An exploratory study of the teaching and learning of secondary science through English in Hong Kong

CLASSROOM INTERACTIONS AND PERCEPTIONS OF TEACHERS AND STUDENTS

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Abstract

Previous studies have shown that teachers and students using English as the medium of instruction (EMI) in science classrooms encounter many language challenges with teaching and learning processes. Problems include the limited English communication skills of science teachers, the lack of EMI training for science teachers, the students' different language abilities and science teachers' beliefs that they are not responsible for addressing students' language needs in science. Teachers' lack of language awareness has led to poor teaching practices and limited interactions in the classrooms. This lack of language awareness, in turn, suggests that there are limited opportunities for students to learn English as a second language in the science classroom.

This study extends the research on EMI classroom interactions in Hong Kong (Lo and Macaro, 2012) to the previously unexamined context of senior secondary science classrooms. A total of 19 teachers and 545 students from grades 10 and 11 EMI science class were recruited in Hong Kong from 'early–full EMI' schools (full EMI instruction from grades 7 to 12) and 'late–partial EMI' schools (Chinese medium from grades 7 to 9 and partial EMI instruction from grades 10 to 12).

The project used multiple sources of qualitative data (i.e. semi-structured interviews and 33 videotaped classroom observations) to explore the similarities

and differences in classroom interactions during the first and second years of the senior science curriculum (grades 10 and 11) in the two types of EMI schools.

This project also investigated these science teachers' and students' perceptions of EMI teaching and learning processes, their preference of instructional language and their beliefs about teaching and learning in the EMI environment. Interviews also probed teachers' language awareness, teachers' and students' belief about EMI, students' self-concepts in science (students' perceptions or beliefs about their ability to do well in science, see Wilkins, 2004)) and their perceptions of language challenges and coping strategies in EMI classrooms.

The results from the observational data show similar interactional patterns in both early–full and late–partial EMI science classrooms when measured as percentages of interaction time, distribution of time between teacher and student talk and frequency of pedagogical functions. However, the nature of the interactions is different. In late–partial EMI schools, overall, there are more (but shorter) student initiations and responses, more use of higher-order questions from the teachers but less direct feedback to students. Both teachers and students tend to use their L1 more. In both types of schools, there was less interaction time and a lower maximum length of student turns and more L1 use in grade 11 than in grade 10.

The discourse analysis of the four biology lesson transcripts also shows that both early–full and late–partial EMI students predominantly produced incomplete sentences consisting of short, technical nouns or noun phrases referring to scientific items. Science teachers rarely made any attempts to correct their students' language mistakes, nor did they encourage students to produce a complete sentence. This lack of teacher feedback on students' L2 language production perhaps reflects the fact that EMI science teachers rarely provide comprehensible input to facilitate students' L2 language learning.

These findings suggest the important role of the teacher's modified input in teacher–student interaction in developing students' content knowledge and language skills. The adoption of EMI appears to lead to the development of students' comprehension of content knowledge more than development of their language production skills. As a result of their language shortfalls, the students' L2 productive skills remain under-developed despite English instruction. This lack of language support by teachers appears to indicate a gap between the aims of the EMI policy and its implementation.

The interview and questionnaire data show that the science teachers from both the early–full and late–partial EMI schools held many of the same views about their EMI teaching experiences, but they differed in their attitudes towards the value of English language skills and their language awareness. The early–full EMI teachers believed English language skills were important and

these early–full teachers have a higher language awareness than the late–partial EMI science teachers.

Students from both types of schools also held similar views about their EMI learning, indicating that they welcome the adoption of EMI instruction. However, while the late–partial EMI students see EMI as an opportunity to improve their English, those in the early–full EMI schools believe that EMI discouraged them from learning.

By providing an evidence-based, pedagogically focused analysis of teacher and student classroom interactions and their perceptions, this research sheds light on ways to improve the quality of instructional practices in different EMI classrooms in Hong Kong and in similar contexts around the world. ■

List of abbreviations

CALP	Cognitive Academic Language Proficiency
CBI	Content Based Instruction
CDC	Curriculum Development Council, Hong Kong
CMI	Chinese as Medium of Instruction
CLIL	Content Language Integrated Learning
CS	Code-switching
EMI	English as Medium of Instruction
EDB	Education Development Bureau, Hong Kong
ESL	English as a Second Language
HKDSE	Hong Kong Diploma of Education
HKAL	Hong Kong Advanced Level Examinations
HKCEE	Hong Kong Certificate of Education Examinations
KLA	Key Learning Areas
IRF	Initiation-Response-Feedback sequence
L1	First Language
L2	Second Language

MOI	Medium of Instruction
SLA	Second Language Acquisition
SPSS	Statistical Package for the Social Sciences

Chapter 1

Introduction: study objectives and overview

1.1 Chapter guide

This chapter introduces the research topic and objectives, describes the research background, provides an outline of the subsequent chapters of the thesis and highlights the significance of the study.

1.2 Objectives

This study arose from my personal experience as a native speaker of Cantonese Chinese growing up in Hong Kong. As a chemistry student, I encountered numerous language challenges during the transition from Chinese as the medium of instruction (CMI) to English as the medium of instruction (EMI) at senior secondary school and university. Until 2009, CMI students studied science subjects in Cantonese. In 2010, the Hong Kong government introduced a 'fine-tuning language policy', allowing all CMI schools to switch to EMI. All students who would previously have studied in Chinese are now instructed in English. The CMI students are now instructed in English for all content subjects such as physics, biology and chemistry. Although CMI schools switched to EMI, with textbooks and examination materials written in English, teachers and students at CMI schools still predominately use a significant amount of

Cantonese for spoken interactions in the classroom (Evans, 2016; Lin 2006; Lo & Macaro, 2012; Lo, 2015; Poon, 2013). As a result, while many students may be learning science through English, they are interacting with their teachers and peers predominantly in the Cantonese environments. My own experience suggests this can be problematic, as students may not have adequate English skills, or the support from teachers that they need for EMI instruction.

The choice of medium of instruction (MOI) for all Hong Kong secondary schools has been a controversial topic (Evans, 2000). Many studies have examined the impact of the medium of instruction on the quality of classroom interactions (Chan, 2013, 2014; Lo and Macaro, 2012; Lo, 2014). In one recent study, Lo and Macaro (2012) examined the quality of teacher–student interaction in junior secondary classrooms. They compared the quality of L2 language teaching before the implementation of the MOI policy in 2010. Students in humanities and science lessons between grades 9 and 10 from EMI and MOI-switching schools (schools switching from CMI to EMI) were recruited. The results showed that science lessons were relatively teacher-centred, and that the teacher–student interactions consisted of simple Initiation–Response–Feedback (IRF) sequences. Thus, Lo and Macaro suggested that these interactional patterns might result in a significantly lower proportion of student talk, with frequent short turns. Teachers in science lessons were found to pay less attention to form-focused instruction (e.g. teaching grammar rules and

vocabulary) in L2. However, Lo and Macaro's study was conducted before the implementation of the 'fine-tuning' MOI policy. Their findings might therefore not accurately describe the current MOI situation in Hong Kong, where students in Chinese-medium schools were encouraged to adopt EMI for teaching science subjects under the fine-tuning policy. We therefore do not know the linguistic implications of the fine-tuning policy on schools electing to switch to EMI for the study of science.

This study was designed to address this research gap and to provide empirical evidence of the current MOI situation at senior secondary levels in Hong Kong. The study set out to explore how teachers and students actually interact in their EMI classrooms and to understand how teachers and students view their EMI experiences. This study thus aimed to explore two main dimensions of the MOI issue: (1) classroom interactions; (2) teachers' and students' perceptions of the teaching and learning process. To understand the impact of the changing MOI situation, the study compared these dimensions in two types of EMI secondary schools: 'early–full EMI' and 'late–partial EMI'. This research therefore extends Lo and Macaro's (2012) study, using a similar research design to examine the quality of classroom interactions in a new context—senior secondary science classroom (physics, biology and chemistry).

A total of 545 grade 10 and 11 science students and 19 teachers in eight EMI schools were recruited for the study; 33 science lessons were observed,

amounting to some 1,360 hours of video-recording. The teacher–student interaction between early–full EMI and late–partial EMI secondary schools and between grades 10 and 11 in each school group were compared. The data were analysed for: interaction time, proportion and length of teacher and student talk, pedagogical functions of teacher and student talk, proportion of L1 and L2 use, and teachers' questions and feedback. The science content in the observed lessons was analysed using Mortimer and Scott's (2003) framework.

In addition, this study examined teacher and student perceptions of their teaching and learning process in EMI science classrooms using a questionnaire and semi-structured interviews. Teachers were asked about their views on EMI teaching, their language awareness in science teaching, their choices of instructional language in the classroom, their personal views on the students' language challenges and the strategies they use to manage these challenges.

Students were asked about their self-concepts in science, that is, students' perceptions or beliefs about their ability to do well in science (Wilkins, 2004). The language challenges and coping strategies used by the teachers and by students in each group were identified and compared to see whether the strategies are similar in early–full and late–partial EMI schools.

In the following sections, I briefly summarise the background to this study, explaining why Hong Kong is an interesting context within which to conduct

EMI research. I also provide an overview of the thesis structure and summarise the content of each chapter.

1.3 Background to the research

The MOI at secondary school has been a controversial topic in Hong Kong for at least the past two decades (Evans, 2013; Poon, 2010, 2013), linked to Hong Kong's history as a British colony from the mid-19th century until its return to Chinese sovereignty in 1997. In recent decades there have been three periods of MOI development (Chan, 2014). The first was the British government's laissez-faire policy from 1946 to 1997. The second was the compulsory mother-tongue policy that followed the handover of Hong Kong to China from 1998 to 2009. This policy allowed only 114 secondary schools to adopt EMI in teaching content subjects (e.g. science, history, geography) while the remaining 307 schools used CMI. The third period has been the fine-tuning of the MOI policy since 2010, allowing individual schools more autonomy to decide their MOI in different content subjects at senior levels (discussed further in chapter two). Under this initiative, secondary schools originally using Cantonese as their MOI who met certain criteria (e.g. the students' learning ability, the teachers' capability, the requirements of individual subjects and school resources) were allowed to switch to use English medium.

In making the switch to EMI these schools have responded to public pressure after evidence of a decline in the English proficiency of graduates and

an increase in the strongly expressed parental desires for children to become fluent in English in EMI schools. In content subjects like science, teachers and students used to a Cantonese environment have now switched to English medium, starting at senior levels (e.g. grade 10) and extending to all levels. However, local studies have pointed out problems with this 'late–partial' English immersion (Lin, 2006; Poon, 2004, 2009). Problems include the students' inadequate English proficiency, especially their lack of technical vocabulary, leading to the students' inability to understand subject content knowledge and express their ideas effectively in English (Yip et al., 2000). For content-subject teachers, the lack of teacher training in delivering content in English is a major cause of poor quality of teaching (Chan, 2014; Kwan, 1989; Poon, 2013). Thus, many teachers respond to their students' limited English proficiency by opting for Cantonese as the main instructional language in addition to English (Lin, 2006).

In these code-mixing classrooms, teachers used Cantonese as the primary instructional language for teaching science subjects, supplemented by English technical vocabulary. English was used as the language for reading and writing in the classrooms. Some teachers speak only Cantonese when teaching English scientific writing (Lin, 1997). Students used English textbooks and memorised technical terms in English but interacted with teachers only in Cantonese for various purposes such as discussion, classroom discipline, and relationship

building (Lin, 2006; Yip et al., 2007). Such mixed-mode instruction was prevalent in Hong Kong secondary schools in the 1980s and 1990s (Tsui, 2004).

The current situation in Hong Kong is that the early–full EMI schools are genuine EMI schools. English is both the spoken and written language in the classroom (Evans, 2011). Teachers and students interact mostly in English. The late–partial EMI schools are code-switching schools, as identified in Lo and Macaro's (2012) study. While teaching and exam materials are written in English, teachers and students interact mainly in Cantonese, with supplementary English technical vocabulary.

Under the fine-tuning language policy in 2010, CMI schools in Hong Kong started to implement EMI instruction at senior levels (Council, 2009; Poon, 2010). Students who were exposed to Chinese as the medium of instruction at junior levels are expected to improve their English skills by adopting English for most of the content subjects like physics, biology and chemistry.

However, most of the students have limited English ability and no experience in EMI learning (Poon, 2013). The expectation that students' English ability will improve through EMI is problematic. The extent of the educational benefits these students can receive from EMI instruction is questionable. This is supported by Chan's study (2014), which explored the views of the principal, teachers and students in content-subject classrooms during the implementation of the fine-tuning language policy in 2010. The study showed that the increase

in the amount of EMI teaching had resulted in many students encountering challenges related to language (e.g. poor English communication skills), and had led to pedagogical and practical issues in content-subject classrooms (e.g. limited interaction with teachers).

Chan argued that the increased amount of EMI instruction benefited the more capable students but at the cost of sacrificing the interests and learning needs of less capable students. Similarly, Poon, Lau and Chu (2013) surveyed 461 grade 7 secondary students about their EMI experience. Again, the majority of the EMI students did not seem to favour the use of English for instruction because they encountered numerous language difficulties when switching from Chinese to English. These difficulties are even greater for students in the late–partial EMI schools, where most of the students do not possess sufficient English skills for EMI instruction. However, the two studies mentioned above (Chan, 2014; Poon, Lau and Chu, 2013) did not examine what the teachers and students do in the EMI classrooms or explain how these language challenges develop or are managed. In fact, the two studies provided very little information about the teaching and learning processes in EMI schools, such as classroom interaction, although interaction is perceived to be crucial for language learning. In the next section, I introduce theoretical arguments that explain why classroom interaction is the context for this research and how

classroom interaction can provide the opportunity for EMI students to achieve language learning.

1.4 Overall arguments of the thesis

Research in second language acquisition (SLA) suggests that meaningful negotiation plays an important role in the L2 acquisition process. Such negotiation can be conducted successfully using the target language with guided feedback. According to the interaction hypothesis (Long, 1983), when learners are exposed to more comprehensible input, they can produce more L2 through meaningful interactions with teachers, who can receive the students' modified input and provide corrective feedback on their L2, which ultimately contributes to students' L2 learning.

