abstract and less threatening to teachers. Successful classroom change requires strong collaboration and support from teachers who can share knowledge and ideas. And more flexible classroom practices need more flexible structures to accommodate them; otherwise, I guess that even the most committed teacher who tries to be innovative, lesson after lesson, and class after class, will become depressed at shouldering the burden of change by him/herself.

Every teacher in the research group was able to implement approaches which could be described as 'catering for students' individual differences'. However, despite the superficial similarity in the teaching approaches and the apparent consensus on how to face the new initiative in the Curriculum Guide, the quality of the ways in which they catered for student diversity varied considerably. From the summary in Chapter 6, it was concluded that the teachers (1) attempted to check students' prior knowledge but only a small number of students were involved; (2) asked questions at different levels, but did not know about the students' learning progress; (3) chose content which was most likely to follow the textbook; (4) were unable to vary the focus to help students to learn; and (5) could not identify what was hindering students in working out problems during seatwork.

This was found to depend on: the learning atmosphere; the opportunities created for student responses; variations in the scaffolding used; and the degree of students' motivation for learning, and the extent to which their articulated thoughts influenced the classroom processes. It is strongly recommended that teachers open their minds to contacts outside the classroom to refresh their teaching repertoire, and try some new methods which are related to the theories discussed in this study. Then teachers might reflect on their daily practice to improve their teaching, especially in the area of catering for students' individual differences.

## Appendix 1 Catering for Learner Differences (Mathematics Syllabus, 1999)

The curriculum is structured with the Foundation Part identified to facilitate teachers to tailor the curriculum for their students' learning needs. Teachers could focus on teaching the Foundation Part of the whole syllabus so as to provide appropriate quantities and a variety of activities for students to conceptualize, construct knowledge and communicate mathematically. For more able students, activities on enrichment topics could also be provided to broaden students' horizon of mathematical knowledge and enhance their interest in mathematics.

Teachers are advised to give due considerations to various aspects such as grouping students of similar ability together, teaching/learning activities, resources and assessment. Teachers find teaching in mixed ability classes harder than teaching in classes where students are relatively close in ability. However, there can be a negative impact on the self-image of those students placed in lower streams. No matter how the students are organized, it is inevitable that students in a class will differ in abilities, needs and interests. Teachers need to use selectively whole class teaching, group work and individual teaching as appropriate to the task in hand.

In daily classroom teaching, teachers could cater for learner differences by providing students with different tasks or activities graded according to the levels of difficulty, so that students work on tasks or exercises that match their stages of progress in learning. For less able students, tasks should be relatively simple and fundamental in nature. For abler students, tasks assigned should be challenging enough to cultivate as well as to sustain their interest in learning. Alternatively, teachers could also provide students with the same task or exercise, but vary the amount and style of support they give, i.e. giving more clues, breaking the more complicated problems into several parts for weaker students.

The use of IT could also provide another solution for teachers to cater for learner differences. Different levels of exercises or activities are always included in the educational software packages. Teachers could make use of these software packages for students with different abilities to work through at their own pace and at their levels of ability. The facilities to record students' performance in these software packages could also provide information for teachers to diagnose students' misconceptions or general weaknesses so as to re-adjust the teaching pace or re-consider the teaching strategies.

# Appendix 2: Sample letters

## Appendix 2a Letter to the Principal

Address

Dear XXX,

**Videotaping classroom lessons**

Thank you very much for agreeing to allow your school to be involved in my PhD research and also for allowing me to videotape your teacher Miss XXX 's F.1 Mathematics classes. To clarify what is involved, I would like to administer questionnaires to the teacher and students before and after the series of lessons. In addition to the video data, I wish to have access to materials such as lesson plans, worksheets and textbook content. If possible, I would like to interview the teacher and the selected students as soon as possible after lessons.

Since the research involves collecting a range of data from your school, this letter sets out some guidelines that I will follow when videotaping in the classroom to comply with advice from the Office of the Privacy Commissioner for Personal Data.

1. The videos are for my PhD research purpose only, so I would show them *only* to people who are directly involved in the assessment process.
2. The class teacher Miss XXX is recommended to inform his pupils beforehand about the videotaping and its purpose. A formal letter will be provided in due course for your reference.
3. If any pupil does not want to appear in the recording, may I suggest:
   a. seating them in an area of the classroom not covered by the camera;
   b. not asking them to answer questions or carry out any activities;

   If they appear in the recording I will undertake to delete this section of videotape.

   If you agree, the teacher may even consider exempting them from the lessons to be videotaped.
4. I will erase the contents of the videos as well as other data that are related to the school after completion of the research.

If you have any queries or problems concerning such privacy issues, do not hesitate to contact me at 2768 XXXX or via e-mail XXXX

Best wishes,

Ellen L C Tseng (Ms)
PhD student in University of East Anglia
12-03-04

**Appendix 2b Letter for teachers**

Address

Dear Miss XXX,

**Videotaping classroom lessons**

Thank you very much for being willing to be involved as a teacher for my PhD research and for agreeing to allow me to videotape your classes. To clarify what is involved, I would like to administer questionnaires for the teacher and students before and after the series of lessons. In addition to the video data, I wish to have access to materials such as lesson plans, worksheets and textbook content. If possible, I would like to interview the teacher and the selected students as soon as possible after each lesson. The details of how to select students for the interview will be discussed in the due course.

Since the research involves collecting a range of data from you and your students, this letter sets out some guidelines that I will follow when videotaping in the classroom to comply with advice from the Office of the Privacy Commissioner for Personal Data.

1 The videos are for my PhD research purpose only, so I would show them *only* to people who are directly involved in the assessment process.

2 You are recommended to inform your pupils beforehand about the videotaping and its purpose. A formal letter will be provided in due course.

3 If any of your pupils do not want to appear in the recording, may I suggest:
   a seating them in an area of the classroom not covered by the camera;
   b not asking them to answer questions or carry out any activities;

   If they appear in the recording I will undertake to delete this section of videotape.

   If the principal agrees, you may even consider exempting them from the lessons to be videotaped.

4 I would erase the contents of the videos as well as other data that are related to you and your class after completion of the research.

If you have any queries problems concerning such privacy issues, do not hesitate to contact me at 2768 XXXX or via e-mail XXXX

Best wishes,

Ellen L C Tseng (Ms)
PhD student in University of East Anglia
12-03-04

## Appendix 3 Observation rubric for Mathematics lesson

**A Diagnosis of students' needs and differences**

The extent to which the teacher demonstrates gathering background information on students, including their interests, and their strong and weak areas.

**B Variation in levels of difficulty and content covered**

The extent to which the teacher demonstrates that the teaching materials are specially selected, adapted or designed to suit the range of students' abilities

B1: for less able students, tasks are relatively simple and fundamental in nature
B2: for more able students, tasks are challenging enough to cultivate their interest in learning.

**C Variation in questioning techniques**

C 1: low-level question
C 2: high-level question

**D Variation in approaches in introducing concepts**

D 1: concrete examples for less able students
D 2: symbolic language for able students

**E Variation in peer learning**

E1: Whole-class teaching
E2: Grouping students
E3: Individual student

**F Variation in the use of computer packages**

# Appendix 4 School teachers' questionnaire record

## Appendix 4a Summary of the results of the teachers' first questionnaire

Teacher questionnaire record

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither agree nor disagree | Agree | Strongly Agree |

| **Questions responded to before lessons were videotaped** | **A** | **B** | **C** | **D** | **E** | **F** |
|---|---|---|---|---|---|---|
| 1 If I could choose again, I would still want to be a Mathematics teacher. | 4 | 5 | 2 | 5 | 5 | 5 |
| 2 Teaching Mathematics is interesting. | 4 | 5 | 4 | 4 | 2 | 5 |
| 3 Teaching Mathematics is difficult. | 3 | 3 | 4 | 2 | 1 | 4 |
| 4 Teaching Mathematics is rewarding. | 4 | 3 | 3 | 4 | 4 | 4 |
| 5 Teaching Mathematics is time-consuming. | 3 | 3 | 4 | 2 | 1 | 4 |
| 6 Students appreciate my teaching. | 4 | 3 | 3 | 4 | 4 | 4 |
| 7 Students' parents appreciate my work. | 4 | 3 | 3 | 3 | 3 | 4 |
| 8 My school head appreciates my teaching. | 4 | 3 | 4 | 4 | 3 | 4 |
| 9 I feel good in teaching Mathematics. | 4 | 4 | 4 | 4 | 4 | 5 |
| 10 I feel tired in teaching Mathematics. | 2 | 2 | 4 | 1 | 2 | 2 |
| 11 I believe students need silence to understand and work. | 5 | 4 | 4 | 4 | 4 | 4 |
| 12 I believe students need to talk to develop mathematical language and understanding. | 4 | 3 | 5 | 3 | 2 | 4 |
| 13 I believe students need instant feedback when they come across difficulties. | 3 | 4 | 5 | 4 | 5 | 4 |
| 14 I believe students need time to think about the problems. | 5 | 4 | 5 | 4 | 5 | 4 |
| 15 I believe students need clear problem statements. | 5 | 5 | 5 | 5 | 5 | 3 |
| 16 I believe students can define, refine and develop problem statements. | 3 | 3 | 1 | 2 | 2 | 3 |
| 17 I believe it is better to show students how to solve problems. | 3 | 4 | 5 | 3 | 4 | 3 |
| 18 I believe students can figure out problem solutions on their own. | 4 | 3 | 1 | 2 | 4 | 4 |
| 19 I believe students need clear single answers for the problems. | 4 | 2 | 4 | 4 | 2 | 2 |
| 20 I believe students need experience with problems which have multiple answers or for which there may be no clear answer at all. | 5 | 3 | 4 | 5 | 4 | 4 |
| 21 I believe student learning can happen in leaps or chunks of understanding – and those leaps may come from solving problems. | 4 | 3 | 4 | 4 | 4 | 3 |
| 22 I believe students need drill to learn new ideas introduced in a lesson. | 5 | 4 | 4 | 4 | 2 | 4 |
| 23 I believe students need to see the whole concept and its relationships. | 4 | 4 | 4 | 3 | 2 | 4 |
| 24 I believe students need to be guided to learn and understand the concept. | 4 | 4 | 4 | 5 | 4 | 4 |
| 25 I believe students need to be given a broad programme to explore the concept. | 3 | 4 | 4 | 4 | 2 | 4 |
| 26 I believe students want to solve problems by different ways. | 1 | 3 | 4 | 2 | 4 | 4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 27 I believe students need to master basic concepts to do more creative or thoughtful work. | 4 | 4 | 4 | 3 | 5 | 4 |
| 28 I believe students need to be given chances to create and think in all parts of mathematics. | 3 | 4 | 4 | 4 | 5 | 4 |
| 29 I believe it is better to separate slower students from more advanced students while teaching. | 4 | 3 | 5 | 5 | 5 | 5 |
| 30 I believe teachers have to know all the answers. | 2 | 5 | 4 | 4 | 1 | 2 |
| 31 I believe teachers and students often benefit from exploring together. | 4 | 4 | 4 | 5 | 5 | 4 |
| 32 I believe class discussions should be well planned beforehand with answers, results or decisions. | 4 | 3 | 4 | 3 | 4 | 4 |
| 33 I believe students learn a lot during the discussion itself. | 4 | 2 | 3 | 4 | 2 | 4 |
| 34 I believe parents are essential for providing positive motivation to help students in learning. | 4 | 4 | 5 | 3 | 5 | 4 |
| 35 I believe many students underrate their mathematics achievement. | 3 | 4 | 4 | 3 | 2 | 4 |