Teacher–student interaction offers a social context where learners can focus on and reflect on language forms and meanings in the process of using them. As well as learning language use and grammar within authentic social contexts of interaction, learners need multiple opportunities to focus on language form and meaning (Swain and Lapkin, 2002). Interacting with others to discuss language forms and meaning helps learners come to understand how the grammar of the language works in contexts of use and how grammatical choices shape the meaning that is created.

The interaction hypothesis is supported by previous research that has explored EMI learning in content subjects in Hong Kong. Such research shows

that students need to develop both the necessary English proficiency and capacity for L2 learning in content subjects by filling in their current language gaps (Yip, Tsang and Cheung, 2003). Yip (2004) argues that efforts should be made to close the gap between how students conceptualise scientific knowledge in L2 and how they conceptualise it in L1. This can be achieved by the use of prompting questions to evaluate their scientific understanding and identify their misconceptions (Yip, 2004). The gap between what students can understand in English and what they can articulate in English can be closed by providing sufficient L2 learning opportunities through classroom interactions to test their L2 hypotheses (Lo, 2014) and by giving corrective feedback on their L2 utterances.

It is questionable whether such language and knowledge gaps can be closed in late–partial EMI secondary schools if teachers and students only interact in the L2. These students were instructed in CMI at junior levels and have now switched to EMI at senior levels. As a result, they have limited English ability and perhaps no experience in EMI learning. This may result in a mixed mode of instruction in many late–partial EMI secondary schools.

While research in SLA argues that language acquisition can result from an L2-only setting, a growing number of studies have validated teachers' L1 use in content teaching, especially for L2 vocabulary (Zhao and Macaro, 2014). There is also overwhelming evidence that most EMI teachers consider the L1 an

indispensable tool in the L2 pedagogy (Lin, 2006; Probyn, 2001; 2009) For example, Lin (2006) analysed teaching practices in Hong Kong science classrooms and proposed that drawing on their L1 and cultural resources could help junior CMI science students with poor English proficiency to manage use of more technical terms in English.

EMI classrooms are predicated on the belief of the benefits that accrue from massive exposure to the L2. However, many students cannot benefit from English-only classrooms where they suffer due to their poor English ability. It is therefore perhaps appropriate to ask whether L1 can play an important role in EMI teaching, in light of the fact that a significant number of studies have reported the benefits of L1 in EMI teaching (Lin, 2006; Lo & Macaro, 2012; Probyn, 2006). L1 can perhaps be beneficial in EMI contexts where content learning is the primary objective rather than language acquisition. Yet very little research evidence on L1 use in the EMI setting is available (Lo and Macaro, 2015), and practical pedagogical suggestions for supporting students' language challenges appear inadequate (Chan, 2014; Poon et al., 2013).

This study is a response to these current knowledge gaps in the EMI literature. This study set out to explore how teachers and students interact in science classrooms, and how they feel about their EMI teaching and learning experiences. Thus, this study compares teacher–student interactions in science classrooms in both 'early–full' and 'late–partial' EMI schools, and investigates

teachers' and students' perceptions of the EMI experience in these science classrooms. The research questions were:

1. What is the nature of classroom interaction in EMI science classrooms?
2. What are the differences and similarities in classroom interaction between early–full and late–partial EMI schools?
3. What are the differences and similarities in classroom interaction between grades 10 and 11 in early–full and late–partial EMI schools?
4. What are teachers' perceptions of teaching science through EMI?

   What are students' perceptions of learning science through EMI?

1.5 The structure of the thesis

Chapter two situates the research problem, critically evaluates previous research on the topic, identifies existing knowledge gaps, presents the research questions and argues for the need to conduct the current research.

Chapter three explains the research design, data collection procedures, and the population, sampling frame and selection criteria. The chapter also reports on the pilot study and the research instruments.

Chapter four, the first of four chapters of findings, reports the similarities and differences between the four early–full and four late–partial EMI science classrooms and compares grades 10 and 11 in both types of school. This part of the analysis addresses the two research questions: (1) What are the differences

and similarities in the features of classroom interaction? (2) What are the differences and similarities in classroom interaction between grades 10 and 11 in both types of school? The chapter presents the analysis of the interaction patterns in terms of percentages of interaction time, proportion of teacher and student talk, the length of the turns, and the ratio of L1/L2 use. These results provide a comprehensive, comparative account of classroom interactions in the two types of EMI schools at a macro level.

Chapter five examines the nature of classroom interactions qualitatively as well as the features of language in school science used in a small case study of four observed EMI classrooms. This part of the analysis extends the findings reported in chapter four and aims to further answer the question: How do teachers and students interact in some of the observed EMI science classrooms? The chapter briefly summarises the analytical frameworks (Mortimer & Scott, 2003) and categories, and then presents an example with four biology lesson transcripts from the data to illustrate how these interactions are different in teaching science and what the observed teaching pedagogies are behind these interactive sequences.

Chapter six reports on the science teachers' perceptions of EMI teaching in science classrooms. This part of the analysis draws from two sets of data: audio-recorded semi-structured interviews with participating science teachers before and after observation. The pre-observation interview lasted around three

minutes and focused on the teaching objectives of each observed lesson. The post-observation interview was between 20 and 40 minutes. Teachers were asked, first, about their overall impression of the observed lessons. The second part of the interviews provides data on teachers' perceptions of EMI teaching. Teachers were asked about their views on using English to teach senior secondary science, the language challenges and coping strategies. The results presented in this chapter aim to address the research question: What are the teachers' perceptions of teaching science through EMI?

Chapter seven reports on the students' perceptions in early–full and late–partial EMI classrooms. The students in the late–partial EMI schools had switched from Cantonese to English medium during the first year of the science classrooms (grade 10 vs. grade 11). This part of the analysis draws from two sets of data: semi-structured interviews with the students in the observed science lessons,and focus groups. Five students from each class were randomly selected to participate in the focus-group interviews. The students were first asked about their overall impression of the observed lessons. Students were then asked about their views on using English to learn senior secondary science, specific language challenges in specific science subjects (physics, biology, chemistry), the language challenges in their interactions with teachers and their coping strategies. The results presented in this chapter aim to address the research question: What are the students' perceptions of learning science through EMI?

Chapter eight summarises all the major findings from each results chapter, and brings them together to provide an overall picture of teaching and learning secondary science in EMI classrooms. The findings will then be used to explain the implications for teaching and learning of using English to teach science in different types of EMI classrooms (early–full and partial-late EMI classrooms) and the role of L1 in the teaching and learning processes in these EMI classrooms. The chapter sets out suggestions for pedagogy and EMI policy. Finally, I discuss the limitations and contributions of this study and suggest further research directions.

The next chapter critically evaluates previous research on EMI that is relevant to my research questions about interaction in EMI classrooms, and teachers' and students' perceptions of EMI in early–full and late–partial EMI secondary science classrooms. ■

Chapter 2

Literature review

2.1 Introduction

This chapter outlines the research background, critically evaluates previous research on the topics, identifies existing knowledge gaps and argues for the need to conduct the current research. In focusing on the topics that are directly related to my research questions, I review different L2 immersion programmes and EMI situations internationally, EMI development in Hong Kong, research on EMI classroom interactions and teachers' and students' views on their EMI experience, language challenges and coping strategies.

2.2 L2 immersion models around the world

The commonsense view is that students benefit more if they are educated in their first language (L1). For this reason, the education systems in many countries use L1 for the MOI. However, in some countries or regions historical, political and socioeconomic circumstances have led to the adoption of L2, very often English, as the MOI. In places like Hong Kong, Singapore, India, Malaysia and some African countries, English is the colonial language of past British sovereignty. In bilingual or multilingual countries, L2 immersion is seen as

promoting appreciation of different cultural groups (e.g. in Canada) and increasing mobility or advanced knowledge transfer in a culturally diverse community (e.g. in the European Union). In English-speaking countries, immersion programmes allow new immigrants to integrate smoothly into the mainstream English education system (US, UK, Australia).

According to Swain and Johnson (1997:6), there are eight key elements of a prototypical immersion programme:

1. L2 is a medium of instruction.
2. The immersion curriculum is parallel to the traditional curriculum which is introduced through first language
3. there is an overt support for the L1.
4. The immersion programme aims to induce learners' additive bilingualism, learning a second language without scarifying the learning of first language.
5. Learners' exposure to L2 is largely constrained into classroom context.
6. Learners in immersion classrooms have similar or limited L2 language proficiency.
7. Immersion teachers are normally bilingual, sharing the same L1 and L2 as their students.

8. The classroom culture only reflects the students' first language culture instead of recreating the L2 culture.

In addition to these key elements, variable features make immersion programmes around the world different from each other. These features include the starting level at which immersion is introduced (at primary, secondary or tertiary levels within the education system); different types of immersion (early immersion: at the start of students' formal education; early mid (grades 4 to 5), and late (grades 6 to 7)); the extent of immersion (full immersion with only L2 or partial immersion with less than half content subjects are taught in L2); the ratio of using L1 and L2 at different stages within same immersion programme; the commitment of teachers and their schools; the attitudes towards the L2 culture and the status of L2 in the society (Swain & Johnson, 1997:7). Although different immersion programmes have their own motives, socioeconomic contexts and manner of implementation, they share the same goal of developing learners' L2 language proficiency through content subjects rather than by teaching L2 as a language subject. The following sections briefly review different L2 immersion models around the world.

Immersion programmes first appeared in Canada in the 1960s. The aim was not only to increase students' cultural awareness but also to develop their L2 language proficiency in subject areas. According to Swain and Johnson (1997), a group of parents in St. Lambert, Quebec, were worried that their

children were not achieving high proficiency in French. This could have a negative impact on their children's future and economic success in Quebec, where French is the official language. These parents urged their school to introduce a completely different language programme, French immersion, to teach French through progressively exposing the students to French as the medium of instruction. The belief was that this immersion approach would promote 'additive bilingualism', i.e. their children would learn French as second language while maintaining their first language, English. In late 1960, many Anglophone communities started to introduce such immersion programmes across Canada, recognising the high levels of communicative competence and advanced language proficiency students could gain through immersion and the value of speaking French.

The additive bilingualism offered by French immersion proved that immersion is one of the most effective approaches to L2 acquisition. The approach influenced second language teaching methods and was later widely adopted in many foreign language teaching contexts. One example is the teaching of English as a foreign language in the U.S. through content-based instruction (CBI) in the 1970s. Unlike Canadian immersion, CBI aims to let new immigrants quickly acquire the necessary English skills to study content subjects like science before beginning their mainstream education with native speakers of English. CBI has also influenced the teaching of English as a foreign

language (EFL) around the world (Davies, 2003). Nevertheless, some critiques have been challenged about the effectiveness of these immersion programmes for foreign language learning. They include teachers' inadequate expertise, competence of language teaching, their lack of experience in teaching content knowledge through the target language and skills to help learners to overcome their language problems, and the challenge of finding adequate levels of challenge to ensure student motivation and matching with their age and cognitive levels (Deusen-Scholl and Hornberger, 2008).

In Europe, the preferred model was content-and-language-integrated-learning (CLIL), which is 'a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language'(Coyle, Hood, & Marsh, 2010, p. 1). Since the 1990s, CLIL has gradually been adopted in different parts of Europe (European Commission, 2000). It aims to increase student mobility around different European countries by increasing their English competence in content-subject areas. CLIL is similar to the immersion programmes in English-speaking countries, with the aim that students acquire the L2 through a natural learning process (Jäppinen, 2005, p. 149), fostering bilingualism. Although CLIL and immersion are often used synonymously in foreign language research, Lasagabaster and Sierra (2009) draw attention to the fact that there are more differences than similarities between CLIL and immersion. They suggest that a clear-cut distinction is

needed as the terminological confusion could have substantial consequences, with teachers not fully understanding clearly the language objectives and language outcomes of these two approaches. Lasagabaster and Sierra (2009) suggest there are differences between CLIL and immersion in terms of classroom language, teacher training, the sociolinguistic context, the teaching principles, types of teaching materials, and the achievable linguistic objectives.

Firstly, the language in CLIL classroom is not spoken in the community and learners only have exposure inside the classroom. This is different from immersion in which the languages exist in the students' local environment. Secondly, compared to immersion teachers, only a relatively low percentage of CLIL teachers are native speakers of the language they are teaching. Thirdly, the vast majority of CLIL programmes are introduced at secondary or tertiary levels, making them late immersion programmes, while many immersion programmes start at an early stage, in pre-school or at primary levels, making them early immersion. The difference in the years of exposure to the foreign language means that CLIL and immersion programmes are not comparable. Fourthly, CLIL students have usually received traditional foreign language teaching at primary level in which English is taught as a subject. In terms of language objectives, immersion programmes aim to help learners achieve a native-like L2 proficiency, and teaching materials are thus written for native speakers. CLIL programmes do not necessary reach the same goal, and thus

their teaching materials are abridged to accommodate learners with limited language proficiency. Dalton-Puffer (2007) notes that in some CLIL classrooms teachers pay special attention to developing students' subject knowledge and L2 communicative competence, while teachers in immersion programmes only teach students the subject knowledge in the target language, with less focus on the language learning. Finally, students in immersion classrooms are often immigrants, whereas in CLIL classrooms, students are local students sharing same first language.

2.3 EMI as a global phenomenon

British colonial regions such as Hong Kong, Malaysia, Singapore and India, have adopted EMI in their mainstream school systems. Graddol (2006) notes that global institutions in many non-English-speaking countries have also started EMI instruction in their university degree courses to attract more international students and teachers. The wide adoption of EMI courses is demonstrated by a recent report on the EMI situation in 55 counrties, with nearly 89% of public universitiies and over 90% of private universities using English as medium of instruction (Dearden, 2015).

In Europe, the Bologna declaration signed in 1999 aims to develop a common Higher Education framework, with comparable degrees, easy academic credit transfer and promotion of student and faculty exchange across the EU (European Ministers of Education, 1999). A direct consequence of this

declaration is the massive growth in the number of EMI courses offered at European universities (Coleman, 2006; Doiz, Lasagabaster, & Sierra, 2011). Studies have also reported a change in the national language policies in some EU countries, with different interpretations of EMI policy by different stakeholders (e.g. school management, lecturers, students). Numerous challenges implementing the EMI courses at university settings in different European countries have been noted in Austria (Tatzl, 2011); Denmark (Thøgersen & Airey, 2011); Italy (Costa, 2012; Crawford, 2010; Francomacaro, 2011); Norway (Ljosland, 2011); Sweden(John Airey & Linder, 2006; John; Airey & Linder, 2008; Björkman, 2008); Spain (Doiz, Lasagabaster, & Sierra, 2014); Switzerland(Studer, 2014).

A Bologna-like plan was also announced at the 2012 Asia Pacific Economic Cooperation (APEC) summit, to explore ways of facilitating faculty and student mobility across Asia. This will inevitably speed up the current widely adopted practice of EMI courses at tertiary level in different Asian universities. The aims of these EMI programmes are to improve teachers' and students' English proficiency, increase university rankings and attract more foreign exchange students (Kirkpatrick, 2014a). Studies have reviewed the issues related to the expansion of EMI programmes at university level, for example, in Africa (Alidou, 2004); Asia-Pacific region (Kirkpatrick, 2011, 2014a, 2014b); China (Hu, Li, & Lei, 2013; Hu, 2009); Hong Kong (Evans & Morrison, 2011a, 2011b;

Flowerdew, Li, & Miller, 1998; Li, Leung, & Kember, 2001; Lin & Morrison, 2010; Tsui, 2004); India (Annamalai, 2004)Korea (Byun et al., 2010; Kim, 2011; Kim & Sohn, 2009); Malaysia (Gill, 2004; Othman & Saat, 2009)Singapore (Pakir, 2004); Thailand (Lavankura, 2013); Taiwan (Hou, Morse, Chiang, & Chen, 2013); Turkey (Demirbulak, 2011; Sert, 2008) and Vietnam (Dang, Nguyen, & Le, 2013; Vu & Burns, 2014).

A review by Hamid and his colleagues (Hamid, Nguyen, & Baldauf, 2013) explores the policy and practices of MOI in 10 Asian regions (Bangladesh, Hong Kong, India, Indonesia, Japan, Malaysia, Maldives, Nepal, Timor-Lester and Vietnam) and concludes that the dominance of English as the medium of instruction is a response to globalisation pressures and the need to increase students' English proficiency as English is an international language. But the MOI practices and different policies on the degrees of EMI adoption in different regions have reflected the regions' different socio-economic and educational motivations and their goals to promote their own identities, cultures and first languages.

Although EMI is recognised as an important move to ensure the competitive success of education systems in many non-English speaking countries, concerns about the quality of EMI implementation continue to arise and problems of EMI adoption are observed in many countries. Problems include the lack of EMI training of teachers and poor English proficiency among students (Tamtam,

Gallagher, Olabi, & Naher, 2012). In addition, Kirkpatrick (2014b) points out that universities in Asia have not developed a language policy that enhances good quality of EMI instruction. He argues that Asian universities do not consider the multilingual setting in which they are located, nor do they recognise the varieties of English that are spoken in the Asian region. In Hong Kong, six government-funded universities are English medium. Two of them have some forms of language policy to promote bilingualism. The Education University of Hong Kong, formerly (Hong Kong Institution of Education, HKIED), has a clear language policy to promote functional trilingualism in Cantonese, Mandarin and English (Kirkpatrick, 2014b). The Chinese University of Hong Kong (CUHK) has a bilingual policy and but was threatened by the desire of the decision by the previous president of CUHK to increase more courses for English medium in order to attract overseas staff and students to improve its ranking and be part of the university internationalization process. This resulted students and alumni of CUHK in 2005 staging an adamant protest, calling for the president's resignation for mishandling the language issue and later a student filed a legal case against the University directives to deliver more EMI which demeaned the importance of Chinese and disregarded the original mission of CUHK. However,this legal challenge failed and the Supreme Court ruled that CUHK had no legal obligation to keep Chinese as MOI because its founding ordinance did not mandate the university to use

Chinese as the principal language of instruction (Kirkpatrick, 2014b) . CUHK was found by a number of previously Chinese-medium private colleges in 1963 to provide a Chinese-medium tertiary education, with (spoken Cantonese and written Modern Standard Chinese) as its medium of instruction, in competition with the only university in Hong Kong, University of Hong Kong which offered English medium education (Lin & Man, 2011). As a result, the university final report on bilingualism states that the universal academic subjects with little emphasis on cultural specificity such as science and engineering should be taught in English. It also suggests the choice for MOI should allow for flexibility, with consideration of the nature of the academic subject, discipline requirements, students' language habits, competence and cultural backgrounds as well as teachers' concerned and practical needs, and such decision can be made and varied at the Department level on the ratio of use Cantonese, Putonghua and English (Chinese University of Hong Kong, 2007). The case of CUHK and HKIED in Hong Kong presented a good example of a localized language policy inside one's institution with consideration of the cultural setting in which they are located. Kirkpatrick suggests that universities in Asia need to recognise the full potential of different 'Englishes' as a lingua franca when adopting EMI.

To summarise, immersion, CBI, EMI and CLIL can be ranged along a continuum according to their degree of focus on language or content. Table 2.1 summarises these different approaches to immersion language learning (Dale & Tanner, 2012; Wannagat, 2007). The columns on the left-hand side indicate that CBI is more language focused than CLIL. EMI and traditional immersion programmes, shown on the far right-hand side, are primarily content focused, and CBI teachers see foreign language proficiency as the natural product of the learning process. EMI is similar to immersion programmes but differs in that those students who have passed the threshold level are allowed to study in full EMI classrooms. In addition, the first language is not normally permitted in the classroom because schools or policy makers see the use of L1 or code-mixing between L1 and English as poor teaching practices which reduce students' opportunity to practice their English. However, in reality, many teachers adopt a code-mixing strategy to accommodate students with poor English abilities because many of them do not attain the levels that they can communicate effectively and express their learn knowledge logically in English (Poon, 2013; Probyn, 2006). There is no language ability assumption for students in traditional immersion classrooms because these immersion programmes start at early stages (e.g. primary level) in the education system. The use and amount of L2 use is progressively increased, in addition to first language instruction, across the years of the programme.

Teachers	Language teachers	CLIL teachers (language or subject teachers)	Subject teachers	Immersion subject teachers
Teachers' language proficiency	Native speakers	Bilingual teachers (same L1 and L2 with students), qualified to teach subject matter only	Bilingual teachers (same L1 and L2 with students),	Native speakers
The kind of language teachers and students are working	Work on language through subject content	Work on the language of subject-content	Work on subject content through English	No attention paid to language as teaching is done in another language
Learners	Immigrants, preparing to migrate to mainstream English education system	Local students who received traditional English teaching as a subject at primary level, same L1 and L2 with their EMI teachers	Local students who received traditional English teaching as a subject at primary level, same L1 and L2 with their EMI teachers	Local students, preparing to study or work in region where another foreign language is the common or official language
Learner's language environment	Dominated by L2, exposure to L2 in both school and local contexts	Dominated by L1, exposure to L2 only restricted to classroom context	Dominated by L1, exposure to L2 only restricted to classroom context	Dominated by L1 but L2 could also be found in the community and outside classroom contexts
Classroom culture	Culture of the L2	Similar to local L1 community	Similar to local L1 community	Culture of the L2
Aims	to teach language	To teach content and language	to teach content subject	to teach content subject
The kind of knowledge teachers refer to	Language knowledge	Content knowledge and knowledge about the language of the subject	Content knowledge	Content knowledge
Assumption teachers make about the learning process	Language is learned in context through topics	Content and language are complementary to each other	Content is learned through English	Content is learned without much attention to language
Examples	CBI in U.S.	CLIL in Italian classrooms	EMI in Hong Kong	Canadian immersion
Goals	To gain subject knowledge by demonstrating the language ability in a foreign language	Learning the foreign language and content knowledge is a dual process and connected, parallel objectives in CLIL classrooms	Learners are expected to demonstrate a threshold level of English proficiency before they admitted to EMI programmes	To gain proficiency of the foreign language as a natural process through exposure in the environment, additive bilingualism

Table 2.1: Summary of the focus and outcomes of different learning approaches
Source: adopted from (Dale & Tanner, 2012; Wannagat, 2007)

2.4 EMI development in Hong Kong

In Hong Kong, a former British colonial city, English is still an official language in government and in the business sector. High proficiency in English still confers superior socioeconomic status and is an essential requirement for academic and career achievement (Evans and Green, 2007; Tsui, 2007). Parents in Hong Kong understand clearly that good English is key to the success of their children in a globalised world where English is the lingua franca (Poon, 2010). While most primary schools are CMI and all government-funded universities adopt EMI, MOI at secondary level has been a controversial topic, leading to a major public debate that has moved through four main stages over the past four decades (Poon, 2013).

Stage 1: In the 1960s, there were two types of secondary school: Anglo-Chinese schools using EMI and traditional Chinese schools using CMI (Education Commission, 1981).

Stage 2: In the 1980s, the priority given to Hong Kong students learning both Chinese and English, combined with the massive expansion in secondary education, led to a new vision for Hong Kong. The aim became not only to produce a group of elite English users but also to foster those for whom Chinese was the main medium for communication. Schools made the shift towards a complete first language education (CMI) in the early compulsory years. The first nine years of schooling (primary grades 1 to 6 and junior secondary grades 7 to

9) were taught in Chinese, with the exception of a few EMI schools that had proven success in teaching content subjects through English. The distinction between Anglo-Chinese and Chinese secondary schools was abandoned; each type of school could use only one language as its MOI.

Stage 3: In the 1980s and 1990s, many schools opting for EMI in fact adopted a mixed-code teaching approach in delivering the curriculum (Education Commission, 1990). This mixed-code instruction was criticised heavily by both the public and education sectors because teachers constantly used Cantonese rather than English to accommodate students' poor English proficiency in some EMI schools (Poon, 2013). For students, the disadvantages of this mixed method were that it could lead to rote-memorisation of facts in English and time wasted on the translation of English texts. The rote memorisation of technical terms in English meant that this approach was also considered to present obstacles to the development of higher-order cognitive thinking (Commission, 1992; Education Commission, 1988, 1990, 1996).

To avoid the claimed drawbacks of mixed-mode teaching and ensure one language in one school, in 1998 the government adopted a clear-cut language policy: all schools should adopt CMI, apart from a few exceptional schools with proven success in EMI teaching. All primary grade 6 students were tested on their English proficiency before they were admitted to secondary schools. Only students who passed the threshold level of English competence could continue

to use English as the MOI at secondary level. In 1998, the number of EMI schools dropped significantly from approximately 90% to 25% (Glenwright, 2003). All secondary schools in Hong Kong were separated into EMI and CMI schools. Hong Kong primary students were classified into different MOI groups according to their performance in the Academic Aptitude Index test at primary grade 6, before they started secondary schooling.

During the eight years of its implementation, the clear-cut mother-tongue policy was severely criticised by stakeholders (employers, parents, teachers and students) for its contribution to the perceived decline in students' overall English proficiency. Criticism was vocal, even though government research suggested that CMI brought many learning benefits to both teachers and students by enabling diversified teaching modes, closer relationships between teachers and students, and effective class discussion. The government claimed that 'CMI is bearing fruit' (Education Bureau, 2005, p. 8), and suggested that students could develop higher-order thinking more effectively in L1, leading to better academic outcomes and student achievements at the junior secondary level (Education Bureau, 2005). However, criticisms linking CMI with unsatisfactory levels of English proficiency among students were a major factor behind a parent-led push urging a reversal of this compulsory policy (Poon, 2013).

Stage 4: In a recent review of the development of MOI policy, the 'fine-tuning' policy and the use of Mandarin as MOI in Chinese Language teaching have added contradictory layers to the current MOI situation by reducing the role of mother-tongue teaching (Evans 2013). In 2010, the government fine-tuned its previous policy. The new policy aimed to improve English proficiency by providing a language environment for English learning in non-language subjects through immersion. This revised policy allows individual schools, especially those CMI schools with greater autonomy, to decide their preferred MOI in content subjects according to the students' learning ability, the teachers' capability, the requirements of individual subjects and school resources. The government stressed that this fine-tuning policy maximises the educational values offered by the two MOIs (Legislative Council, 2009). While students with poor English proficiency can learn effectively during mother-tongue teaching in their early years, those in the same school who have improved their English to a threshold level can progress from partial to total immersion in English in subject areas. The implementation of this policy is also believed to reduce the labelling effects arising from the segregation of CMI from EMI schools. The intention was that students with poor English proficiency skills would not be discriminated against if they were attending a CMI school.

However, the two studies available since 2010 that have reviewed the implementation of the fine-tuning language policy show conflicting results as to

its educational value to students. Chan (2014) explored stakeholders' perspectives (i.e. the views of the principal, teachers and students in content subject classrooms) on the implementation of the policy in one MOI-switching school (allow EMI for students who met the language threshold), and reported that the increased amount of EMI teaching had resulted in many linguistic challenges and had raised pedagogical and practical issues in content classrooms. Chan argued that the increased amount of EMI instruction under the new policy only 'benefited the more capable students but sacrificed the interests and learning needs of less able students' (Chan, 2014, p. 459). Similarly, Poon et al. (2013) surveyed 461 first-year secondary school students on their perceptions of the EMI policy. Although at least half of the students preferred to be placed in EMI classrooms, the majority of these students did not seem to favour the use of English for instruction since they encountered numerous language difficulties when switching from Chinese to English.

In the current MOI situation in Hong Kong, nearly all the CMI schools have now adopted EMI instruction at senior secondary levels. As indicated by Chan (2014) and Poon et al. (2013), the educational values offered by the fine-tuning MOI decision appear limited. When students encounter many language challenges in the EMI classrooms, it is questionable whether these CMI students, particularly those with poor English proficiency, can learn effectively in an English environment.

However, the two studies (Chan, 2014; Poon et al, 2013) have provided very little information about the teaching and learning processes, such as the nature of classroom interaction, which is perceived to be crucial for learning. The next section reports on the major findings from studies that have examined classroom interactions in EMI classrooms.