## Appendix 4b Summary of the results of the teachers' second questionnaire

| **Questions responded to after lessons were videotaped** | **A** | **B** | **C** | **D** | **E** | **F** |
|---|---|---|---|---|---|---|
| 1 I know students' prerequisites very well. | 4 | 3 | 2 | 4 | 5 | 4 |
| 2 I recognize students' individual needs, potentials and strengths. | 4 | 3 | 3 | 5 | 4 | 4 |
| 3 I know where to get the teaching resources. | 4 | 4 | 4 | 4 | 5 | 4 |
| 4 I prepare my lessons well. | 4 | 3 | 3 | 4 | 4 | 4 |
| 5 I always stick closely to the textbook when teaching. | 4 | 3 | 3 | 3 | 2 | 2 |
| 6 I like to use worksheets to help students to learn. | 5 | 3 | 3 | 4 | 2 | 3 |
| 7 I like to give lecture to the whole class. | 3 | 3 | 4 | 4 | 5 | 4 |
| 8 I like to have group activities or competitions. | 3 | 2 | 4 | 2 | 1 | 3 |
| 9 I like to use teaching aids to teach. | 4 | 3 | 4 | 4 | 4 | 4 |
| 10 I like to use computers to teach. | 2 | 4 | 3 | 2 | 1 | 3 |
| 11 I like to pose challenging questions, open-ended questions. | 4 | 4 | 3 | 4 | 4 | 4 |
| 12 I encourage free association of thoughts. | 4 | 3 | 4 | 4 | 3 | 4 |
| 13 I encourage active participation and discussion. | 3 | 3 | 4 | 4 | 4 | 4 |
| 14 I allow trial and error, mistakes. | 4 | 4 | 4 | 5 | 4 | 4 |
| 15 I encourage pupils to talk and ask questions. | 5 | 3 | 5 | 5 | 4 | 4 |
| 16 I encourage independent learning and thinking. | 4 | 3 | 5 | 5 | 3 | 4 |
| 17 I introduce debates, projects and presentations. | 3 | 3 | 3 | 3 | 1 | 4 |
| 18 I use most of the time to demonstrate how to solve textbook problems. | 3 | 3 | 3 | 4 | 5 | 2 |
| 19 I use most of the time to let students solve problems independently. | 3 | 3 | 3 | 4 | 4 | 2 |
| 20 I use most of the time to solve problems related to real life. | 3 | 3 | 3 | 3 | 1 | 4 |
| 21 When solving problems, I focus on the procedures. | 4 | 4 | 4 | 4 | 5 | 3 |
| 22 When solving problems, I focus on the relevant concept. | 5 | 4 | 4 | 4 | 5 | 4 |
| 23 I give students sufficient time to think and answer the question or solve the problem. | 4 | 3 | 3 | 4 | 5 | 4 |
| 24 I establish good rapport with students. | 3 | 4 | 4 | 4 | 5 | 4 |
| 25 I encourage learning beyond syllabi and textbooks. | 3 | 3 | 4 | 3 | 3 | 3 |
| 26 Students and I have frequent interaction during the lesson. | 4 | 3 | 3 | 4 | 2 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 27 Students always ask me questions when they do not understand. | 4 | 3 | 3 | 4 | 2 | 4 |
| 28 I let students present their solutions on the blackboard. | 5 | 3 | 3 | 5 | 2 | 4 |
| 29 I use a variety of assessment modes to assess students. | 3 | 3 | 3 | 4 | 2 | 3 |
| 30 I facilitate immediate self- and peer evaluation. | 3 | 3 | 3 | 3 | 2 | 4 |
| 31 I accept different approaches to a problem. | 5 | 4 | 5 | 4 | 4 | 4 |
| 32 I encourage brainstorming, problem solving. | 3 | 3 | 5 | 4 | 2 | 2 |
| 33 I encourage logical, analytical thinking. | 4 | 4 | 5 | 4 | 4 | 4 |
| 34 I infuse thinking strategies and skills into learning. | 4 | 4 | 3 | 4 | 4 | 4 |
| 35 I empower students with responsibility and leadership. | 3 | 3 | 4 | 4 | 3 | 4 |
| 36. I always check whether students understand the concept or not by asking them questions. | 4 | 4 | 4 | 4 | 5 | 4 |
| 37 Most students can answer my questions correctly. | 4 | 3 | 3 | 4 | 4 | 3 |
| 38 I give different levels of questions for students of different abilities | 4 | 3 | 4 | 5 | 5 | 3 |
| 39 After the lesson, I can tell what students learned. | 5 | 4 | 4 | 4 | 4 | 4 |
| 40 I set learning standards, and evaluate learning outcomes. | 4 | 4 | 4 | 4 | 4 | 4 |
| 41 For every lesson, I assign homework to students. | 4 | 3 | 3 | 4 | 2 | 4 |
| 42 I drill students by using textbook exercises. | 4 | 3 | 4 | 4 | 5 | 4 |
| 43 Most students hand in their homework without any difficulty. | 3 | 2 | 2 | 3 | 2 | 3 |
| 44 I am always firm and consistent. | 4 | 3 | 3 | 5 | 4 | 4 |
| 45 I always try to be imaginative and creative. | 3 | 3 | 4 | 5 | 4 | 4 |

## Appendix 5 Questionnaire for ALL students after the lesson videotaping

(to find out about the learning atmosphere and their teachers' teaching characteristics)

Dear Students,

Thank you very much for being involved in my PhD Research and for being willing to complete this questionnaire. Please fill in all the data. I will delete the contents of the questionnaire that related to you after the completion of the research.

Personal data: Please indicate √ in the appropriate box ☐.

1 Student Name: ______________ Class: __________

2 Sex: Male ☐ Female ☐

3 Do you like learning Mathematics? Yes ☐ No ☐

4 What result level you get in Mathematics? Good ☐ Average ☐ Poor ☐

According to your own situation, circle the most appropriate number.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Strongly Disagree | Disagree | Agree | Strongly Agree |

***Learning atmosphere***

| | | | | |
|---|---|---|---|---|
| 1 I appreciate my teacher's teaching. | 1 | 2 | 3 | 4 |
| 2 I learned a lot from my Mathematics teacher. | 1 | 2 | 3 | 4 |
| 3 My teacher is firm and consistent. | 1 | 2 | 3 | 4 |
| 4 My teacher is friendly and helpful. | 1 | 2 | 3 | 4 |
| 5 I like to answer my teacher's questions. | 1 | 2 | 3 | 4 |
| 6 I like to raise questions when I do not understand. | 1 | 2 | 3 | 4 |

***Students and teacher interaction***

| | | | | |
|---|---|---|---|---|
| 7 I can get instant feedback from the teacher when I come across difficulties. | 1 | 2 | 3 | 4 |
| 8 My teacher and my classmates have frequent interaction during the lesson by questioning and answering. | 1 | 2 | 3 | 4 |
| 9 My classmates have frequent interaction in discussing problems during the lesson. | 1 | 2 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| 10 My teacher uses a variety of methods to check whether or not we understand the mathematics content. | 1 | 2 | 3 | 4 |
| 11 My teacher facilitates us to evaluate each other right after the teaching. | 1 | 2 | 3 | 4 |
| 12 My teacher always checks whether we understand the concept or not by asking us questions. | 1 | 2 | 3 | 4 |
| 13 All my classmates are always able to answer questions from the teacher. | 1 | 2 | 3 | 4 |

***Lesson planning***

| | | | | |
|---|---|---|---|---|
| 14 My teacher always reminds us of work we did in the previous lesson. | 1 | 2 | 3 | 4 |
| 15 My teacher knows where to get suitable teaching materials for us. | 1 | 2 | 3 | 4 |
| 16 My teacher prepares lessons well. | 1 | 2 | 3 | 4 |
| 17 My teacher always sticks closely to the textbook when teaching. | 1 | 2 | 3 | 4 |
| 18 My teacher likes to design his/her own worksheets to help us to learn. | 1 | 2 | 3 | 4 |

***Teacher's teaching styles***

| | | | | |
|---|---|---|---|---|
| 19 My teacher likes to give a lecture to the whole class. | 1 | 2 | 3 | 4 |
| 20 My teacher likes to have group activities or competitions. | 1 | 2 | 3 | 4 |
| 21 My teacher likes to pose challenging questions which are different from the textbook problems. | 1 | 2 | 3 | 4 |
| 22 My teacher introduces debates, project work and presentations. | 1 | 2 | 3 | 4 |
| 23 My teacher uses the majority of the lesson time to demonstrate how to solve textbook problems. | 1 | 2 | 3 | 4 |
| 24 My teacher uses the majority of the lesson time to let us solve problems independently. | 1 | 2 | 3 | 4 |
| 25 My teacher uses the majority of the lesson time to solve problems related to our real lives. | 1 | 2 | 3 | 4 |
| 26 My teacher encourages active participation and discussion. | 1 | 2 | 3 | 4 |
| 27 My teacher allows trial- and-error, mistakes. | 1 | 2 | 3 | 4 |
| 28 My teacher encourages independent learning and thinking. | 1 | 2 | 3 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| 29 | When solving problems, my teacher will pinpoint the procedures. | 1 | 2 | 3 | 4 |
| 30 | When solving problems, my teacher will pinpoint explaining the relevant concepts. | 1 | 2 | 3 | 4 |
| 31 | My teacher encourages learning beyond the syllabus and textbook. | 1 | 2 | 3 | 4 |
| 32 | My teacher accepts us using different approaches to a problem. | 1 | 2 | 3 | 4 |

## Appendix 6 Students' focus group interview questions

1 Please tell me whether you like Mathematics or not and why. Does that relate to your teacher?

2 Please tell me the level of your Mathematics results. Does that relate to your teachers' teaching methods?

3 How could you learn Mathematics better? When do you understand a new concept during a lesson?

4 How does your Mathematics teacher teach normally during a lesson? Any small group discussion experience?

5 You study Mathematics lessons in a half class. Do you prefer whole-class teaching? Why? (for small-class students only)

6 With which ability level of students would you like to study in the class?

7 How does the teacher teach so that you can understand most? Why?

8 Do you like small-group discussion? Do you think you can learn Mathematics through small-group discussion?

9 Do you think you can really learn Mathematics by following your teacher on how to work out all the textbook problems? Why/why not?