2.5 Classroom interactions in EMI classrooms

Research on classroom interactions in the context of EMI principally focuses on teacher–student interactions and the teaching practices of individual science teachers in the context of EMI classrooms (Chan, 2013, 2014; Lin, 2006; Lo and Macaro, 2012; Lo, 2014; Wannagat, 2007; Yip et al, 2007). These studies employ an ethnographic approach (observations and interviews), together with discourse analysis, and identify patterns of interactions between the teacher and students. These studies describe different types of talk and pedagogies for delivering scientific content through English or code mixing between Cantonese and English.

Wannagat (2007) observed and video-recorded the classroom interactions between EMI and CLIL settings from two English-taught secondary grade 9 and 10 history classes in Hong Kong and Germany. He found that EMI students in Hong Kong had more exposure to English, with over 50% of classroom discourse in English, while CLIL students in Germany only had 20% in two to three subjects conducted in English, which suggests that EMI seems to be more

successful than CLIL. He added that although EMI teachers seem to take the language issue into account (by using simplified texts and providing key terms in L1), the role of language in the learning goals is not clearly explicated in EMI policy, and thus very often the language issue is largely ignored in curriculum development and teacher training. Thus, in Wanngat's view, in reality EMI is less successful than CLIL given the absence of language focus in EMI curriculum.

Lo and Macaro (2012) used classroom observations to explore classroom interaction between EMI and MOI-switching secondary schools (Schools that moved from being Chinese MOI to allowing English instruction) in Hong Kong. They compared the quality of L2 language learning in the humanities and science secondary classrooms by the numbers of student turns at talk, length of student turns, and Initation-Response-Feedback (IRF) patterns (Sinclair and Coulthard, 1975), as well as types of focus-on-form exchanges (by paying attention to specific grammatical rules and lexical items) (Costa, 2012). They looked at 22 lessons from grades 9 and 10 and found that science lessons were teacher-centred, teacher–student interactions were reduced to I–R–F sequences, and there was a significantly lower proportion of student talk, with frequent short turns. Teachers also paid less attention to form-focused instruction in L2. The register of science and the availability of other semiotic resources for teaching science could largely reduce the L2 language learning opportunities for

students to engage in discussions and interact with their teacher. For example, teachers would draw a diagram to explain the process of photosynthesis. Thus, teachers would spend less time on spoken interactions with students to explain the concepts because they believed that students would understand by looking at the diagram.

Lo and Macaro (2015) conducted another study to investigate differences in overall interaction patterns between late and very late EMI classrooms with students at the same academic level (grade 10). They collected 15 audio/video recorded classroom observations of grade 10 content-subject classrooms (e.g. history, geography, biology, physics) with eight content-subject teachers and approximately 320 students from one EMI and two MOI-switching schools in Hong Kong. They analysed the observed interactive patterns quantitatively in terms of their distribution of teacher and student talk; functions of teacher and student talk; duration of teacher and student turns; IRF exchange sequence patterns between teacher and student; and teacher's questioning skills.

Lo and Macaro found that in a MOI-switching school, where students had no EMI experience, students lacked fluency in their L2 utterances. This was shown by their longer turns with less content richness (measured in syllables). When students interacted with their teachers, there were fewer verbal exchanges observed and these exchanges usually used much simpler forms of IRF sequences (e.g. yes/no responses). This suggested that the teachers were less

able to modify their questions to elicit students' additional responses after students failed to give the expected answer to the original question. Lo and Macaro concluded that this MOI switching school was teacher-centred and monologic. Students had difficulties communicating their ideas in L2 and the sequences of questions and answers were constrained. Lo and Macaro suggest that teachers and students should be allowed to use code switching during the early stage of EMI adoption to prepare for full immersion in L2.

According to Cummins (1979), it might take at least three to five years for students to successfully gain the proficiency to fully benefit from immersion programmes. Teachers also need to be familiar with EMI instruction strategies and develop the necessary teaching skills to interact with students in extended verbal exchanges. Students also need to attain the threshold level of English proficiency allowing effective spoken interactions in the classroom.

Other studies have reported that science teachers have to deal with a diversity of student English proficiency (Probyn, 2001b, 2006, 2009). Substantial research in Hong Kong on learning science through English reports that students have inadequate English proficiency (Marsh et al 2000; Yip et al 2007). Yet no study has investigated whether the English achievement of science students in Hong Kong is poorer than Hong Kong students' achievements in humanities subjects. This is difficult to investigate as, under the new education

curriculum, students are no longer identified as either arts or science focused students.

Lin (2006) examined classroom interactions in the 1980s and found that in some of the bilingual classrooms with effective teachers identified by the school principals and the education bureau, interactions promoted higher cognitive gain and conceptual change in students. She concluded that practical bilingual pedagogies could be drawn from these classrooms through the use of the students' available linguistic resources including rich L1 semantic context, code-mixing strategies and specific I–R–F patterns in L1 followed by a recap in L2. However, a recent study by Jiang et al (2016) examined how EMI instruction is implemented at university level and explored the teachers' perceptions and students' motivations in EMI. Drawing on observations of nine classrooms, three post-observation interviews and a questionnaire, the authors point out that although code-switching may facilitate students' content understanding, the meaning construction and transmission in L2 depended primarily on written texts on the PowerPoint slides. As a result, this code-mixing instruction perhaps only developed learners' L1 and L2 receptive skills (reading comprehension, listening), rather than developing their productive skills in L2 (writing and speaking). The results of code-mixing instruction perhaps suggests that many of these observed EMI classrooms have provided very few

opportunities to develop students' disciplinary English skills in a comprehensive way.

Lin and Wu (2015) conducted a detailed analysis of five minutes of classroom discourse from an EMI junior secondary science classroom in Hong Kong with below-average students. The researchers provide an example of how a skilful bilingual science teacher interacts with the students through their everyday language in L1 in order to develop their disciplinary language in L2. In their analysis Lin and Wu show that the teacher first engages with students through 'languaging' (Swain, 2009), which serves to mediate second language learning, a vehicle through which thinking is articulated and transformed into an artifactual form. In SLA classroom context, languaging is a pedagogical stance that teachers and students take on that allows them to draw on all of their linguistic (e.g. L1, L2) and semiotic recourses (e.g. symbols) as they teach and learn both language and content materials (Mazak, 2016). This languaging process allows students to fully understand the content by operating between L1 and L2.

This is done by a number of teacher-led questions in the form of IRF patterns, designed to help students master the thematic patterns of scientific discourse. This study demonstrates in the Hong Kong context that even students with low proficiency in English are able to develop their disciplinary language in L2 in the content-subject classroom. However, this can only happen

if the bilingual teacher provides sufficient teacher-led guidance and comprehensible input in the form of languaging between L1 and L2. Under these conditions, students are able to understand the content knowledge and thus contribute to class discussion in L1, and gradually develop knowledge of the equivalent meanings in L2. Lin and Wu argue that the role of content-subject teacher is as a bilingual teacher and they demonstrate how skilful these teachers are in asking meaningful questions that can create space for translanguaging and thus develop content knowledge.

In many observational studies, researchers of science education have proposed that skilful questioning by teachers can lead to meaningful learning in science. The meaningful learning in science requires interactive teaching styles that encourage students to express their views and ask questions, and promote a learning culture based on discussion and other student-centred activities (Yip et al., 2007, 2003; Yip and Tsang, 2006; Yip, 1999, 2001, 2004). Hong Kong science teachers identified as generally skillful in questioning in Yip's study (2003) tended to use a wide range of question types in their classrooms (lower order, higher order, motivational, concept-changing). However, although teachers aim to use these questions in order to stimulate higher-order cognitive thinking, Yip pointed out that on many occasions such aims were not achieved because the teachers did not make use of students' prior experiences and existing knowledge. Yip's study indicates that science teachers tend to use recall

questions with lower cognitive demands for a number of reasons: the time constraints on teaching, the pressure to cover the examination syllabus within a tight schedule (Yip, 1999), the low English proficiency of students and the poor communication skills of some EMI science teachers (Yip and Tsang, 2006). Some of these science teachers do not have adequate pedagogical content knowledge due to the fact that these teachers' teaching duties do not match their science qualification; thus many of them have to teach outside their subject specialisation and this greatly reduces the quality of their teaching and the teaching strategies they can draw on (Yip, 2003).

In a later study, Yip (2004) observed Hong Kong science teachers' questioning techniques. He identified 10 types of teacher questions that induced science conceptual changes in their students. These questions are: lower order (recalling, explanation); higher order (analysis, evaluation, synthesis); and motivation and conceptual change (eliciting, challenging, extending, application). Yip's results showed that science teachers in Hong Kong are skilful in questioning but focus on questions with a lower cognitive demand. Although some teachers use higher-order questions to promote students' higher-order thinking, they rarely consider students' prior knowledge when asking these questions. The pedagogical values of these questions are not achieved and this leads to student confusion and frustration. Some teachers use a number of conceptual questions to identify student misconceptions, but the teachers fail to

promote students' cognitive thinking in resolving inconsistent ideas and constructing new ideas from their existing knowledge. Yip's study shows that there is a relationship between the types of questions used by teachers and their pedagogical functions in student learning in science. His study provides a valuable framework for researchers to examine teacher–student interaction in a science classroom. For instance, skilful teachers use more 'conceptual change' questions to elicit preconception and misconception from their students and promote 'meaningful learning' in science Yip (2004: p.79).

The research mentioned above shows that EMI science classrooms in Hong Kong generally take a teacher-centred approach. Use of these practices can be seen as a strategy to reduce the linguistic demands of the lesson, and so cater for students' limited English proficiency. However, by lowering their expectations or 'downgrading' their teaching practice, teachers may have a substantial negative effect on the quality of the learning experience in the science classroom (Yip, 1999). For example, students have little opportunity to practise how to present abstract and complex ideas or to express their ideas or arguments systematically in English during class. A reduced quality of teaching in science indirectly promotes rote learning (Poon, 2013) and makes learning more of a mechanical learning process (Yip and Tsang, 2006). Tung, Lam and Tsang (1997) conducted a large-scale survey of the attitudes of students, parents and teachers towards the use of English as the medium of instruction in Hong Kong

secondary schools. Their findings show that while students and their parents consistently value English over Chinese as the teaching medium for pragmatic reasons (e.g. associated with career), many teachers hold an opposite attitude towards it as they believe English to be educationally less effective.

It is also important to consider teachers' beliefs about EMI instruction as their perceptions could have an impact on their teaching practices. As Tung, Lam and Tsang (1997) point out, decisions about whether teachers adopt fully EMI instruction or use code-mixing between Cantonese and English or fully Cantonese are influenced by the realities of the classroom (e.g. students' English proficiency), and whether their students can achieve the educational goals of the schools. The next sections will describe previous studies that examined teachers' and students' perceptions of EMI experiences.

2.6 Teachers' attitudes towards EMI teaching and their teaching practices in EMI classrooms

Previous studies have provided inconclusive evidence with regard to teachers' views towards EMI. Teachers generally welcome the adoption of English as the medium of instruction in their classrooms, knowing this may increase students' L2 learning opportunity. However, many studies have reported that teachers face numerous issues when teaching through English only in their classrooms (Dearden, 2015; Llurda, 2013; Tatzl, 2011). Othman and Saat (2009) reported that pre-service science teachers in Malaysia encounter challenges even though

they receive some EMI training. The challenges are lack of teaching skills for integrating both content and language teaching, no appropriate instructional materials for teaching both content and language, and poor English ability. Teachers in other countries receive no specific EMI training (Dearden, 2015), with the result that many teachers do not develop the necessary linguistic competence and pedagogical skills to deliver content knowledge in English.

In addition, teachers generally resist being made responsible for teaching both content and language (Probyn, 2001). Unlike European CLIL teachers who accept the emphasis on learning both content and language in their teaching curriculum, most of the EMI teachers around the world believe that their responsibility is only to teach content knowledge but not language. Probyn (2006) interviewed EMI science teachers in Africa. A number of the participating science teachers claimed that teaching English in science was the responsibility of English language teachers. The science teachers observed said they should not be expected to make science content more accessible to their students in English. Probyn's two studies have shown that most EMI science teachers do not believe they have a role in teaching the language of science.

In Hong Kong, similar attitudes on the part of teachers were observed in the EMI science classrooms. In a study of Hong Kong junior secondary science teachers, Hoare (2003) found that many of the EMI science teachers did not have very developed language awareness and that they thus paid less attention to

their students' L2 language needs in the EMI classroom. Hoare's study recognised that the fact that teaching a content subject is not just a simple matter of translating what one knows into English.

Yip and Tsang (2007) examined the impact of EMI on science teaching and the learning process in junior secondary EMI classrooms. Their observations indicated that the science teachers studied were mostly unprepared for integrating science and language. These teachers lacked the communicative competence to explain abstract and complex science concepts and thus were reluctant to use higher-order questioning and conceptual change questions for science teaching. The observed EMI science teachers had poor communication skills and thus may have lacked confidence in teaching science through English (Yip, Coyle and Tsang, 2007).

In a recent study, Lo and Macaro (2012) compared teacher–student interactions in both junior science and humanities classrooms in Hong Kong. They observed a very minimal frequency of teacher–student interaction and short I-R-F sequences in the science classrooms. EMI teachers focused only on lower-order questions, by asking students to recall factual information in science. Teachers rarely provided corrective feedback on students' L2 language production (Lo, 2014).

According to Mortimer and Scott's science communication framework (2003), the teaching practices observed in Lo and Macaro's and Yip's studies

employ a non-interactive and authoritative communicative approach. Such a teacher-centred teaching style is likely to greatly reduce the opportunity for meaningful interactions leading to L2 production between teachers and students (Yip, 2003). In science education research, teacher and student interactions are important for students to develop the scientific enquiry skills that are essential to science learning (Wellington and Osborne, 2001). According to Long's (1983) interaction hypothesis in the field of second language acquisition theory (SLA), meaningful interaction helps to promote students' natural L2 development. Students acquire the necessary L2 linguistics competence through comprehensible input and guided feedback from their teachers (Krashen's comprehensible input hypothesis, 1982). If teachers do not make efforts to interact with students, this may have a negative influence on their students' learning.