10 If your teacher raises a difficult problem, do you think you will try to solve it by yourself or discuss the problem with your classmates in a small group?

11 Have you ever tried to solve an open-ended problem? If so, did you like it?

12 If your teacher gives you a very difficult open-ended problem, how will you deal with it? Which way you do prefer to learn through this problem: think by yourself, small-group discussion or let the teacher explain to the class?

13 Have you tried to raise your hand to ask a question? Do you think you learn more from interaction with teacher directly?

14 When you will you raise up your hand to ask questions? How frequently do you ask questions?

15 Have you ever had the experience of you could not understanding anything from the teacher's lecture? If so, what you will do then?

# Appendix 7 Interview questions for teachers before and after videotaping

## Appendix 7A Interview questions for teachers before videotaping

### *Teaching atmosphere during the lesson*

- How would you describe your Mathematics lessons?
- What kind of teaching atmosphere do the Mathematics lessons appear to have? Why?
- Do you like to ask students questions? What levels of questions do you ask students most often? Why?
- Do students ask you any questions during the lessons? If not, why not?

### *Lesson planning*

- How do you plan your Mathematics lessons? Do you:
    - consider students' learning prerequisites?
    - consider students' individual differences?
    - consider what motivates students' learning?
    - set different levels of learning outcomes?
    - choose different levels of activities and problems?
    - use various assessment methods to assess students?
    - prepare different kinds of teaching aids?
    - design suitable worksheets for students, etc?

### *Teacher's perceptions of students' individual differences*

- How well do you know your students?
- Do you know the whole class's ability level? How many students are in higher level / middle level / lower level?
- Do you know individual students' ability levels? (Pick a student name and ask the teacher what the ability level of the student is.)
- Do any students need special help in learning Mathematics? Why? How do you handle these students during the class / after class?
- Do any students ignore your teaching during a lesson? Why? How do you handle these students during the class / after class?
- What sort of activities motivate most of the students in learning?
- What levels of questions do you ask most? Why?
- What criteria do you have in your mind when choosing students to answer your questions?
- How do you handle the situation when no one answers your questions?

- Who do you prefer for answering your questions?
- What kind of teaching is preferred by most of the students?
- When and where does most of students' learning happen?
- During seatwork, who needs your private tutoring most? Why?
- How can you assess students of different levels during a lesson?

***Teacher's teaching characteristics and style***

- How would you describe your teaching style or characteristics in a lesson?
- Why do you divide your lessons? For example do you use most time to:
    - motivate students in learning
    - give a lecture to explain the main concept
    - demonstrate how to solve problems
    - let students sit quietly and do exercises
    - check students' solutions.

**Appendix 7B  Interview questions for teachers after videotaping**

This interview will be held after the series of videotaped lessons. The main purpose of the interview is to find more information about the teacher by showing the videotaped data of the actual performance during the lessons. So the interview questions would not be fixed and will vary with different teachers.

This instrument mainly comprises four parts: the teaching atmosphere during the lesson, the lesson planning, their perception of students' individual differences and the teacher's teaching characteristics and style.

With the videotaped records, teachers were asked why they teach in the following ways. *[Ask teacher generally about why they teach in that way and use some of the following questions as prompts if needed.]*

**1 *Why do you teach problem-solving in those ways?***

- Where do you choose problems for your students from? (from real life that you create by yourself or from the textbook)
- What type of problems do you choose or design for your students? (closed-ended problems which are commonly found in textbooks or open-ended problems which you create by yourself to challenge students)
- How do you choose problems for your students? (e.g. according to students' ability levels and separate problems into levels)
- When do you pose a problem? (e.g. at the beginning of the lesson in order to motivate students; during the lecture time when explaining the concept; for the activities; for the group work; during a demonstration or before the seatwork)

- When solving a problem, why do you solve the problem with the students in these ways? (e.g. step-by-step following a clear, unique way to guide students by asking them questions; letting students take risks to explore different approaches to solve the problem without any guidance)
- How do you handle individual differences when solving a problem with the whole class?
- During seatwork time, can you foresee the learning difficulties among students of different levels and give them appropriate instruction? Any videotape record which could show this?
- After solving a problem, how can you make sure your students learned from it? How do you assess your students?
- What are the aims of giving students time to work on an exercise or homework assignment? (practice, consolidation or drilling the techniques)

***Teaching atmosphere during the lesson***

- How would you describe your Mathematics lessons?
- What kind of teaching atmosphere do the Mathematics lessons appear to have? Why?
- Do you like to ask students questions? What levels of questions do you ask students most often? Why?
- Do students ask you any questions during the lessons? If not, why not?

***Lesson planning***

- How do you plan your Mathematics lessons?
- What factors do you consider when planning a mathematics lesson?
  *[Don't give these prompts initially to see what they come up with on their own – then ask about any they don't raise themselves.]*
- Do you:
  - consider students' learning prerequisites?
  - consider students' individual differences?
  - consider what motivates students' learning?
  - set different levels of learning outcomes?
  - choose different levels of activities and problems?
  - use various assessment methods to assess students?
  - prepare different kinds of teaching aids?
  - design suitable worksheets for students, etc?

***Teacher's perceptions of students' individual differences***

- How well do you know your students? *[Find out what they suggest by themselves – use the list as a prompt for any they don't identify]*

- Do you know the whole class's ability level? How many students are in higher level / middle level / lower level?
- Do you know individual students' ability levels? (Pick a student name and ask the teacher what the ability level of the student is.)
- Do any students need special help in learning Mathematics? Why? How do you handle these students during the class / after class?
- Do any students ignore your teaching during a lesson? Why? How do you handle these students during the class / after class?
- What sort of activities motivate most of the students in learning?
- What levels of questions do you ask most? Why?
- What criteria do you have in your mind when choosing students to answer your questions?
- How do you handle the situation when no one answers your questions?
- Who do you prefer for answering your questions?
- What kind of teaching is preferred by most of the students?
- When and where does most of students' learning happen?
- During seatwork, who needs your private tutoring most? Why?
- How can you assess students of different levels during a lesson?

***Teacher's teaching characteristics and style***

- How would you describe your teaching style or characteristics in a lesson?
- Describe how you structure you lessons? *[Again see what they say without any prompts – give examples below only if needed.]*
  (e.g. using the majority of the time to:
  - motivate students in learning
  - give a lecture to explain the main concept
  - demonstrate how to solve problems
  - let students sit quietly and do exercises
  - check students' solutions.

**With the videotaped records of schools with other bandings, teachers were asked how they would teach in those schools.**

If you were the teacher in a school with this banding, what would you do to:

- prepare the lesson? (select problems, activities, worksheets, teaching aids)
- create a good learning atmosphere?
- motivate the students?
- interact with the students?
- teach the Mathematics content? (select the topics, problems, notes)

- ask questions?
- cater for individual differences?
- assess students after teaching?

## Appendix 8 Comparison between the old and new codes

| Old codes | New codes |
|---|---|
| **A. Diagnosis of students' needs and differences:**<br>A1: self-designed test<br>A2: observation of students' performance in class<br>A3: written assignment in class | **A. Diagnosis of students' needs and differences** |
| **B. Variation in levels of difficulty and contents covered:**<br>B1: suitable tasks to stimulate students' learning<br>B2: suitable tasks to sustain students' learning<br>B3: simple tasks for less able students<br>B4: challenging tasks for more able students | **B. Variation in levels of difficulties and contents covered:**<br>B1: simple tasks for less able students<br>B2: challenging tasks for more able students |
| **C. Variation in questioning techniques**<br>C1: Drilling question<br>C2: Recitation type questioning<br>C3: level of questions<br>C3a: low-level question<br>C3b: high-level question | **C. Variation in questioning techniques**<br>C1: low-level question<br>C2: high-level questioning |
| **D. Variation in approaches in introducing concepts**<br>D1: concrete examples for less able students<br>D2: symbolic language for able students | **D. Variation in approaches in introducing concepts**<br>D1: concrete examples for less able students<br>D2: symbolic language for able students |
| **E. Variation in peer learning**<br>E1: Whole class teaching<br>E2: Grouping students<br>E3: Individual student | **E. Variation in peer learning**<br>E1: Whole class teaching<br>E2: Grouping students<br>E3: Individual student |
| **F. Variation in using computer packages** | **/** |

## References

Adelman, C., Jenkins, D. and Kemmis, K., 1980. Rethinking case study: notes from the second Cambridge conference. In: H. Simons, ed. *Towards a science of the singular*. Centre for Applied Research in Education: University of East Anglia. pp. 45-61.

Anderson, L. W., Ryan, D. W. and Shapiro, B. J. eds., 1989. *The IEA classroom environment study*. Oxford: Pergamon Press.

Andrews, P. and Hatch, G., 1999a. A new look at secondary teachers' conceptions of mathematics and its teaching. *British Educational Research Journal*, 25(3), pp. 203-223.

Arthur, M., Gordon, C. and Butterfield, N., 2003. *Classroom management*. Melbourne: Thomson-Nelson.

Atkinson, P. and Hammersley, M., 1994. Ethnography and participant observation. In: N. Z. Denzin and Y. S. Lincoln, eds. *Handbook of qualitative research*. Thousand Oaks: Sage Publications. pp. 248-61.

Aydin, E. and Tugal, I., 2005. On the influence of grouping practices on classroom Teaching. University of South Carolina. Available at: <http://www.usca.edu/essays/vol142005/aydin.pdf> [Accessed 3 July 2007].

Bales, R. F., 1950. *Interaction process analysis: a method for the study of small groups*. Cambridge, MA: Harvard University Press.

Ball, D. L., 1990 The mathematical understandings that prospective teachers bring to teacher education. *The Elementary School Journal*, 90(4), pp. 449-66.

Banbrook, L. and Skehan, P., 1989. Classroom and display questions. In: C. Brumfit and R. Mitchell, eds. *ELT documents: 133 research in the language classroom*, pp. 141-52.

Bauersfeld, H., 1986. Warum interaktionsanalysen in didaktischer forschung und lehrerfortbildung? In: H. Bauersfeld, J. Voigt and W. Münzinger, eds. *Habt Ihr das immer noch nicht kapiert? – Fachspezifische Interaktionsanalysen für Schule und Unterricht*. Kassel: Hessisches Institut für Lehrerfortbildung. pp. 10-19.

Bauersfeld, H., 1992. Integrating theories for mathematics education. *For the Learning of Mathematics*, 12(2), pp. 19-28.

Bauersfeld, H., 1995. Theoretical perspective on interaction in the mathematics classroom. In: R. Biehler, R. W. Scholz, R. Sträβer and B. Winkelmann, eds. *Didactics of mathematics as a scientific discipline*. Dordrecht: Kluwer Academic Publishers. pp. 133-46.

Beaton, A. E., Mullis, I. V. S., Martin, M. O. Gonzalez, E. J., Kelly, D. L. and Smith, T. A., 1996. *Mathematics achievement in the middle school years: IEA's Third International Mathematics and Science Study.* Chestnut Hill, MA: Boston College.

Beswick, K., 2007. Teachers' beliefs that matter in secondary mathematics classroom. *Educational Studies in Mathematics*, 65(1), pp. 95-120.

Biggs, J. B., 1994. What are effective schools? Lessons from East and West (the Radford Memorial Lecture). *Australian Educational Researcher*, 21, pp. 19-39.

Biggs, J., 1996a. Academic development in Confucian heritage culture. In: *International symposium on child development*, Hong Kong.

Biggs, J., 1996b. Western mis-perceptions of the Confucian-heritage learning culture. In: D. Watkins and J. Biggs (eds.). *Teaching the Chinese learner: psychological and pedagogical perspectives*. Hong Kong: Comparative Education Research Centre, University of Hong Kong. pp. 3–23.

Boaler, J., 1997. *Experiencing school mathematics: teaching styles, sex and setting*. Buckingham: Open University Press.

Boaler, J., 2008. Promoting 'relational equity' and high mathematics achievement through an innovative mixed ability approach. *British Educational Research Journal*, 34(2), pp. 167-94.

Boaler, J., Wiliam, D. and Brown, M., 2000. Students' experiences of ability grouping disaffection, polarisation and the construction of failure. *British Educational Research Journal*, 26(5), pp. 631-48.

Board of Education, 1997. *Report of review of compulsory education*, Hong Kong: Government Printer.

Bogdan, R. C. and Biklen, S. K., 1998. *Qualitative research for education: an introduction to theory and methods*. 3rd ed. Boston: Allyn and Bacon.

Bowden, J. A. and Marton, F., 1998. *The university of learning*. London: Kogan Page.

Brannen, J. ed., 1992. *Mixing methods: qualitative and quantitative research*. Aldershot: Avebury.

Bransford, J. D., Zech, L., Schwartz, D., Barron, B., Vye, N. and The Cognition and Technology Group at Vanderbilt, 1996. Fostering mathematical thinking in middle school students: lessons from research. In: R. J. Sternberg and T. Ben-Zeev, eds. *The nature of mathematical thinking*. Mahwah, NJ: Lawrence Erlbaum Associates. pp. 203-50.

Brickhouse, N. W., 1993. Evolving conceptions of ethical practice in interpretative research. *International conference on interpretative research in science education*. National Taiwan University.

Brophy, J. E., 1983. Research on the self-fulfilling prophecy and teacher expectations. *Journal of Educational Psychology*, 75(5), pp. 631-61.

Brophy, J. and Good, T., 1973. *Looking in classrooms*. New York: Harper and Row.

Bryman, A., 1988. *Quantity and quality in social research*. London: Unwin Hyman.

Bryman. A., 1992. Quantitative and qualitative research: further reflections on their Integration. In: J. Brannen, ed. *Mixing methods: qualitative and quantitative research*. Aldershot: Avebury.

Caine, R. and Caine, C., 1997. *Unleashing the power of perceptual change: the potential of brain-based learning*. Alexandria, VA: Association for Supervision and Curriculum Development.

Calderhead, J., 1996. Teachers: beliefs and knowledge. In: D. Berliner and R. Calfee, eds. *Handbook of educational psychology*. New York: Macmillan Library Reference. pp. 709-25.

Campbell, D., 1975. Degrees of freedom and the case study. *Comparative Political Studies*, 8, pp. 178-85.

Carless, D., 1997. Managing systemic curriculum change: a critical analysis of Hong Kong's Target-Oriented Curriculum initiative. *International Review of Education*, 43(4), pp. 349-66.

Carless, D., 1999. Catering for individual learner differences: primary school teachers' voices. *Hong Kong Journal of Applied Linguistics*, 4(2), pp. 15-39.

Carless, D., 2001. *Curriculum innovation in the primary ELT classroom: case studies of three teachers implementing Hong Kong's Target-Oriented Curriculum (TOC).* unpublished PhD thesis. University of Warwick.

Carless, D., 2003. Factors in the implementation of task-based teaching in primary Schools. *System*, 31, pp. 485-500.

Carless, D. and Wong, J. P. M., 1999. Professional competencies for Hong Kong's Target-Oriented Curriculum initiative: perceptions of teachers and teacher educators. *Asia-Pacific Journal of Teacher Education and Developmen*t, 2(1), pp. 95-107.

Chan, D. W. ed., 1998. *Helping students with learning difficulties*. Hong Kong: Chinese University Press.

Chan, C. W. M, Chang, R. M. L., Westwood, P. and Yuen, M., 2002. Teaching adaptively: how easy is it in practice? A perspective from Hong Kong. *Asia-Pacific Educational Researcher*, 11(1), pp. 27-58.

Chaudron, C., 1988. *Teacher talk in second language classrooms*. In: C. Chaudron, ed. *Second language classrooms*. Cambridge: Cambridge University Press. pp. 50-89.

Cheng, K. M., 1997. The education system. In: G. Postiglione and W. O. Lee, eds. *Schooling in Hong Kong: organisation, teaching and social context*. Hong Kong: Hong Kong University Press.

Cheng, K. M. and Wong, K. C., 1996. School effectiveness in East Asia: concepts, origins and implications. *Journal of Educational Administration*, 34(5), pp. 32-49.

Chi, M., 1997. Quantifying qualitative analyses of verbal data: a practical guide. *Journal of the Learning Sciences*, 6, pp. 271-316.

Clark, J., Lo, Y. C., Hui, M. F., Kam, M., Carless, D. and Wong, P. M., 1999. *An investigation into the development and implementation of the TOC initiative with special reference to professional competencies, professional development and resources: final report*. Hong Kong: Hong Kong Institute of Education.

Clark, J., Scarino, A. and Brownell, J, 1994. *Improving the quality of learning: a framework for Target-Oriented Curriculum renewal*. Hong Kong: Institute of Language in Education.

Clarke, D., 2002. The learner's perspective study: exploiting the potential for complementary analyses. *Annual conference of the American Educational Research Association, Symposium on primary research, secondary research and research synthesis: theory, value and linkage*. New Orleans, 2-5 April.

Clarke, D. J. ed., 2001. *Perspectives on practice and meaning in mathematics and science classrooms*. Dordrecht, Netherlands: Kluwer Academic Press.

Cobb, P. and Bauersfeld, H. eds., 1995. *The emergence of mathematical meaning*: *interaction in classroom cultures*. Hillsdale, NJ: Lawrence Erlbaum.

Cohen, L., Manion, L. and Morrison, K., 2000. *Research methods in education*. 5th ed. London and New York: Routledge. Chapters 3, 4, 5, 9, 13, 14 and 15.

Confrey, J., 1995. How compatible are radical constructivism, sociocultural approaches, and social constructivism? In: L.P. Steffe and J. Gale, eds. *Constructivism in education*. Hillsdale, NJ: Lawrence Erlbaum. pp. 185-225.

Cornett, J. W., Yeotis, C. and Terwilliger, L., 1990. Teacher personal practice theories and their influences upon teacher curricular and instructional actions: a case study of a secondary science teacher. *Science Education*, 74, pp. 517-29.

Croll, P., 1986. *Systematic classroom observation*. London: Falmer Press.

Croll, P., 1998. *Systematic classroom observation*. 2nd ed., London: Falmer Press.

Curriculum Development Council, 1999a. *Syllabuses for secondary schools: syllabus for Mathematics (Secondary 1–5)*. Hong Kong: Education Development.

Curriculum Development Council, 1999b. *A holistic review of the Hong Kong school curriculum proposed reforms* (consultative document). Hong Kong: Government Printer.

Curriculum Development Council, 2002. *Mathematics education key learning area curriculum guide (Primary 1–Secondary 3)*, Hong Kong: Printing Department.

Dane, F. C., 1994. Survey methods, naturalistic observations, and case-studies. In: A. M. Colman *Companion encyclopaedia of psychology, vol. 2*. London: Routledge.

Darling-Hammond, L, 2000. Teacher quality and student achievement. *Educational Policy Analysis Archives*, 8(1). Available at: <http://epaa.asu.edu/epaa/v8n1>. [Accessed 10 July 2012].

Diezmann C., Thornton C. and Watters J., 2003. Addressing the needs of exceptional students through problem solving. In: F. Lester and R. Charles, eds. *Teaching mathematics through problem solving*. Reston, VA: National Council of Teachers of Mathematics. pp. 169-82.

Dillon, J. T., 1988. *Questioning and teaching: a manual of practice*. New York: Teachers College Press.

Dufour-Janvier, B., Bednarz, N. and Belanger, M., 1987. Pedagogical considerations concerning the problem of representation. In: C. Janvier, ed. *Problems of representation in the teaching and learning of mathematics*. Hillsdale, NJ: Erlbaum. pp. 109-22.

Education Bureau, n.d. Catering for individual differences. Available at: <http://cd1.edb.hkedcity.net/cd/id/index_en.html> [Accessed 12 November 2005].

Education Bureau, 2003. 'Strategy – building on variation'. Available at: <http://cd1.edb.hkedcity.net/cd/id/en/strategy/variation/index.html> [Accessed 18 June 2005].

Education Department, 1994. *General introduction to Target-Oriented Curriculum*. Hong Kong: Education Department.

Education Department, 1999. *Comparative study of the mathematics curriculum of major Asian and Western countries*. Hong Kong: Education Department.

Education Department, 2000. *Report on holistic review of the Mathematics curriculum*. Hong Kong: Education Department.

Education Department, 2001. *Integrated education* (pamphlet). Hong Kong: Integrated Education Unit.

Eisenhart, M. A., 1991. Conceptual frameworks for research circa 1991: ideas from a cultural anthropologist; implications for mathematics education researchers. In: *Proceedings of the 13th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, vol. 1*. Blacksburg, VA. pp. 202-19.

Eisner, E. W., 1991. *The enlightened eye: qualitative inquiry and the enhancement of educational practice*. New York: Macmillan Publishing Company.

Ellett, L., 1993. Instructional practices in mainstream secondary classes. *Journal of Learning Disabilities*, 26(1), pp. 57-64.

Erickson, F., 2004. Origins: a brief intellectual and technical history of the emergence of multimodal discourse analysis. In: P. Levine and R. Scollon, eds. *Discourse and technology: multimodal discourse analysis*. Washington, DC: Georgetown University Press. pp. 196-207.

Ernest, P., 1989. The impact of beliefs on the teaching of mathematics. In: P. Ernest, ed. *Mathematics teaching: the state of the art*. Lewes: Falmer.