This can be seen in Yip and colleagues' (2007), which observed the quality of instructional activities in Hong Kong EMI science classrooms and which showed that many teachers adopt a monologic teaching style. According to Yip and colleagues' observations, the quality of instructional activities suffers. They suggested that a possible reason for the monologic teaching style is teachers' perceptions of EMI. In these monologic EMI classrooms, students spent most of their time listening to teachers' explanations, watching demonstrations and following teachers' manuals when performing experiments. The possible

consequences of such a monologic teaching style on the students' learning are well documented in the literature, as the following summary indicates.

Firstly, students have fewer opportunities for knowledge construction and meaning negotiation, which is one of the key pedagogies that can help students construct an identity as novice members of a scientific community of practice (Evnitskaya and Morton, 2011, discussed further in 2.7 below). Secondly, there are fewer interactions between teachers and students, yet these interactions can be valuable opportunities for teachers to evaluate students' understanding, correct their inconsistent concepts, identify misconceptions, and promote conceptual change from their existing knowledge (Yip, 2004). Thirdly, when teaching follows a teacher-centred approach with emphasis on memorisation and instruction, students are engaged only in rote learning (Poon, 2013) and therefore have relatively few opportunities to design their own methods of investigation, which would require greater creativity and higher-order thinking skills (Yip and Tsang, 2008).

In sum, the literature clearly documents the teaching challenges that most teachers experience in EMI classrooms. These challenges cannot be easily resolved, even by teachers who have received EMI training. The belief of these teachers that they do not have any language responsibilities has shaped the teaching style of their science teaching to be monologic, teacher-centred and based around rote-learning. Such a teaching style may have a negative impact

on the quality of instructional activities in the classroom, on interactions with students and on achievement of learning goals. However, the extent of this negative impact depends on the coping strategies these EMI teachers use to overcome these challenges. The following section describes some of the coping strategies reported in previous studies that EMI teachers use to resolve teaching challenges in EMI classrooms.

2.7 Coping strategies related to the teaching process

In order to handle the duties of teaching both scientific knowledge and language, Yu suggests that teachers can provide comprehensible input to integrate language and science instruction through a range of instructional activities (Yu, 2002). These activities could include promoting language use and scientific thinking through group work; explicitly teaching learning skills; acknowledging cultural differences; using modified classroom talk; appreciating diversity; using students' prior knowledge in science; enriching the curriculum; and providing a rich L2 language use environment

Researchers have also observed that effective science teachers use a range of semiotic supports in delivering science content in English. Flowcharts, diagrams, body language or visual aids, practical demonstrations, and multi-media software can help students make connections between the content and their everyday experiences (Ferreira, 2011). Noting that students' ability to understand examination questions is directly related to their science

achievement, researchers recommend that teachers use simple English with short phrases, thus avoiding student misinterpretation of exam questions and allowing a more accurate measurement of their science achievements (Prophet and Badede, 2007).

Other researchers suggest strategies to make the disciplinary language in L2 more accessible to students by using blackboards for illustrations; encouraging students to speak English by extending their vocabulary (Probyn, 2006); using translation, simplification, and emphasis on key words; and speaking slowly to ensure that students fully understand the content (Huang and Normandia, 2008; Tan, 2011). Othman and Saat (2009) stress that it is important for EMI teachers to introduce new vocabulary before teaching a topic to ensure students' full understanding.

Strategies suggested to increase the quality and frequency of classroom interactions in different language ability groups include code-switching with students with poor English proficiency, with extended turn exchange sequences of IRFRF (Initiation-Response-Feedback-Response-Feedback) (Lo and Macaro, 2012). Lin (2006) analysed teaching practices in Hong Kong science classrooms and proposed that a practical bilingual pedagogical approach, where most teaching subject content is delivered in L1, except for key terms and recapping in L2, is said to allow students more time to make the transition from L1 to L2. This approach could help junior CMI science students with poor English

proficiency to manage accessing more technical terms in English and understand the language style in science discourse by using their L1 and cultural resources. Teachers may occasionally supplement their explanations or instructions with L1 during the early stage of EMI instruction to prepare students. Teachers interviewed about their EMI classroom teaching report using different coping strategies to help students to respond to questions in English, express abstract concepts, understand scientific terminology (Ferreira, 2011), construct science knowledge with their peers, and help manage student discipline and interpersonal relations (Yip et al., 2007).

Evnitskaya and Morton (2011) conducted a conversation analysis of two secondary CLIL biology classrooms in Spain, a context similar to EMI with a focus on both content and language learning. They found teachers and students interact in ways consistent with membership of a 'community of practice' (CoP) (Wenger, 1998). Community of practice is a concept used to refer to members in a community sharing common goals and interests and pursuing these goals through engaging in a joint activity. The teachers and students observed in the Spanish biology classrooms interacted to share both linguistic and other non-verbal meaning-making resources, developed joint learning goals, and engaged as a group when doing school science. A highly interactive classroom is believed to improve student autonomy in undertaking scientific enquiry and to

encourage students to feel membership of a scientific community of practice through co-construction of knowledge with teachers and their peers.

Some science teachers have attempted to foster students' cognitive development through higher-order questions. Yip (2004) explored the impact of training student science teachers with a focus on a conceptual change model of science instruction. Conceptual change suggests that teachers correct students' misconceptions in science through questioning. Based on observations of the classrooms of 14 in-service science teachers (with three to six years of teaching experience) who completed their teacher training in Hong Kong, two assessors reviewed 405 questions asked by the teachers and categorised them according to their pedagogical functions. Yip identified 10 questions: lower order (recalling, explanation); higher order (analysis, evaluation, synthesis); and motivation and conceptual change (eliciting, challenging, extending, application). These 10 questions serve four different pedagogical functions that are said to encourage conceptual changes in students' understandings about science: (1) check students' understanding of factual information and their abilities to explain a science phenomenon (low order); (2) evaluate their higher cognitive skills (higher order); (3) investigate students' learning motivation; and (4) lead to conceptual changes in a student's science knowledge.

Yip suggests a range of questioning techniques that effective science teachers use in Hong Kong classrooms to evaluate students' understanding,

correct inconsistent concepts, identify misconceptions and promote conceptual change from students' existing knowledge. Similarly, Chin (2007) in Singapore observed 36 grade 7 science classrooms and identified four types of questioning approaches by science teachers (Socratic questing, verbal jigsaw, semantic tapestry, framing) that are useful to scaffold students' thinking and construct scientific knowledge.

Othman and Saat (2009) conducted a questionnaire survey to explore the instructional strategies that pre-service science teachers use in Malaysia's EMI science classrooms when they overcome the language-related challenge of delivering science content in English. They reported that effective pre-service science teachers use questions to help students construct concepts; use higher-order questions to induce cognitive thinking; use probes to explore preconceptions; and create constructive chalkboard layouts in a logical sequence to summarise learned concepts. To deal with different-ability groups, Ferreira (2011) conducted focus group interviews with 28 experienced Life Sciences teachers in South Africa with between 16 and 29 years of teaching experience to understand the coping strategies used by these teachers to help their English second language learners. He points out that teachers can group learners with the same level of science achievement but with different language competence in classroom activities, creating opportunities for those who understand to help others.

Science teacher training programmes have been found to not equip teachers with the necessary linguistic competence and pedagogical skills to teach science in English in many EMI contexts such as Hong Kong and Malaysia (Othman & Mohd. Saat, 2009; Yip, 2004; Yip et al., 2003;Walker, 2010). For example, although pre-service teachers in Malaysia receive some training in teaching science, studies have identified a lack of teaching skills in integrating content with language teaching, and a lack of appropriate instructional materials (Saat and Othman, 2010; Othman and Saat, 2009). Yip et al. (2007) believe that science teachers need to develop and use a repertoire of context-embedded language skills (e.g. everyday English) for conveying meaning. As students in senior secondary levels (grades 9-10) progress to higher levels and develop greater competence in English, teachers can convey complex and abstract concepts with context-reduced language skills (e.g. technical language) (Walker, 2010).

Walker's study is echoed by researchers in functional linguistics, who see language and learning as social processes. They believe that language use is shaped by the kind of activity taking place and who is doing it (Halliday and Matthiessen, 2004). Language structure is an integral part of a text's social context and function (Martin and Rose, 2008). These functional linguists believe that an understanding of registers and genres in scientific texts significantly affect a learner's ability to read and write effectively in the science community (Halliday and Martin, 1993; Martin and Veel, 1998; Schleppegrell, 2004). The

European CLIL context has now introduced a genre-based pedagogy into content-subject classrooms as an attempt to address the academic literacy challenges when students engage in different text types and improve their language competence in producing subject-specific discourse with appropriate choices of vocabulary, grammar, and language style (Llinares, Morton, and Whittaker, 2012; Lorenzo, 2013).

In addition, teachers' language awareness has been shown to be closely associated with the effectiveness of the language learning process for students (Hoare, 2003). Responsibility for language awareness is also relevant for those who teach content subjects through English. Language awareness can be realised through teaching practices and operationalised through self-designed teaching interventions, such as using simple English to make science more accessible to students (Hoare, 2003). Hoare conducted an empirical study to investigate any differences in teaching practices between teachers with high language awareness (who pay attention to students' English needs in learning science) and those with low language awareness in Hong Kong junior science classrooms. He examined six junior science teachers in EMI classrooms with multiple sources of data including interviews with teachers and students, a teachers' questionnaire about their degree of language awareness, and a test of their students' science achievements. The findings show that students with higher language awareness are better able to express their science

understanding learned through English. There is also a qualitative difference in teaching practices. Teachers with more language awareness were observed to operationalize their awareness as strategies to make scientific meanings more explicit and accessible to their students through English. Science teachers who have higher language awareness tend to simplify their English and make science more accessible to students using a wide range of teaching strategies. Other researchers (Arkoudis, 2005; Barwell, 2005; Lo, 2014; Poon, 2013) recommend collaborative teaching with English language teachers who can inform the science teacher about the language features necessary for science learning in an English environment.

Literature on teachers' professional development suggests that science teachers should be given more opportunities to review and strengthen their subject knowledge, skills and confidence in teaching for conceptual change (Mak et al., 1999; Yip, 2001). Recommendations include mixed discipline peer reviews in which groups of science teachers with different specialisms reflect on their own preconceptions. Some, such as Yip (1999), suggest that a cultural change is needed to create more supportive cultures within the school and a collaborative team across different science departments. Senior science teachers in each school could offer school-based advice and experience on subject matter development (CDC and HKEAA, 2007). A collaborative team with teachers from all science departments in a school, together with internal and external

support for staff development, can help to introduce and implement innovations such as new teaching interventions for conceptual change in the classroom (Lo, 2014a; Yip, 1999).

In sum, the previous studies have documented some of the strategies content teachers can use to attempt to resolve the teaching challenges of the EMI context. These strategies include:

- combining content and language learning in different instructional activities
- making L2 disciplinary language more accessible verbally and non-verbally, by drawing from students' everyday experiences
- improving the quality of teacher–student interaction through extensive IRF patterns
- using the L1 effectively in scaffolding
- improving teacher's questioning techniques
- increasing students' understanding of academic registers and genres
- increasing teacher's language awareness, providing more professional development for content teachers to strengthen their subject knowledge
- developing collaborative teaching with language teachers.

While teachers and students are in a reciprocal relationship, it is worth noticing some of the students' experience in EMI, their achievements, their challenges and their coping strategies in EMI classrooms. The following section discusses studies that have examined students' perceptions of their EMI experience. The specific focus is on the two areas previously examined in MOI studies in Hong Kong that relate to students' EMI experience: students' achievements in academic subjects and students' self-concepts in science (Lo and Lo, 2014; Marsh, Hau and Kong, 2000; Yip and Tsang, 2007).

2.8. Students' views on their EMI experiences (achievements and self-concepts)

2.8.1 Research on EMI students' achievements in academic subjects

Research into language policy provides empirical evidence of the correlation between the impact of different mediums of instruction (Chinese and English) and student academic achievements. Academic achievements refer to students' school examination results in their language subjects (English and Chinese) and content subjects (e.g. mathematics, science). Two studies have explored the science achievements of Hong Kong students at junior and senior levels in an English learning environment (Marsh et al., 2000; Yip and Tsang, 2006).

At junior secondary level, Yip and Tsang conducted a longitudinal study of a sample of 12,000 students to investigate the effects of the compulsory mother-tongue policy in 1998 on student science learning during the first two years of junior secondary school (grades 7 and 8) in EMI and CMI groups. They

examined the impact of different mediums of instruction (EMI versus CMI) on students' achievements. Drawing on 100 EMI and CMI schools, they recruited grade 7 students with the same academic achievements prior to their admission to secondary schools and measured their science achievements for grades 7 to 9 for three years.

They compared the two groups using a science achievement test, a questionnaire on their self-concept in science and classroom observations of science lessons. The results showed that EMI junior secondary school students had lower science achievement scores and a lower self-concept than their counterpart CMI students. Yip and Tsang concluded that EMI students experience greater difficulties when understanding abstract concepts, making distinctions between scientific terms and applying concepts in different situations through their L2. They also conducted observations in some of these EMI classrooms and concluded that EMI negatively affected the quality of science learning in these classrooms due to the students' limited English proficiency and the inadequate repertoire of instructional strategies used by their science teachers.

Moving from junior to senior secondary classrooms, Marsh, Hau and Kong (2000) conducted a similar study with a sample of 7,802 students to examine the impact of CMI and EMI instruction on student achievements in language and content subjects from grades 7 to 11. The researchers concluded that in early

secondary years EMI has a substantial negative influence on students' self-concept and science achievement. However, the disadvantage of learning science through L2 is offset to a limited extent in senior secondary years when students' English proficiency has improved and students have become more used to English instruction. A strong emphasis by schools on promoting English in their language lessons was also found to reduce the L2 disadvantages.

2.8.2 Research on students' academic self-concepts

'Self-concept' in science refers to students' beliefs about their academic abilities and performance in science. Formation of a positive self-concept is regarded as an important outcome of the learning process. In a language immersion context, studies of students' academic self-concept are primarily concerned with the correlation between students' self-concept and their academic achievements (Marsh et al., 2000; 2002; Yip et al., 2007; Yip and Tsang, 2006; Yip, 2001). Studies also have suggested that there is a reciprocal relationship between academic achievement and self-concept (Marsh and Yeung, 1997; Marsh, 1993). In other words, once students' academic achievement has improved, their self-concept will also improve, and this leads to improved academic achievement.