Ernest, P., 1994. Social constructivism and the psychology of mathematics education. In: P. Ernest, ed. *Constructing mathematical knowledge: epistemology and mathematics education*. London: Falmer Press.

Ernest, P., 1995. The one and the many. In: L. Steffe and J. Gale, eds. *Constructivism in education*. New Jersey: Lawrence Erlbaum Associates, Inc.

Faragher, R. M., 2001. Including everyone in mathematics. Changing the question from 'How can we?' to 'How can we not?'. Mathematics: what changes?' *AAMT virtual conference*, May-June.

Feagin, J., Orum, A. and Sjoberg, G., eds., 1991. *A case for case study*. Chapel Hill, NC: University of North Carolina Press.

Feiman-Nemser, S. and Loden, R. E., 1986. The cultures of teaching. In: M. C. Wittrock, ed. *Handbook of research on teaching*. 3rd ed. New York: Macmillan. pp. 505-526.

Felder, R. M. and Brent, R., 2001. Effective strategies for cooperative learning. *Journal of Cooperation and Collaboration in College Teaching,* 10(2), pp. 69-75.

Fiedler, E. D., Lange, R. E. and Winebrenner, S., 2002. In search of reality: unraveling the myths about tracking, ability grouping, and the gifted. *Roeper Review*, 24(3), pp. 108-11.

Fink, R., 1993. How successful dyslexics learn to read. *Teaching Thinking and Problem Solving*, 15(5), pp. 1, 3-6.

Fishbein, M. and Ajzen, I., 1975. *Belief, attitude, intention, and behavior*: *introduction to theory and research*. Reading, MA: Addison-Wesley.

Fishman, B. J. and Davis, E. A., 2006. Teacher learning research and the learning sciences. In: R. K. Sawyer, ed. *The Cambridge handbook of the learning sciences* Cambridge: Cambridge University Press. pp. 535-50.

Flanders, N., 1970. *Analyzing teacher behavior*. Reading, MA: Addison-Wesley.

Foss, D. and Kleinsasser, R. C., 1996. Preservice elementary teachers' views of pedagogical and mathematical content knowledge. *Teaching and Teacher Education*, 12(4), pp. 429-42.

Foster, P., 1996. *Observing schools: a methodological guide*. London: Paul Chapman Publishing Ltd.

Frank, M. L., 1990. What myths about mathematics are held and conveyed by teachers? *Arithmetic Teacher*, 38(5), pp. 10-12.

Fraser, B. J., 1981. Using environmental assessments to make better classrooms. *Journal of Curriculum Studies*, 13, pp. 131-44.

Fraser, B. J., 1986. *Classroom environment*. London: Croom Helm.

Fraser, B. J., and Fisher, D. L., 1983a. Student achievement as a function of person environment fit: a regression surface analysis. *British Journal of Educational Psychology*, 53, pp. 89-99.

Fraser, B. J. and Fisher, D. L., 1983b. Use of actual and preferred classroom environment scales in person-environment fit research. *Journal of Educational Psychology*, 75, pp. 303-13.

Freeman, R., 1993. The importance of participant role in cooperative learning. *Working Papers in Educational Linguistics*, 9(1), pp. 1-20.

Frost & Sullivan, n.d. Focus groups. Available at: <http://www.frost.com/prod/servlet/mcon-methodologies-focus-groups.pag> [Accessed 20 November 2011].

Fuchs, L., Fuchs, D., Karns, K., Hamlett, C., Dutka, S. and Katzaroff, M., 1996. The relation between student ability and the quality and effectiveness of explanations. *American Educational Research Journal*, 33(3), pp. 631-64.

Fullan, M. G. (1999). *Change forces: the sequel*. Philadelphia, PA: Falmer Press.

Fullilove, J., 1992. The tail that wags. *Institute of Language in Education Journal*, 9, pp. 131-47.

Gall, M. D, 1984. Synthesis of research on teachers' questioning. *Educational Leadership*, 42(3), pp. 40–47.

Gardner, H., 1993. *Multiple intelligences: the theory in practice*. New York: Basic Books.

Garigliano, L. T., 1972. The relationship of wait-time to student behaviors in science curriculum improvements study lessons. *Dissertation Abstracts International*, 33, pp. 4199-A.

Gibbs, G. and Coffey, M., 2004. The impact of training of university teachers on their teaching skills, their approach to teaching and the approach to learning of their students. *Active Learning in Higher Education*, 5, pp. 87-100.

Ginsburg, H. P., Kaplan, R. G., Cannon, J., Cordero, M. I., Eisenband, J. G., Galanter, M. and Morgenlander, M., 2006. Helping early childhood educators to teach. mathematics. In Z. Martha and I. Martinez-Beck, eds. *Critical issues in early childhood professional development.* Baltimore, MD: Paul H. Brookes Publishing Co. pp. 171-202.

Gooding, C. T., Swift, P. R. and Swift, J. N., 1983. Improving and encouraging discussions in the classroom. In: *Annual meeting of the Eastern Educational Research Association*. Baltimore, MD.

Grant, C. M., 1996. Professional development in a technological age: new definitions, old challenges, new resources. Available at: <http://ra.terc.edu/publications/TERC_pubs/tech-infusion/prof_dev/prof_dev_intro.htm> [Accessed 11 April 2003].

Greene, J. C., Caracelli, V. J. and Graham, W. F., 1989. Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, 11, pp. 255-74.

Gu, L., Huang, R. and Marton, F., 2004. Teaching with variation: a Chinese way of promoting effective mathematics learning. In: L. Fan, N. Y. Wong, J. Cai and S. Li eds. *How Chinese learn mathematics: perspectives from insiders.* Singapore: World Scientific. pp. 309–47.

Guba, E. G.. and Lincoln, Y. S., 1982. Epistemological and methodological bases of naturalistic inquiry. *Educational Communications and Technology Journal*, 30(4), pp. 233-52.

Guba, E. G.. and Lincoln, Y. S., 1989. *Fourth generation evaluation*. Newbury Park CA: Sage.

Gummesson, E., 1991. Marketing orientation revisited: the crucial role of the part-time marketer. *European Journal of Marketing*, 25(2), pp. 60-75.

Guskey, T. R., 1995. Results-oriented professional development: in search of an optimal mix of effective practices. North Central Regional Educational Laboratory (NCREL), Naperville, IL. Available at: < http://www.ncrel.org/sdrs/areas/rpl_esys/pdlitrev.htm> [Accessed 24 February 2003].

Hallam, S. and Ireson, J., 2006. Secondary school pupils' preferences for different types of structured grouping practices. *British Educational Research Journal*, 32(4), pp. 583-99.

Halpern, D. F., 1996. *Thought and knowledge: an introduction to critical thinking*. Mahwah , NJ: Lawrence Erlbaum.

Hamel, J., Dufour, S. and Fortin, D., 1993. *Case study methods*. Newbury Park CA: Sage Publications.

Harlen, W. and Malcolm, H., 1997. *Setting and streaming: a research review*. Scottish Council for Research in Education, University of Glasgow.

Hattie, J., 2002. The power of feedback (cassette recording No. PF8, recorded by Auckland Recording Service Ltd). A keynote address. *New Zealand Principals' Federation conference*. Wellington, June.

Hattie, J. and Timperley, H., 2007. The power of feedback. *Review of Educational Research*, 77(1), pp. 81-112.

Hattie, J. and Watkins, D., 1988. Preferred classroom environment and approach to learning. *British Journal of Educational Psychology*, 58, pp. 345-49.

Hiebert, J., Gallimore, R., Garnier, H., Givvin, K. B., Hollingsworth, H., Jacobs, J., Chui, A., Wearne, D., Smith, M., Kersting, N., Manaster, A., Tseng, E., Etterbeek, W., Manaster, C., Gonzales, P. and Stigler, J. W, 2003. *Teaching mathematics in seven countries: results from the TIMSS 1999 Video Study*. NCES 2003-013. Washington, DC: US Department of Education, National Center for Education Statistics.

Hill, J. and Hawk, K., 2000. Four conceptual clues to motivating students: learning from the practice of effective teachers in low-decile, multi-cultural schools. *NZARE conference*. Waikato, November.

Hitchcock, G. and Hughes, D., 1995. *Research and the teacher: a qualitative introduction to school-based research*. 2nd ed. London: Routledge.

Ho, D. Y. F., 1986. Chinese patterns of socialization: a critical review. In: M. H. Bond, ed. *The psychology of the Chinese people*. Hong Kong: Oxford University Press. pp. 1-37.

Ho, I. T., 2001. Are Chinese teachers authoritarian? In: D. A.Watkins and J. B. Biggs eds. *Teaching the Chinese learner: psychological and pedagogical perspectives*. Hong Kong: Comparative Education Research Centre, University of Hong Kong. pp. 99-114.

Howe, R. and Lewis, R., 1993. *A student guide to research in social science*. Cambridge: Cambridge University Press.

Howe, K. R. and Moses, M. S., 1999. Ethics in educational research. *Review of Research in Education*, 24, pp. 21-26.

Huang, R. J., 2002. Mathematics teaching in Hong Kong and Shanghai: a classroom analysis from the perspective of variation. Unpublished Ph.D. thesis. Hong Kong: The University of Hong Kong

Huang, R., Mok, I. A. C. and Leung, F. K. S., 2006. Repetition or variation: Practicing in the mathematics classroom in China. In: D. J. Clarke, C. Keitel and Y. Shimizu, eds. *Mathematics classrooms in twelve countries: the insider's perspective.* Rotterdam: Sense Publishers. pp. 263–74.

Hui, K. P. and Yung, K. K., 1992. *Helping pupils with learning difficulties*. Hong Kong: Longman.

Inagaki K., Morita, E. and Hatano, G., 1999. Teaching-learning of evaluative criteria for mathematical arguments through classroom discourse: a cross-national study. *Mathematical Thinking and Learning*, 1(2), pp. 93-111.

Ireson, J., Hallam, S., Hack, S., Clark, H. and Plewis, I., 2002. Ability grouping in English secondary schools: effects on attainment in English, mathematics, and sciences. *Educational Research & Evaluation*, 8(3), pp. 299-319.

Ireson, J., Hallam, S. and Hurley, C., 2002. Ability grouping in the secondary school: effects on GCSE attainment in English, mathematics and science. *British Educational Research Association annual conference*, Exeter University, September 10–14.

Janney, R. and Snell, M. E., 2000. *Modifying schoolwork*. Baltimore: Brookes.

Jaworski, B., 1994. *Investigating mathematics teaching: a constructivist enquiry*. London: The Falmer Press.

Jaworski, B., 1998. The centrality of the researcher: rigor in a constructivist inquiry into mathematics teaching. In: A. R. Reppo, ed. *Qualitative research methods in mathematics education*. Reston: National Council of Teachers of Mathematics, Inc. pp. 115-27.

Kagan, D. M., 1990. Ways of evaluating teacher cognition: inferences concerning the Goldilocks principle. *Review of Educational Research*, 60, pp. 419-69.

Kawanaka, T. and Stigler, J., 1999. Teachers' use of questions in eighth-grade mathematics classrooms in Germany, Japan, and the United States. *Mathematical Thinking and Learning*, 1(4), pp. 255-78.

Kellough, R.D. and Carjuzaa, J., 2006. *Teaching in the middle and secondary schools.* 8th ed. Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

Kelly, A., 1989. Education or indoctrination? The ethics of feminist educational research. In R. G. Burgess, ed. *The Ethics of Educational Research*, Philadelphia, PA: Falmer, pp. 100-13.

King, A., Staffieri, A. and Adelgais, A., 1998. Mutual peer-tutoring: Effects of structuring tutorial interaction to scaffold peer learning. *Journal of Educational Psychology*, 90(1), pp. 134-52.

Ko, P.Y. and Chik, P. M., 2000. 'Jiaoxue jihue de bawu he liushi' [The grasp and loss of teaching and learning opportunities – lesson analysis of a primary Chinese language lesson], *Asia Pacific Journal of Language in Education*, 2(2).

Ko, P. Y. and Kwok, W. Y. eds., 2006. Learning study manual – Cases for different key learning areas (「課堂學習研究」實踐手冊──不同學習領域之案例). Hong Kong: The Centre for Learning-study and School Partnership. [in Chinese]

Kreuger, R. A., 1988. *Focus groups: a practical guide for applied research*. London: Sage.

Krummheuer, G., 2000. Mathematics learning in narrative classroom cultures: studies of argumentation in primary mathematics education. *For the Learning of Mathematics*, 20(1), pp. 22-32.

Krummheuer, G., 2004. Wie kann man mathematikunterricht verändern? Innovation von unterricht aus sicht eines ansatzes der interpretativen unterrichtsforschung. *Journal für Mathematik-Didaktik*, 25(2), pp. 112-29.

Krummheuer, G., 2011. Representation of the notion 'learning-as-participation' in everyday situations of mathematics classes. *The International Journal on Mathematics Education–ZDM*, 43(1), pp. 81-90.

Kulik, J. A. and Kulik, C-L.C, 1992. Meta-analytic findings on grouping programs. *Gifted Child Quarterly*, 36(2), pp. 73-77.

Kutnick, P., Sebba, J., Blatchford, P., Galton. M. and Thorp, J., 2005a *The effects of pupil grouping: literature review*. London: DfES.

Kutnick, P. et al., 2005b. Teachers' understandings of the relationship between within-class (pupil) grouping and learning in secondary schools. *Educational Research*, 47(1), pp. 1-24.

Kwok, W. Y. and Chik, P. M. P., 2005. The effect of learning studies on student learning outcomes. In: M. L. Lo, W. Y. Pong and P. M. P. Chik, eds. *For each and everyone: catering for individual differences through learning studies*. Hong Kong: Hong Kong University Press.

Kyriacou, C., 1997. *Effective teaching in schools: theory and practice*. 2nd ed. Cheltenham: Stanley Thornes.

Lampert, M. and Ball, D, 1998. *Teaching, multimedia, and mathematics: investigations of real practice*. New York: Teachers College Press.

Lee, S. Y., 1998. Mathematics learning and teaching in the school context: reflections from cross-cultural comparisons. In: S. G. Garis and H. M. Wellman, eds. *Global prospects for education: development, culture, and schooling*. Washington, DC: American Psychological Association. pp. 45–77.

Leinhardt, G.., Putnam, R. T., Stein, M. K. and Baxter, J., 1991. Where subject knowledge matters. In: J. Brophy, ed. *Advances in research in teaching* (vol. 2), Greenwich, CT: JAI Press, Inc. pp. 87-113.

Lerman, S., 1994. Articulating theories of mathematics learning. In P. Ernest, ed. *Constructing mathematical knowledge: epistemology and mathematical education*. London: The Falmer Press.

Leung, F. K. S., 1992. A comparison of the intended mathematics curriculum in China, Hong Kong, and England and the implementation in Beijing, Hong Kong and London. unpublished PhD thesis. The University of London Institute of Education.

Leung, F. K. S., 1995. The mathematics classroom in Beijing, Hong Kong and London. *Educational Studies in Mathematics*, 29, pp. 297–325.

Leung, F. K. S., 2001. In search of an East Asian identity in mathematics education. *Educational Studies in Mathematics*, 47, pp. 35-51.

Leung, F. K. S., 2002. Mathematics education in East Asia and the West: does culture matter? *International congress of mathematics instruction's comparative study conference*. The University of Hong Kong, Hong Kong, China, 20–25 October.

Leung, F. K. S., 2005. Some characteristics of East Asian Mathematics classrooms based on data from the TIMSS 1999 video study. *Educational Studies in Mathematics*, 60, pp. 199-215.

Lewis, C., Perry, R. and Murata, A., 2006. How should research contribute to instructional improvement? The case of lesson study. *Educational Researcher*, 35(3), pp. 3-14.

Linchevski, L. and Kutscher, B., 1998. Tell me with whom you're learning, and I'll tell you how much you've learned: mixed-ability versus same-ability grouping in mathematics. *Journal for Research in Mathematics Education*, 29(5), pp. 533-554.
Lincoln, Y. S. and Guba, E. G., 1985. *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Lipset, S. M., Trow, M. and Coleman, J., 1956. *Union democracy: the inside politics of the International Typographical Union*. New York: Free Press.

Little, J. W., 1993. Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis*, 15(2), pp. 129-151.

Lo, M. L., Pong, W. Y. and Chik, P. M. eds, 2005. *For each and everyone – catering for individual differences through learning study*. Hong Kong: Hong Kong University Press.

Lo, M. L., Pong, W. Y., Marton, F., Leung, A., Ko P. Y., Ng, F. P. et al., 2002. *Catering for individual differences: building on variation: the first findings*. Hong Kong: In-service Teacher Education Programme (INSTEP), Faculty of Education, The University of Hong Kong.

Lo, M. L., Chik, P. M. and Pang, M. F., 2006. Patterns of variation in teaching the colour of light to primary 3 students. *Instructional Science*, 34(1), pp. 1-19.

Lo, M. L., Hung, H. H. Y. and Chik, P. P. M. (2007). Improving teaching and learning through a learning study – using patterns of variation to teach electro-chemical series in Hong Kong. *Curriculum Perspectives,* 27(3), pp. 49–62.

Lou, Y., Abrami, P. C., Spence, J. C., Poulsen, C., Chambers, B. and d'Apollonia, S., 1996. Within class grouping: a meta-analysis. *Review of Educational Research,* 66(4), pp. 423–58.

Lovitt, T. C., 2000. *Preventing school failure*, 2nd ed. Austin, TX: ProEd.

Marshall, C. and Rossman, G. B., 1989. *Designing qualitative research*. Newbury Park: Sage.

Marton, F., 1999. Variatio est mater studiorum. *8th EARLI conference*, Göteborg, Sweden, August.

Marton, F., 2008. Building your strength: Chinese pedagogy and the necessary conditions of learning. *The World Association of Lesson Studies (WALS)*. Available at http://www.ied.edu.hk/wals/conference08/program1.htm [Accessed 28 February 2009].

Marton, F. and Booth, S., 1997. *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum Associates.

Marzano, R. J., Pickering , D. J. and Pollock, J. E., 2001. *Classroom instruction that works: research-based strategies for increasing student achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.

McMillion, H. G., 1994. Small groups: an instructional approach to learning. *Research and Teaching in Developmental Education*, 10(2), pp. 71-80.

Merriam, S. B., 1988. *Case study research in education*. San Francisco, CA: Jossey-Bass Inc., Publishers.

Merton, R. K., Fiske, M. and Kendall, P .L., 1990. *The focused interview: a manual of problems and procedures*. 2nd ed., London: Collier MacMillan.

Miles, M. and Huberman, A. M., 1994. *Qualitative data analysis*. Thousand Oaks, CA: Sage Publications.

Mok, I. A. C., 2000. An open mathematics lesson in Shanghai. In: *ICME-9*, Japan, July. Available at <http://www.math.admu.edu.ph/tsg22/mol.htm> [Accessed 25 January 2002].

Mok, I. A., Cai, J. and Fung, A., 2005. Teaching mathematics through problem solving: struggles a Hong Kong teacher faces. *Earcome3 conference*, Shanghai, China.

Mok, I., Chik, P. M., Ko, P. Y., Kwan, T., Lo, M. L., Marton, F. et al., 2001. Solving the paradox of the Chinese teacher? In: D. A. Watkins and J. B. Biggs, eds. *Teaching the Chinese learner: psychological and pedagogical perspectives*. Hong Kong/Melbourne: Comparative Education Research Centre, the University of Hong Kong/Australian Council for Education Research. pp. 161–80.

Mok, I. A. C. and Morris, P., 2001. The metamorphosis of the ‘virtuoso’: pedagogic patterns in Hong Kong primary mathematics classrooms. *Teaching and Teacher Education*, 17, pp. 455-68.

Morris, P., 1985. Teachers’ perceptions of the barriers to the implementation of pedagogic innovation: a South East Asian case study. *International Review of Education*, 31, pp. 3-18.

Morris, P., 1988. Teachers’ attitudes towards a curriculum innovation: an East Asian Study. *Research in Education*, 40, pp. 75-87.

Morris, P., 1992. Preparing pupils as citizens of the special administrative region: curriculum change and control during the transitional period. In: *Curriculum development in Hong Kong*. 2nd ed. Hong Kong: Faculty of Education, University of Hong Kong.

Morris, P. and Sweeting, A., 1995. *Education and development in East Asia*. Reference Books in International Education, vol. 31, Garland Reference Library of Social Science, vol. 942. New York and London: Garland Publishing, Inc.

Morris, P. and twelve project associates, 1996. *Target-Oriented Curriculum evaluation report: interim report*. Hong Kong: Faculty of Education, University of Hong Kong.

Morris, P., Lo, M. L. and Adamson, B., 2000. Improving schools in Hong Kong: lessons from the past. In: B. Adamson, T. Y. L. Kwan and K. K. Chan, eds. *Changing the curriculum: the impact of reform on Hong Kong's primary schools*. Hong Kong: Hong Kong University Press.

Mullis, I. V. S., Martin, M. O., Beaton, A. E., Gonzalez, E. J., Kelly, D. L. and Smith, T. A., 1997. *TIMSS 1995 International Mathematics Achievement in the Primary School Years*: Center for the Study of Testing, Evaluation, and Educational Policy, Boston College.

Nespor, J., 1987. The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, 19(4), pp. 317-28.

Ng, S. M., 1994. *Language teaching and bilingual literacy at pre-primary and primary levels in Hong Kong*. Hong Kong: Report to Education Commission.