Marsh, Hau and Kong (2000) examined the impact of CMI and EMI instruction on self-concepts in addition to the impact on student achievements from grades 7 to 11. They measured students' academic performance and self-concepts in science and found statistically that there is a strong relationship

between students' lower self-concept in science and their science achievement. This also confirms the finding that students' prior achievements have an impact on their subsequent self-concepts in science, but that such effects do not differ between L1 and L2 instructions (Marsh et al., 2002). Although Marsh and his colleagues have provided evidence to show that EMI has a substantial negative influence on students' self-concept and science achievements at junior levels, as already noted above, the disadvantage of learning science through English is offset to a limited extent at senior level when students have gained English proficiency and have had increased exposure to full English instruction. However, as yet no research has examined senior science classrooms in detail in terms of the kind of teaching practices and patterns of classroom interactions found in EMI classrooms. It is unclear how these students' English proficiency has been developed in EMI science classrooms. There is a lack of empirical evidence about the types of teaching activities these science teachers employ during classroom interactions to support their students to acquire science knowledge and scientific English to express the knowledge learned in EMI science classrooms.

In a longitudinal study, Yip and Tsang (2006) compared EMI and CMI groups during the first three years of junior secondary school. They found that although EMI students had low self-concept in science, their science achievement was better than those instructed in a CMI context. However, they

did not confirm whether or not English immersion had induced an adverse effect on science students' self-concept because they failed to control for student academic ability in the different immersion groups. Most EMI students are at Band 1, i.e. they have above-average academic achievements. They are more academically capable than those in CMI schools, who are at Band 2, i.e. with average or below average academic achievements.

Yip et al. (2007) reported that EMI students showed higher self-concepts in Chinese, English and mathematics, but lower self-concepts in science. The EMI students showed a greater interest in learning science than CMI students, but perceived a lower self-concept in science than those taught in L1. Although EMI students had a lower self-concept and self-competence in science, they performed better in science achievement tests than many of the CMI students.

In sum, the literature indicates that EMI students potentially face disadvantages in students' self-concepts, language and science achievements at the beginning of junior secondary but that these disadvantages gradually disappear when students' English proficiency has improved and they have become more used to English instruction in senior secondary school. Other studies have also shown contradictory results, i.e. that EMI students performed better in science achievement tests despite their lower self-concept. It is therefore unclear to what extent EMI may negatively affect the quality of science learning in these classrooms due to students' limited English proficiency. The

next section will report relevant research findings about the language challenges EMI students experience in their classrooms and the kinds of coping strategies they adopt in addressing these challenges.

2.9. Language challenges and coping strategies in EMI classrooms

2.9.1 Challenges related to the learning process

Students in EMI science classrooms face 'double challenges' in learning science through English (Probyn, 2006; Rollnick and Rutherford, 1996). They must not only learn the scientific knowledge but also English in order to read and write scientific ideas (Schleppegrell, 2004). Discourse analysts suggest that scientific language has a specific register, discourse and lexico-grammatical features (Halliday and Martin, 1993). Students may fail to understand scientific terms and to conceptualise the abstract and complex relationships between science concepts in English due to their poor English ability (Probyn, 2009; Yip and Tsang, 2006).

Research shows that even EMI students with high academic ability at the beginning of their secondary education are negatively affected in their learning during the initial years of immersion in English. English skills developed through English lessons at primary school are not sufficient for these students to master scientific content in English. At junior levels, EMI students perform worse than their counterpart CMI students in science achievement tests, with problems understanding abstract concepts, distinguishing scientific terms,

applying concepts in different situations, and applying learned scientific knowledge in everyday situations. (Yip et al., 2003).

In senior years, the negative impact still exists but the disadvantage of learning science through English is offset to a limited extent as students have improved their English proficiency, become more familiar with EMI instruction or been encouraged by their school's strong emphasis on English in their English lessons. However, these science students may still be significantly disadvantaged compared with their counterparts in CMI, as well as with EMI students who study geography, history and mathematics (Marsh et al., 2000; 2002). Such challenge of learning science through English could be explained by research examining the nature of school science discourse. The language demands in science are different from those for English students learning in English classrooms. The language of science has a register distinct from daily language, a response to the fact that the shape and role of scientific activities are largely different from everyday human experiences (Halliday and Martin, 1993; Martin and Rose, 2008). If the unique features of scientific English are ignored, constructing and expressing science knowledge will be problematic (Christie and Derewianka, 2008). For instance, students may become frustrated by the

ambiguity and imprecise referents of nominalisation[1] if they fail to retrieve the hidden meanings from nominal phrases and gain a full understanding (Fang, 2005). An example of nominalisation is changing a verb '*neutralize*' into a noun '*neuturalisation*' in the following sentences: "*An acid and a base 'neutralize' each other. The products of 'neutralization' are salt and water only. Neutralization is the reaction of an acid with a base producing salt and water only."* Students may have difficulty in presenting science knowledge and developing logical arguments in their writing if they pay no attention to the role of nominalisation in science texts (Schleppegrell, 2004).

In sum, EMI students potentially face many language challenges in EMI classrooms. These challenges include integrating both content and language, mastering the register of science discourse, understanding the differences between scientific English and general English, understanding abstract concepts, distinguishing scientific terms and applying concepts in different situations. To overcome some of these language challenges, the following section summarises previous studies about the coping strategies that may help EMI students to tackle their language issues in their EMI classrooms.

[1] Nominalisation is the most common strategy used in science to theorise and construe science processes into abstract entities. This way, scientists can 'pick up' salient items from a complex sequence and 'package' them into a single semantic configuration in the subject position.

2.9.2 Coping strategies related to the learning process

Walker (2010) evaluated the effectiveness of an English enrichment course for grade 10 science students on English proficiency. The study recruited 430 secondary school students switching from Chinese to English in studying science. Students who participated in a support programme aimed at increasing their English proficiency were compared with those who did not participate. The two groups of students were then tested for their ability in note taking, grammatical patterns, and accuracy of writing scientific definitions and explanations in English. Results showed that there was no direct cause and effect relationship between the programme and student achievement in the English proficiency science test. All programme participants demonstrated low proficiency in written English. Walker concluded that English bridging courses in Hong Kong pay limited attention to students' needs related to their language development in content learning or what is known as their 'cognitive academic language proficiency, CALP' (Cummins, 1979).

Walker's claim is echoed by Yip and his colleagues' study. They suggest that students need to develop both the necessary English proficiency and the capacity for L2 learning in science by filling in their current language gaps. For this to happen, two gaps must be closed. First an effort should be made to close the gap between how students conceptualise scientific knowledge in L2 and how they conceptualise it in L1. This is achieved by the use of prompting

questions to evaluate students' scientific understanding and to identify their misconceptions (Yip, 2004). Second, there is a gap between what students can *understand* in English and what they can *articulate* in English. This gap is closed by providing sufficient L2 learning opportunities through classroom interactions to test their L2 hypotheses (Lo, 2014) and by giving corrective feedback to their L2 utterances. In sum, the English enrichment course for students switching into EMI might help prepare students with the necessary English proficiency for studying content subjects in English but the programme's effectiveness is limited due to the lack of attention to students' needs in developing their L2 disciplinary language and by failing to bridge the gaps between how students conceptualise scientific knowledge in L1 and L2.

2.10 Summary of issues

As the review above has shown, approaches towards and challenges of teaching and learning science through EMI are subject to debate in the Hong Kong context. At this point it is helpful to summarise the major issues and findings that informed the research questions motivating my research project:

1. EMI science lessons seem to be teacher-centred and have limited teacher–student interactions. It is questionable whether these teacher-centred teaching practices in EMI science classrooms are the result of poor-quality classroom interactions or a reflection of science teachers' inability to implement the curriculum principles. Other learning

opportunities (Lo and Macaro, 2012), such as student–student interactions that are crucial to science learning are yet to be investigated.

2. EMI seems to have a negative effect on the quality of science learning because of students' limited English proficiency. However, previous studies such as Yip (2003) falsely assumed that students in both EMI and CMI groups acquire the same level of language ability in both Chinese and English. Recognition of the difference between L1 (Chinese) and L2 (English) and of their roles in teaching and learning science opens up the research space so that we may better understand the challenges and strategies of different English ability groups with different EMI experience.
3. EMI has a substantial negative influence on students' self-concepts and science achievement at junior secondary levels (Marsh, Hau, Kong, 2000). However, it is not clear when and how such disadvantage is offset at senior levels and how these students' English proficiency develops.
4. There is a correlation between the inadequate English ability of students and the effectiveness of teaching, and this accounts for the poor quality of science learning in EMI classrooms (Yip et al., 2000). Perceptions and attitudes of science teachers towards EMI have a significant effect on their teaching practices and classroom interactions in science. Research also indicates that the quality of teachers' explanations, their interactions

with students, their questioning skills and their language awareness of students' English needs in science seem to affect the quality of students' learning processes (Marsh, Hau, Kong, 2000; Yip, 2003).

5. Most research has only investigated the effectiveness of EMI on students' science achievements at junior secondary levels by comparing it with those instructed in another language medium. The research to date fails to arrive at agreed conclusions on identifying the different types of language challenges and the corresponding strategies that could or should be adopted.

2.10 Summary of the chapter

This literature chapter has demonstrated how the historical development and recent change of language policy have shaped the complicated MOI situation in Hong Kong. Changes in MOI policy at secondary level have had an impact on the teaching and learning process in senior secondary science classrooms. The consequences of the adoption of EMI for teaching and learning in science classrooms have been reported by research exploring classroom interactions, teachers' and students' views on their EMI experience, their language challenges, and coping strategies. The new MOI situation in Hong Kong, with both CMI and EMI schools adopting EMI for instruction, has stimulated a new research context yet to be explored: that of 'early–full' versus 'late–partial' EMI schools. Students in EMI science classrooms, particularly those from the late–

partial EMI schools who switched from Chinese medium to English medium at senior levels, have encountered numerous language challenges. It has been argued by SLA theories (Long's interaction hypothesis) and research in science education (Mortimer and Scott's framework) that classroom interaction plays an important role in students' content and language learning. Thus, one of the possible ways to understand students' language challenges in these EMI classrooms would be through an investigation of the classroom interaction in both types of EMI schools, with examination of the frequency and functions of teachers' and students' interactional contributions, teachers' questioning skills, and the choices of instructional language. The next chapter presents the study's aims, research questions, and research design to explore classroom interactions, and teachers' and students' perceptions of EMI in early–full and late–partial EMI secondary science classrooms. ■

Chapter 3

Methodology

3.1 Introduction

Informed by the literature review in chapter two, this chapter presents the study's aims, research questions and research design. The chapter describes the target population, the sampling procedures and criteria for selecting participants and then reviews the method used in the pilot study and for the data collection of the main study. After describing the research instruments and the frameworks used for analysing different types of data, the chapter concludes by referring to the data analysis procedures and the project's ethical issues.

The study explores classroom interactions in different EMI science classrooms. It compares the interaction patterns of full EMI[2] and partial EMI[3] secondary schools in Hong Kong and compares grades 10 and 11 within each group. This project also analyses the perceptions of the teachers and students of their teaching and learning in the two types of schools. The study addresses the following research questions:

1. What is the nature of classroom interaction in EMI science classrooms?
2. What are the differences and similarities in classroom interaction between full and partial EMI schools?
3. What are the differences and similarities in classroom interaction between grades 10 and 11 in each group?
4. What are teacher perceptions of teaching science through EMI?
5. What are student perceptions of learning science through EMI?

[2] According to literature on Canadian immersion programmes, early immersion refers to primary schools switching to foreign language (English) instruction. With late immersion, the switch to foreign instruction starts at junior secondary schools. Very late immersion starts at senior secondary. This is why I use 'late EMI' and 'very late EMI' to refer to the EMI immersion programmes in Hong Kong. The terms 'late and very late' are problematic to readers in other countries, where they have a different meaning for the age of admission in public schools. Therefore, I use 'early–full EMI' and 'late–partial EMI' to refer to the EMI immersion programmes in Hong Kong. The term 'early–full EMI secondary schools' refers to schools that opt for English only instruction for all content subjects from grades 7 to 12.

[3] Late–partial EMI secondary schools refer to schools that opt for Cantonese from grades 7 to 9 and later switch to English medium from grades 10 to 12.

3.2 Research design in detail

This study adopted a mixed-method approach, employing a cross-sectional (2 x 2) design to investigate whether there were any significant differences in classroom interactions, teacher and student perceptions between full and partial EMI secondary schools, and between grades 10 and 11 in each group. The relationship between different sampling groups and the research questions are presented in figures 3.1 and 3.2.

A. Observations

RQ1:

What is the nature of classroom interaction in EMI science classrooms?

RQ2:

What are the differences and similarities in classroom interaction in early–full and late–partial EMI science classrooms?

Schools	A. early–full EMI schools 4 schools	B. late–partial EMI schools 4 schools
Grade 10	5 lessons (1 physics, 1 chemistry, 3 biology)	12 lessons (3 physics, 6 chemistry, 3 biology)
	RQ3: What are the differences and similarities in classroom interaction between grades 10 and 11 in each group?	
Grade 11	5 lessons (1 physics, 1 chemistry, 3 biology)	11 lessons (4 physics, 4 chemistry, 3 biology)

Figure 3.1 Research design (classroom interactions)

B. Interviews, questionnaires

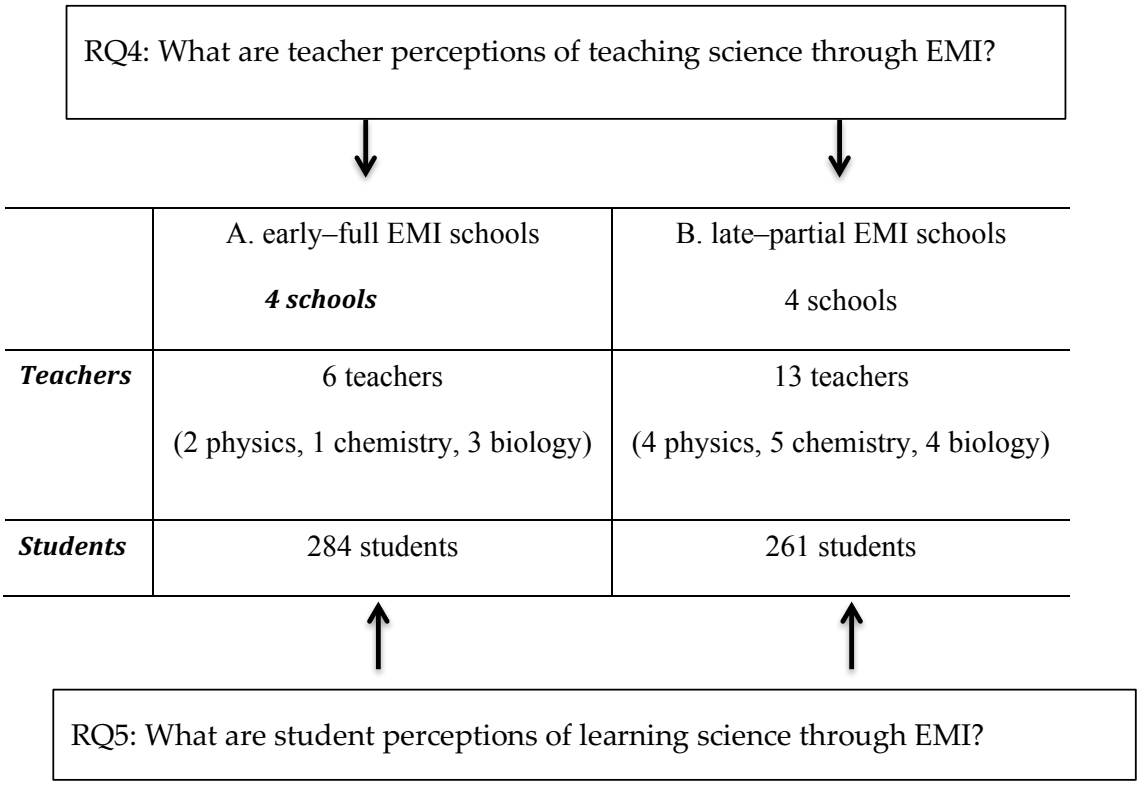


Figure 3.2 Research design (teachers' and students' perceptions)

This study has three parts. The first is a case study of the nature of classroom interaction in EMI science classrooms. The case study compares classroom interaction patterns between early–full and late–partial EMI schools using video-recorded observation data of classes. This component of the methodology identifies similarities and differences in the classroom interactions in the two types of schools, and at both grades 10 and 11 in order to address the first three research questions listed above.

The second component is an investigation of the participants' views on EMI instruction using interview data (i.e. interviews with the teachers and students).

This component addresses research questions 4 and 5 above, by identifying recurrent issues from the teachers' and students' interviews about their views, attitudes and personal experiences of teaching and learning science through English in both types of school.

The third component also addresses research questions 4 and 5 above, by exploring the relationships among the variables that are related to teachers' and students' perceptions, using survey data (i.e. teacher and student questionnaires). The variables include participants' choice of classroom language, their thoughts on teaching and learning science through the medium of English, the language challenges of doing so, coping strategies in EMI science classrooms, and other learning outcomes such as the students' self-concept in science and self-reported academic achievements in English and science. My exploration of the possible relationships among these variables identifies differences in teacher and student attitudes towards EMI instruction in the two types of school. It also suggests the extent to which the students' academic achievements in English and science are related. Table 3.1 summarises the aims, research instruments, data sources and analytical methods.

1. What is the nature of classroom interaction in EMI science classrooms? 2. What are the differences and similarities in classroom interaction between early–full and late–partial EMI schools? 3. What are the differences and similarities in classroom interaction between grades 10 and 11 in each group?	Classroom observations	Transcripts of the video-recorded lessons, the observation notes, grades 10 and 11 EMI science classrooms (n=33 observations)[4]	Discourse analysis of classroom interactions using EMI science classrooms
4. What are teacher perceptions of learning science through EMI? 5. What are student perceptions of learning science through EMI?	Questionnaire Interviews	Survey data (n=19 teachers; n=545 students) Interviews data (pre- and post observation) (n=19 teachers; n=52 students)	Mean-comparison scores of teacher perceptions and student perceptions of teaching and learning in different groups Factor analysis to identify the major factor loading among the survey items related to language challenges and coping strategies. Major factors are further examined by *t*-test/ Mann-Whitney test to determine significant group differences.

Table 3.1 Summary of the research aims, methods and analysis

3.2.1 Justification for a mixed-methods approach

The research design adopted a multiphase mixed-method approach, combining qualitative and quantitative components in an interactive manner across all

[4] Within the 33 observations, there are 10 lessons in full EMI schools and 23 lessons in late–partial EMI schools; 15 Grade-10 lessons and 18 Grade-11 lessons; 8 physics lessons, 10 chemistry lessons and 15 biology lessons.

stages in the research design. This methodology provides a continuous 'dialogue' between the quantitative and qualitative approach in various stages of the research process, including instruments, data collection and integration of analyses and findings (Kington, Sammons, Day, and Regan, 2011).

The combination of quantitative and qualitative approaches is more likely to offer a comprehensive understanding of the phenomena under investigation. This is because a mixed-method can overcome the weaknesses of either a qualitative or a quantitative approach used on its own. In particular, the quantitative approach has been criticised as simplistic, de-contextualised and unable to capture the true meaning of the data; the qualitative approach has been criticised as very context-specific, using samples that are not representative enough (Dörnyei, 2007). Combining both approaches can therefore compensate for the weaknesses of each, and increase the validity of the results (Dörnyei, 2007).

The study followed an exploratory–sequential design (Creswell and Plano Clark, 2011). The qualitative components are followed by quantitative components. The method involved five stages.

In the first stage, qualitative and quantitative instruments were developed based on an intensive literature review of empirical studies relevant to this study. In the second stage, qualitative data (observations and semi-structured interviews) were collected and analysed. Classroom interactions were observed

in both early–full and late–partial EMI schools and in both grades 10 and 11 classrooms. The interactions were coded and analysed quantitatively according to the type of interactive sequences (i.e. teacher–student, student–student) and sequence patterns (IRF, Initiation–Response–Feedback; or IRFRF, extended IRF), the choice(s) and duration of the instructional language, and the frequency and type of teacher and student questions.

In the third stage, emerging findings from the qualitative data (e.g. background information about the context) were used to refine the items covered in a larger scale quantitative questionnaire. These qualitative findings from observation and interviews also informed the content validity of the quantitative survey. The survey provided mean-comparison scores of teacher perceptions and student perceptions of EMI science learning and a list of factor loadings of different language challenges and coping strategies during interactions.

In the fourth stage, analysis of the questionnaire results provided more guided questions for follow-up interviews with teachers and students. Any noticeably consistent or inconsistent views between respondents' perceptions and their actual behaviour in the classroom were identified.

Finally, data collected at different stages underwent a triangulation process to ensure the validity of the study. This involved checking the consistency of findings generated by the different data collection methods. As Patton points

out (1999, p. 1192), 'Studies that use only one method are more vulnerable to errors linked to that particular method (e.g. loaded interview questions, a biased or untrue response) than are studies that use multiple methods in which different types of data provide cross-data validity checks'. This requires comparing and cross-checking the consistency of information collected at different stages and by different means within the qualitative method as well as within the quantitative method—for instance, comparing observational data with interview data, and comparing the quantifiable data from qualitative classroom interactive patterns with the survey data about teacher and student perceptions of EMI learning, language challenges and coping strategies.

Patton (1999) noted that triangulation of data sources within a single method seldom leads to a single and completely consistent result because different kinds of data have captured different results. Such discrepancies do not mean that the data is invalid but offer an opportunity for researchers to explore the reasons for the differences. However, consistency in the overall patterns of data from different sources such as observational data and interview data in the qualitative method, and reasonable explanations for any discrepancy between them, are essential to the overall credibility of the findings.

Based on the quantitative survey and qualitative data from observations and interviews, group differences in classroom interactions and respondent perceptions were identified. A small sample of these classrooms with notably

inconsistent views between perception and actual interactions were selected for an in-depth case study, which used discourse analysis to examine the interaction patterns. Observational notes and interview data supplemented the discourse analysis and provided information on background and context (i.e. learning targets, the researcher's comments on the observed lesson, the teachers' justifications for a bilingual pedagogical act or use of a code-switching strategy in a teaching episode). The case study of classrooms with inconsistency between perception and interaction generated additional research questions or hypotheses that were further examined in the subsequent analyses using the larger sample of quantitative data.

Figure 3.3 shows an overview of the mixed-method approach adopted. The figure illustrates how the qualitative components are linked to the quantitative components at different stages of the study. The diagram highlights the five stages in the research process.

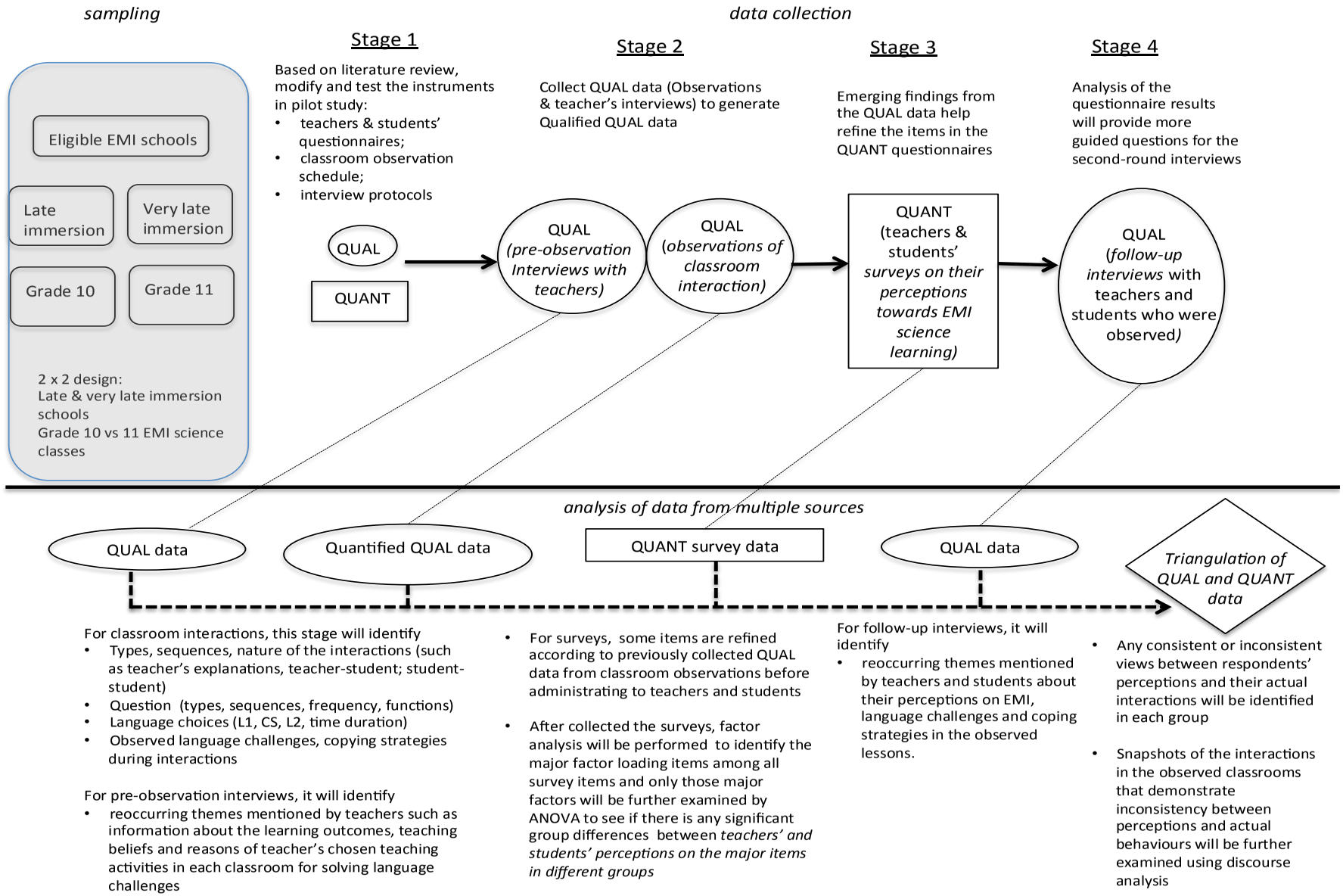


Figure 3.3 The five stages in this research process

3.4 Data collection

3.4.1 The population

The 485[5] secondary schools in Hong Kong that deliver six years of secondary education according to the Hong Kong Diploma of Secondary Education curriculum (HKDSE) form the population used here. This study examines two types of these schools: early–full EMI schools (EMI instruction from grades 7 to 12 for most content subjects) and late–partial EMI schools (Cantonese instruction in grades 7 to 9 and English instruction from grade 10 to 11 for most content subjects).

The participants are teachers and students from grades 10 and 11 EMI science classrooms (physics, chemistry and biology) from early–full and late–partial EMI secondary schools in Hong Kong. Students are 15 to 18 years old, and have completed six years of primary and three years of junior secondary compulsory education. Regardless of their medium of instruction at junior levels, students in both groups have studied integrated science in grades 7 to 9. During the data collection stage, students were studying the Hong Kong Diploma of Secondary Education science curriculum in grades 10 to 12. These students had already received three to four years of integrated science training,

[5] Source: Education Bureau, Hong Kong Special Administrative Region, Figures and Statistics on Secondary Education, http://www.edb.gov.hk/tc/about-edb/publications-stat/figures/sec.html.

covering topics including scientific investigation, life and living, the material world, energy and change, the Earth and the relationship between science, technology and society (CDC, 2002).

This study examined teacher and student perceptions of their EMI experience, particularly their classroom interactions, during the first and second years of the senior curriculum. This senior secondary period (grades 10 and 11) is considered especially significant, as these students are at the early stage of two major transitions. First, they have moved from the junior science curriculum to the senior curriculum. Previously, these students had studied science in one integrated subject (i.e. 'science'), but in grades 10 and 11 they are streamed into different specialised science disciplines (i.e. physics, biology, chemistry). Second, grades 10 and 11 science students in late–partial EMI schools have to switch from Cantonese to English as the medium of instruction.