Ng, D. F. P., Kwan, Y. L. and Chik, P. M., 2000. 'Yi tang xiaxue yuwei ke de Fenxie – Xianxiang tushixu [Lesson analysis of a primary Chinese language lesson – phenomenography approach], *Curriculum Forum*, 9(2), pp. 82-91 (in Chinese).

Ng, D. F. P., Tsui, A. B. M. and Marton, F., 2001. Two faces of the reed relay – exploring the effect of the medium of instruction. In: D. A. Watkins and J. B. Biggs, eds. *Teaching the Chinese learner: psychological and pedagogical perspectives*. Hong Kong/Melbourne: Comparative Education Research Centre, the University of Hong Kong/Australian Council for Education Research. pp. 135-60.

Nisbett, R. E. and Wilson, T. D., 1977. Telling more than we can know: verbal reports on mental processes. *Psychological Review*, 84, pp. 231-259.

Norton, S., McRobbie, C. and Cooper, T., 2002. Teachers' responses to an investigative mathematics syllabus: their goals and practices. *Mathematics Education Research Journal*, 14(1), pp. 37-59.

Okano, K. and Tsuchiya, M., 1999. *Education in contemporary Japan*. Cambridge: Cambridge University Press.

Olesen, V., 1998. Feminisms and models of qualitative research. In: N. K. Denzin and Y. S. Lincoln, eds. *The landscape of qualitative research: theories and issues*. London: Sage. pp. 300-332.

Oppenheim, A. N., 1992. *Questionnaire design, interviewing and attitude measurement*, new edn. London: Heinemann.

Ornstein, A. C., 1988. Questioning: the essence of good teaching – part II. *NASSP Bulletin*, 72(505), pp. 72-80.

Pajares, M. F., 1992. Teachers' beliefs and educational research: cleaning up a messy construct. *Review of Educational Research*, 62(3), pp. 307-32.

Pang, M. F., 2002. Making learning possible: the use of variation in the teaching of school economics. unpublished PhD thesis. The University of Hong Kong.

Pong, W. Y. and Morris, P., 2002. Accounting for differences in achievement. In: F. Marton and P. Morris, eds. What matters? discovering critical conditions of classroom learning. Goteborg: Acta Universitatis Gothoburgensis. pp. 9-18.

Park K. and Leung, F. K. S., 2002. A comparative study of the mathematics textbooks of China, England, Hong Kong, Japan, Korea, and the United States. *Pre-conference proceedings of the ICMI comparative conference*, Faculty of Education, The University of Hong Kong, Hong Kong SAR, China 20–25 October. pp. 225-34.

Park, K. and Leung, F. K. S., 2006. A comparison of the mathematics textbooks in China, Hong Kong, Japan, Korea, United Kingdom, and the United States, Chapters 2-5 in F. K. S. Leung, K.-D. Graf and F. J. Lopez-Real, eds. *Mathematics education* *in different cultural traditions: a comparative study of East Asia and the West***.** 13th ICMI Study. New York: Springer, pp. 227-38.

Perry, B., Wong, N. Y. and Howard, P., 2002. Beliefs about mathematics, mathematics learning and mathematics teaching: a comparison of views from primary and secondary mathematics teachers in Hong Kong and Australia. *Pre-conference proceedings of the ICMI comparative conference*, Faculty of Education, The University of Hong Kong, Hong Kong SAR, China, 20–25 October. pp. 151-58.

Prawat, R. S., 1999. Dewey, Peirce, and the learning paradox. *American Educational Research Journal*, 36(1), pp. 47-76.

Punch, M., 1998. Politics and ethics in qualitative research. In: K. K. Denzin and Y. S. Lincoln, eds. *The landscape of qualitative research*. Thousand Oaks, CA: Sage. pp. 156-84.

Pyecha, J., 1988. *A case study of the application of noncategorical special education in two states*. Chapel Hill, NC: Research Triangle Institute.
Redfield, D. L. and Rousseau, E. W., 1981. A meta-analysis of experimental research on teacher questioning behaviour. *Review of Educational Research*, 51(2), pp. 237-45.

Rentoul, J. A. and Fraser, B. J., 1980. Predicting learning from classroom individualization and actual-preferred congruence. *Studies in Educational Evaluation*, 6, pp. 265-77.

Riley, J. P., 1981. The effects of preservice teachers' cognitive questioning level and redirecting on student science achievement. *Journal of Research in Science Teaching*, 18, pp. 303-9.

Rokeach, M., 1968. *Belief, attitudes, and values: a theory of organization and Change*. San Francisco: Jossey-Bass.

Rose, R., 2001. Primary school teacher perceptions of the conditions required for including pupils with special educational needs. *Educational Review*, 53(2), pp. 147-56.

Rosenbaum, J. E., 1999. If tracking is bad, is detracking better? *American Educator*, 23(4), pp. 24-29. Available at:
<http://www.aft.org/pdfs/americaneducator/winter9900/TrackingWint99_00.pdf>

[Accessed 20 November 2003].

Rossman, G. B. and Wilson, B. L., 1994. Numbers and words revisited: being 'shamelessly eclectic'. *Quality and Quantity*, 28, pp. 315-27.

Rowe, M. B., 1974. Wait-time and rewards in instructional variables, their influence on language, logic, and fate control: part one – wait time. *Journal of Research in Science Teaching*, 11, pp. 81-94.

Rowland, T., 2008. The purpose, design, and use of examples in the teaching of elementary mathematics. *Educational Studies in Mathematics*, 69, pp. 149-63.

Runesson, U., 1997. The experience of mathematics teaching. *PME 21 Proceedings*, 4, pp. 88-95.

Runesson, U., 1999. The pedagogy of variation: different ways of handling a mathematical topic. In: *Variationens Pedagogik: Skilda Sätt att behandla ett matematiskt innehåll*. Göteborg: Acta.

Runesson, U., 2001. What matters in the mathematics classroom? Exploring critical differences in the space of learning. In: C. Bergsten, ed. *Proceedings of NORMA01*, Kristianstad.

Salili, F., 2001. Teacher-student interaction: attribution implications and effectiveness of teachers' evaluative feedback. In: D. A. Watkins and J. B. Biggs, eds. *Teaching the Chinese learner: psychological and pedagogical perspectives*. Hong Kong: Comparative Education Research Centre, University of Hong Kong. pp. 77-98.

Saxe, G. G. and Bermudez, T., 1992. Emergent mathematical environments in children's games. In: International Congress on Mathematical Education, Quebec City, Canada, August.

Schaub, M. and Baker, D., 1994. What makes for effective mathematics instruction? Japanese and American classrooms compared. In: I. Westbury, C. Ethington, L. Sosniak and D. Baker, eds. *In search of more effective mathematics education* Norwood: Ablex. pp. 151-167.

Schmidt, W. H., McKnight, C., Cogan, L. S., Jakwerth, P. M. and Houang, R. T., 1999. *Facing the consequences: using TIMSS for a closer look at U.S. mathematics and* *science education*. Boston: Kluwer Academic Press.

Schmidt, W. H., McKnight, C.C., Valverde, G. A., Houang, R. T. and Wiley, D.E., 1996. *Many visions, many aims: a cross-national investigation of curriculum intentions in school mathematics*, Norwell, MA: Kluwer Academic Press.

Schoenfeld, A. H., 1982. Some thoughts on problem-solving research and mathematics education. In: F. K. Lester and J. Garofalo, eds. *Mathematical problem solving: issues in research*. Philadelphia: Franklin Institute Press. pp. 27-37.

Schoenfeld, A. H., 1992. Learning to think mathematically: problem solving, metacognition, and sense making in mathematics. In: D. A. Grouws, ed. *Handbook of research on mathematics teaching and learning*. New York: Macmillan. pp. 334-70.

Seale, C., 1998. Qualitative interviewing. In: C. Seale, ed. *Researching society and culture*. London: Sage. pp. 202-32.

Sfard, A. and McClain, K. eds, 2002. Analyzing tools: perspectives on the role of designed artifacts in mathematics education [special issue]. *Journal of the Learning Sciences*, 11, pp. 2-3.

Shavelson, R. J. and Stern, P., 1981. Research on teachers' pedagogical thoughts, judgments, decisions, and behavior. *Review of Educational Research*, 51, pp. 455-98.

Shimizu, Y., 2002. Discrepancies in perceptions of lesson structure between the teacher and students in the mathematics classroom. In: American Educational Research Association, *Symposium on international perspectives on mathematics classrooms*. New Orleans, 4 April.

Silver, E. A., 1987. Foundations of cognitive theory and research for mathematics problem-solving instruction. In: A. H. Schoenfeld, ed. *Cognitive science and mathematics education: an overview*. Hillsdale, NJ: Lawrence Erlbaum Associates. pp. 33-60.

Silverman, D., 1985. *Qualitative methodology and sociology*. Aldershot: Gower.

Simon, M., 1997. Developing new models of mathematics teaching: an imperative for research on mathematics teacher development. In: E. Fennema and B. S. Nelson, eds., *Mathematics teacher in transition.* Mahwah, NJ: Lawrence Erlbaum. pp. 55-86.

Simon, M. and Tzur, R., 2004. Explicating the role of mathematical tasks in conceptual learning: an elaborating of the hypothetical learning trajectory. *Mathematical Thinking and Learning*, 6, pp. 91-104.

Simons, H., 1989. Ethics of the case study in educational research and evaluation. In: R. G. Burgess, ed. *The ethics of educational research*. Philadelphia, PA: Falmer. pp. 114-40.

Slavin, R. E., 1987. Ability grouping and student achievement in elementary schools: a best-evidence synthesis. *Review of Educational Research*, 57, pp. 293-336.

Slavin, R. E., 1990, Achievement effects of ability grouping in secondary schools: a best-evidence synthesis. *Review of Educational Research*, 60(3), pp. 471-99.

Smith, C. M. M. and Sutherland, M. J., 2002. Setting or mixed ability? Pupils' views of the organizational arrangement in their school. *Annual conference of the Scottish Educational Research Association (SERA)*, Dundee.

Smith, C. M. M. and Sutherland, M. J., 2003. Setting or mixed ability? Teachers' views of the organisation of pupils for learning. *Journal of Research in Special Educational Needs*, 3(3), pp. 141-46.

Stake, R. E., 1988. Case study methods in educational research: making sweet water. In: R. M. Jaegar, ed. *Complementary methods for research in education*. Washington, DC: American Educational Research Association. pp. 253-65.

Stake, R., 1995. *The art of case research*. Thousand Oaks, CA: Sage Publications.

Starkey, P. & Klein, A. (2008). Sociocultural influences on young children's mathematical knowledge. In O. N. Saracho & B. Spodek (eds), Contemporary perspectives on mathematics in early childhood education (pp. 45–66). Baltimore. MD: IAP, INC.

Stein, M., Grover, B. and Henningsen, M., 1996. Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal*, 33(2), pp. 455-88.

Stein, M. K. and Smith, M. S., 1998. Mathematical tasks as a framework for reflection: from research to practice. *Mathematics Teaching in the Middle School*, 3(4), pp.

268-275.

Steinbring, H., 2000. Interaction analysis of mathematical communication in primary teaching: the epistemological perspective. *Zentralblatt für Didaktik der Mathematik*, 32(5), pp. 138-48.

Stevenson, D. L. and Baker, D. P., 1996. Does state control of the curriculum matter? A response to Westbury and Hsu. *Educational Evaluation and Policy Analysis*, 18(4), pp. 339-42.

Stevenson, H. W. and Stigler, J. W., 1992. *The learning gap: why our schools are failing and what we can learn from Japanese and Chinese education*. New York: Simon & Schuster.

Stevenson, H. W., Chen, C. C. and Lee, S. Y., 1993. Mathematics achievement of Chinese, Japanese, and American children: ten years later. *Science*, 25(9), pp. 53-59.

Stevenson, H. W. and Lee, S. Y., 1995. The East Asian version of whole-class teaching. *Education Policy*, 9, pp. 152-68.

Stevenson, H. W. and Stigler, J. W., 1992. *The learning gap: why our schools are* failing and what we can learn from Japanese and Chinese education. New York: Summit Books.

Stigler, J. W. and Hiebert, J., 1997. Understanding and improving classroom mathematics instruction: an overview of the TIMSS Video Study. *Phi Delta Kappan*, 79(1), pp. 14-21.

Stigler, J. W. and Hiebert, J., 1999. *The teaching gap: the best ideas from the world's teachers for improving education in the classroom*. New York: The Free Press.

Stigler, J. W. and Perry, M., 1988. Cross cultural studies of mathematics teaching and learning: recent findings and new directions. In: D. A. Grouws and T. J. Cooney *Perspectives on research on effective mathematics teaching*. Reston, VA: Lawrence Erlbaum Associates, NCTM. pp. 194–223.

Sukhnandan, L. with Lee, B., 1998. *Streaming, setting and grouping by ability*. Slough: National Foundation for Educational Research.

Tang, K. W. and Lau, A., 2001. Conceptions of individual differences: a phenomenographic study of teachers' ways of experiencing and coping with student diversity. *9th European Association for Research on Learning and Instruction conference*, Fribourg, Switzerland.

Taylor, S. J. and Bogdan, R., 1984. *Introduction to qualitative research methods*. 2nd ed. New York: Wiley.

Teppo, A. R., 1998. Diverse ways of knowing. In: A. R. Teppo, ed. *Qualitative research in mathematics education*. Reston: The National Council of Teachers of Mathematics. pp. 1–16.

Thompson, A. G., 1984. The relationship of teachers' conceptions of mathematics and mathematics teaching instructional practice. *Educational Studies in Mathematics*, 15 (2), pp. 105-127.

Tieso, C. L., 2003. Ability grouping is not just tracking any more. *Roeper Review*, 26(1), pp. 29-37.

Tomlinson , C. A., 1999. *The differentiated classroom: responding to the needs of all learners*. Alexandria , VA: Association for Supervision and Curriculum Development.
Tomlinson, C. A. (2001). Grading for success. *Educational Leadership*, 58(6), pp. 12-15.

Tong, J. W. M., 1996. Hong Kong Chinese students'approach towards English language learning revisited. *Hong Kong Polytechnic University Working Papers in ELT and Applied Linguistics*, 2(1), pp. 73-88.

Tong, K. M., 1970. *Educational ideas of Confucius*. Taipei: Youth Book Store.

Topping, K., 1995. *Paired reading, spelling and writing*. London: Cassell.
Tschannen-Moran, M., Hoy, A. and Hoy, W., 1998. Teaching efficacy: its meaning and measure. *Review of Educational Research*, 68(2), pp. 202-48.

Tsuruda, G.., 1994. *Putting it together: middle school math in transition*. Portsmouth, NH: Heinemann.

Visiting Panel, 1982. *A perspective on education in Hong Kong*. Hong Kong: Hong Kong Government.

Voigt, J., 1994. Negotiation of mathematical meaning and learning mathematics. *Educational Studies in Mathematics*, 26, pp. 275-98.

Voigt, J., 1995. Thematic patterns of interaction and sociomathematical norms. In: P. Cobb and H. Bauersfeld, eds. *The emergence of mathematical meaning: interaction in classroom culture*. Hillsdale, NJ: Erlbaum. pp. 163-201.

Voigt, J., 1996. Negotiation of mathematical meaning in classroom processes: social interaction and learning mathematics. In: L. P. Steffe, P. Nesher, P. Cobb, G. A. Goldin and B. Greer, eds. *Theories of mathematical learning*, Mahwah, NJ: Lawrence Erlbaum Associates. pp. 21-50.

von Glasersfeld, E., 1995. A constructivist approach to teaching. In: L. P. Steffe and J. Gale, eds. *Constructivism in education*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. pp. 3-16.

Watkins, D. A. and Biggs, J. B. eds., 1996. *The Chinese learner: cultural, psychological and contextual influences*. Hong Kong/Melbourne: Comparative Education Research Centre, The University of Hong Kong/Australian Council for Education Research.

Watkins, D. A. and Biggs, J., 2001. The paradox of the Chinese learner and beyond. In: D. Watkins and J. Biggs, eds. *Teaching the Chinese learner: Psychological and pedagogical perspectives* Hong Kong: Comparative Education Research Centre, University of Hong Kong. pp. 3-23.

Watson, A. and Chick, H., 2011. Qualities of examples in learning and teaching. *ZDM: The International Journal in Mathematics Education* 43(2), pp. 283-94.

Watson, A. and Mason, J., 2005. *Mathematics as a constructive activity: learners generating examples.* Mahwah, NJ: Erlbaum.

Watson, A. and Mason, J., 2006. Seeing an exercise as a single mathematical object: Using variation to structure sense-making. *Mathematics Thinking and Learning*, 8(2), pp. 91-111.

Waysman, M. and Savaya, R., 1997. Mixed method evaluation: a case study. *Evaluation Practice*, 18(3), pp. 227-37.

Wedell, M., 2009. *Planning educational change: putting people and their contexts first*. London: Continuum.

Welch, W. W. and Walberg, H. J., 1972. A national experiment in curriculum evaluation. *American Educational Research Journal*, 9, pp. 373-83.

Weston, P., Taylor, M., Lewis, G. and McDonald, A., 1998. *Learning from differentiation*. Slough: NFER.

White, B. Y. and Frederiksen, J. R., 1998. Inquiry, modelling, and metacognition: making science accessible to all students. *Cognition and Instruction*, 16(1), pp. 3-118.

Wiliam, D. and Bartholomew, H., 2004. It's not which school but which set you're in that matters: the influence of ability grouping practices on student progress in mathematics. *British Educational Research Journal*, 30(2), pp. 279-93.

Wolcott, H. F., 1992. Posturing in qualitative inquiry. In: M. D. LeCompte, W. L. Millroy and J. Preissle, eds. *The handbook of qualitative research in education*. New York: Academic Press. pp. 3-52.

Wong, N. Y., 1993. Mathematics education in Hong Kong: development in the last Decade. In G. Bell, ed. *Asian perspective on mathematics education*. Lismor, NSW: The Northern Rivers Mathematics Association, pp. 56-69.

Wong, N. Y., 1998. In search of the "CHC" learner: smarter, works harder and something more. In: H. S. Park, Y. H. Choe, H. Shin and S. H. Kim, eds. *Proceedings of the ICMI-East Asia Regional conference on mathematical education*, 1, pp. 85-98.

Wong, N. Y., 2000. Mathematics education and culture: the "CHC" learner phenomenon. Available at <http://www.math.admu.edu.ph/tsg22/wong.html> [Accessed 21 November 2003].

Wong, N. Y., 2004. The CHC learner's phenomenon: its implications for mathematics education. In: L. Fan, N. Y. Wong, J. Cai and S. Li, eds. *How Chinese learn mathematics: perspectives from insiders.* River Edge, NJ: World Scientific. pp. 503–34.

Wong, N. Y., Lam, C. C., Leung, F. K. S., Mok, I. A. C., & Wong, K. M., 1999. An analysis of the views of various sectors on the mathematics curriculum. Available at http://cd1.edb.hkedcity.net/cd/maths/en/ref_res/document/Research2.htm [Accessed 22 November 2005].

Woods, P., 1996. *Researching the art of teaching: ethnography for educational use*. London: Routledge.

Wu, K. Y., 1993. Classroom interaction and teacher questions revisited. *RELC Journal*, 24, pp. 49-68.

Yackel, E., Cobb, P. and Wood, T. (1999) The interactive constitution of mathematical meaning in one second grade classroom: an illustrative example. *Journal of Mathematical Behavior*, 17, pp. 469-88.

Yin, R., 1989. *Interorganizational partnerships in local job creation and job training efforts*. Washington, DC: COSMOS Corp.

Yin, R., 1993. *Applications of case study research*. Beverly Hills, CA: Sage Publishing.

Yin, R., 1994. *Case study research: design and methods*. 2nd ed. Beverly Hills, CA: Sage Publishing.

Yin, R. K, 2009. Case study research: design and methods. 4th ed. Thousand Oaks, CA: Sage.

Yin, R. and Moore, G., 1987. The use of advanced technologies in special education. *Journal of Learning Disabilities*, 20(1).

Yuen, M., 2002. Exploring Hong Kong Chinese guidance teachers' positive beliefs: a focus group study. *International Journal for the Advancement of Counselling*, 24, 169-82.

Zevenbergen, R., 2001. Is streaming an equitable practice?: students' experiences of streaming in the middle years of schooling. In: J. Bobis, B. Perry and M. Mitchelmore, eds. *Numeracy and beyond. Proceedings of the 24th Annual conference of the Mathematics Education Research Group of Australasia*. Sydney, MERGA, pp. 563-70.

Zevenbergen, R., 2003. Explaining success in school mathematics: mythology, equity and implications for practice. In M. Goos and T. Spencer, eds. *Mathematics ~ making waves*. *Proceedings of the nineteenth biennial of the Australian Association of Mathematics Teachers Inc*., Brisbane, AAMT. pp. 277-89.

Zevenbergen, R. and Lerman, S., 2002. Communicative competence in school mathematics: on being able to *do* school mathematics. In J. Bobis, B. Perry and M. Mitchelmore, eds. *Numeracy and Beyond*. *Proceedings of the 24th Annual conference of the Mathematics Education Research Group of Australasia*, Sydney: MERGA, pp. 571-78.

Zodik, I., and Zaslavsky, O., 2008. Characteristics of teachers' choice of examples in and for the mathematics classroom. *Educational Studies in Mathematics*, 69, pp. 165-82.

Zonabend, F., 1992. The monograph in European ethnology. *Current Sociology*, 40(1), pp. 49-60.