Teachers selected from those teaching the senior science curriculum in the two types of school had a Bachelor of Science degree in their teaching area and a postgraduate diploma in secondary education. All the selected teachers delivered science content that matched their disciplinary training in science, as the study design tried to ensure that the participating teachers had adequate pedagogical content knowledge and were familiar with the teaching curriculum in the Hong Kong Diploma of secondary education senior science curriculum

(see further CDC and HKEAA, 2007a, 2007b, 2007c). Table 3.2 summarises the information on the schools' MOI and their years of exposure in EMI.

When did EMI start?	Grades 7 to 12		Grades 10 to 12	
Other medium of instruction	Only English, except for Chinese Language subject, Chinese History		Cantonese: Grades 7–9	
MOI of Science subjects	English (Grade 7-9 integrated science) English (Grade 10-12 Physics, Chemistry, Biology)		Cantonese (Grade 7-9 integrated science) Cantonese and English (Grade 10-12 Physics, Chemistry, Biology)	
Grades	Grade 10	Grade 11	Grade 10	Grade 11
Years of experience in EMI instruction	4	5	0	1

Table 3.2 Summary of the schools' MOI and years of experience in EMI

3.4.2 The sampling frame

A sampling frame was developed to ensure the balance between the generalisability and validity of the chosen sampling. The sampling frame considered:

1. the representativeness of the selected school in reflecting a typical secondary school in Hong Kong. Schools were chosen only from the districts where students had similar and homogenous demographic backgrounds (e.g. New Territories).

2. inspection of the student cohort's academic achievement[6] during the year of admission to the school. Only schools that had admitted students with above-average academic achievements were included. This was done in order to reduce a significant confounding variable—individual student differences in academic achievement when comparing the classroom interactions between the early–full and late–partial EMI schools.

3. other confounding variables of individual students, such as previous educational background, family education and socioeconomic status, students with behaviour difficulties, international schools or those with curricula other than the Hong Kong Diploma of Secondary Education (i.e. International Baccalaureate Diploma Programme schools) and schools where the first language of students was not Cantonese (i.e. the minority groups from Pakistan, Filipino, Nepalese backgrounds) were not included.

[6] Primary Six school-leavers in Hong Kong are rated on a three-band scale according to their academic performance, or the AAI score (Academic Aptitude Index), to determine which secondary schools they will be admitted to. The AAI score is based on a student's academic achievements in the school-based examinations in primary five and six. Band 1 is the above average band in the three-tier categorisation system, with high academic achievement. Band 2 is average academic achievement. Band 3 is below average academic standard.

3.4.3 The sample

Based on the above criteria, I investigated which schools would be eligible for this study. First, I examined the government's school profile list, 'Secondary School Profile 2013–14' (Committee on Home-School Co-operation, 2014). This document lists information such as school type (private or public), funding sources (government-subsidised, self-financed), medium of instruction at different grades, academic achievement level of the students in each grade and type of curriculum (Hong Kong Diploma of Secondary Education or not). Second, I visited school websites for further details about their student population at each grade, the socioeconomic status of students (the number of students who received textbook and stationary subsidies from the government, similar to the free school meal), the science subject(s) offered, the nature of the science curriculum at senior levels, and the number of science teachers.

With this information, I identified a number of eligible schools from early–full and late–partial EMI schools in different areas of Hong Kong. I then referred to the government's annual statistical report, which summarises demographic information for each district in Hong Kong, including median monthly household income, major occupations of residents and educational attainment level of the residents (Census and Statistics Department, 2014). Eight districts have residents who share similar demographic characteristics. These districts

are located in different areas of Hong Kong: the New Territories, Kowloon, and Hong Kong Island.

In Hong Kong, 450 of the total of 485 secondary schools (92.7%) deliver the Hong Kong Diploma of Secondary Education science curriculum. After eliminating those that did not offer the curriculum and those that admitted students with average or low academic achievement (band 2 and 3 schools), 173 schools remained (35.7%). Of the remaining schools with above-average students (band 1 schools), 118 are full EMI schools that use English as the medium of science instruction; 55 are late–partial EMI schools, which switch from Cantonese to English medium at grade 10. Six out of 55 schools were then eliminated as they offered either Chinese medium curriculum, or only arts subjects. In all, 118 full EMI schools (24.3%) and 39 late–partial EMI schools (8%) in the 8 districts in Hong Kong were eligible for recruitment. Figure 3.4 summarises the school selection process.

3.4.4 Recruitment

Based on the complete list of 118 early–full EMI schools and 39 late–partial EMI schools, I contacted each school by email or telephone to invite them to participate in the study. Once I received the approval of the school principal, I contacted eligible teachers by telephone or email to introduce myself and explain the purpose of my study. With those who agreed to participate, I discussed which science topic I could observe and confirmed the schedule for

observations and interviews. On the day of data collection, I gave a general briefing about the study to the teachers and their students, reminding them that this study was voluntary and informing them that those who did not want to be part of it could leave at any stage and their data would be destroyed.

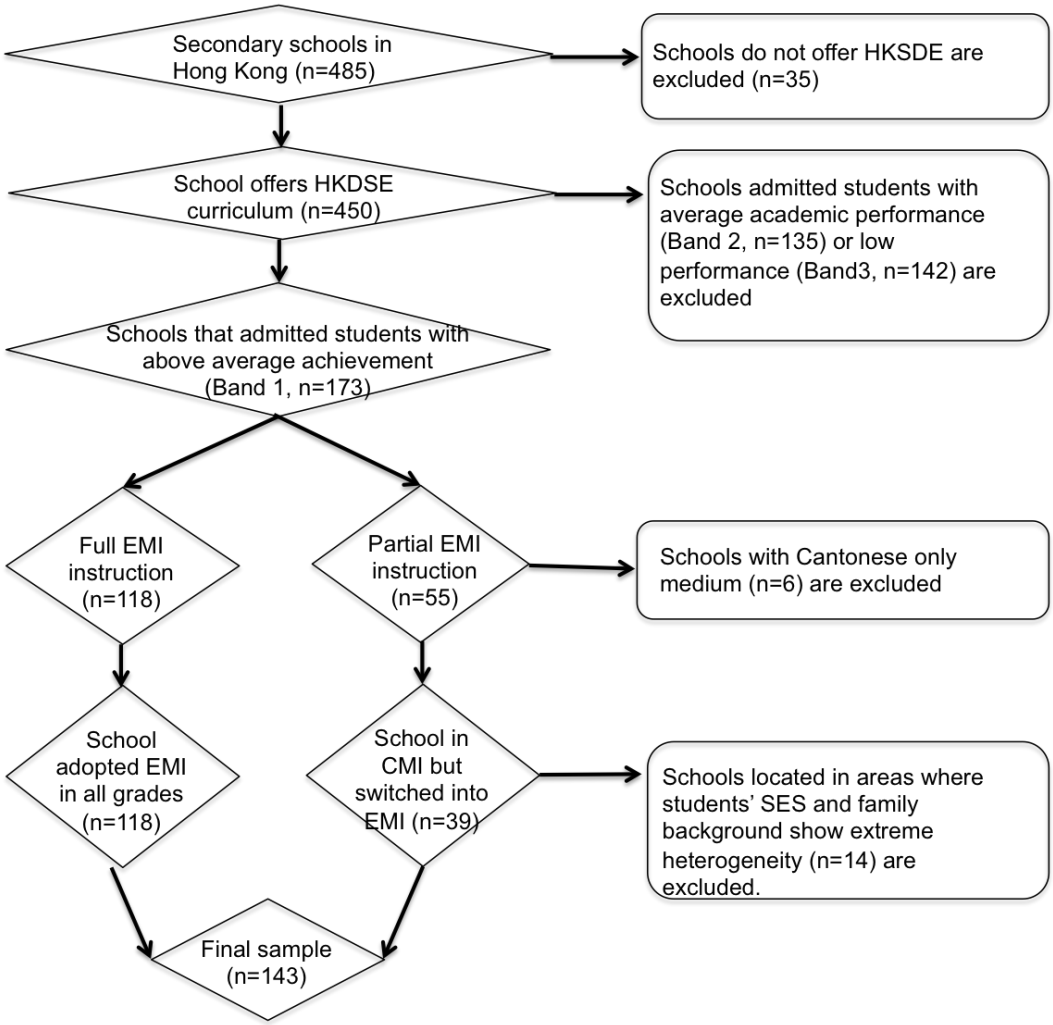


Figure 3.4. Flowchart of the schools selection process

3.4.5 Challenges of getting access into the schools

During the main data collection phase, I encountered a number of problems getting access to secondary schools in the first two months, including:

- I did not have local connections with school principals. Most schools that agreed to participate were via a personal contact, but the rejection rate from the 143 eligible schools was high.

- There appears to be little interest in educational research amongst Hong Kong secondary schools.
- Teachers were not keen to be audio or video recorded. This was the primary reason for teachers' rejection of my invitation.
- School principals and teachers expected additional support (e.g. professional development workshops for teachers) from the researcher in return for taking part in the study.

3.5 Participants

3.5.1 The eight participating schools

A letter inviting participation in the study was mailed from the researcher to the school principals and science panel heads of the 114 eligible schools. Forty schools replied; only 20 schools expressed their interest. The response rate was 17.5%. Of these 20 schools, only 8 schools offered both grades 10 and 11 science classes for video-recorded observations. The 8 schools were chosen according to the sampling frame described above. There were 4 full EMI schools and 4 late–partial EMI schools; the success rate of getting schools participating in this study was 7%.

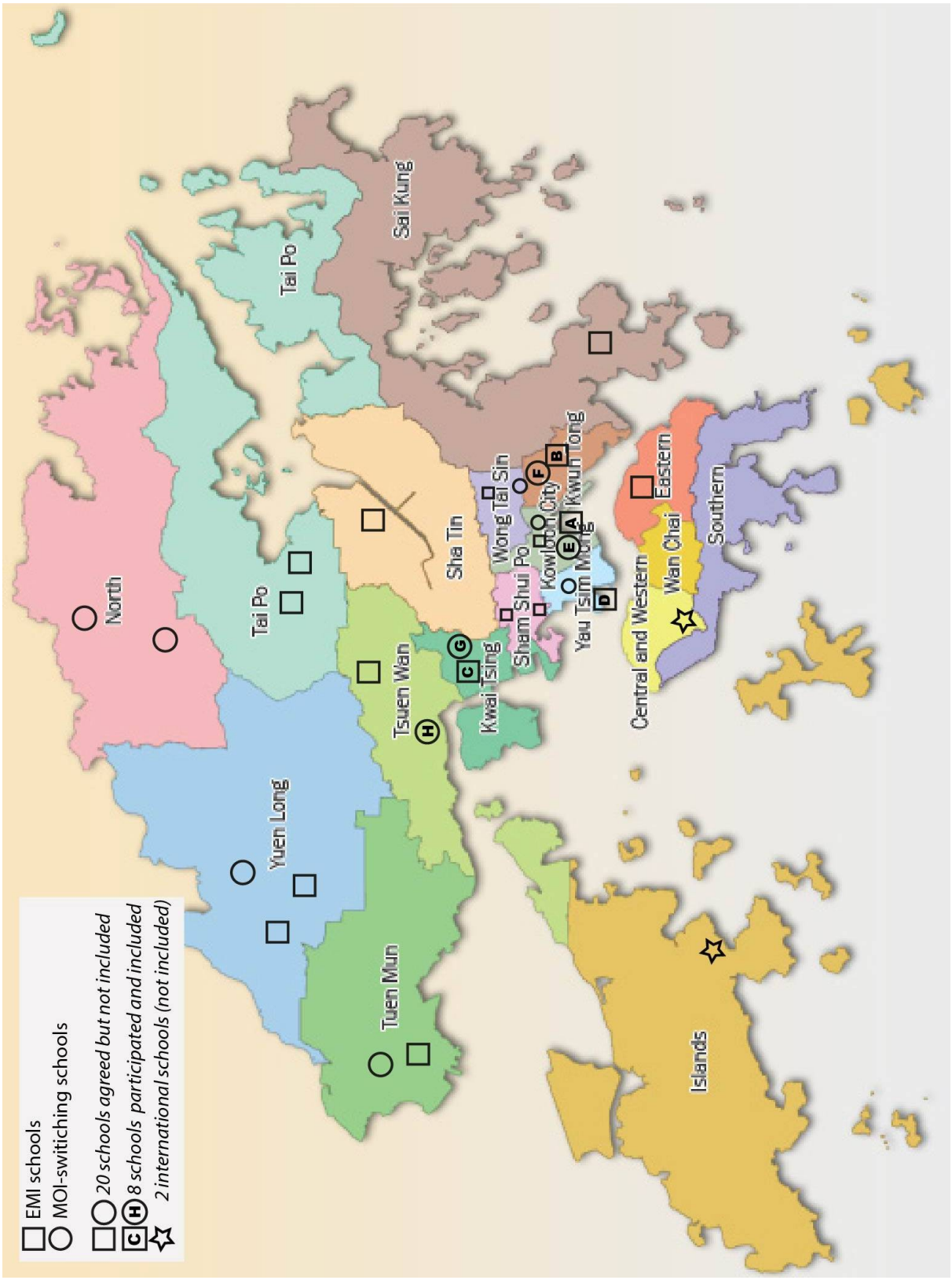
The participating schools in this study included 8 secondary schools in 5 districts in Hong Kong with similar demographic backgrounds. These sampled

schools were carefully selected, based on the planned sampling frame[7] (see section 3.4.2), according to the school's official medium of instruction (MOI), geographical location, students' academic performance and school curriculum. The selection was intended to ensure that all the sampled schools were representative of Hong Kong secondary schools and that they were closely matched in socio-economic status and students' academic ability. Figure 3.5 illustrates the locations of 8 participating schools, and another 20 schools which agreed to participate but were excluded from this study.

[7] To avoid noticeable demographic differences such as those in residents' socio-economic status and educational qualifications across different areas in Hong Kong, only schools located in districts with similar demographic characteristics were selected and areas where mainly lower- and middle-class residents were preferred. For students' academic ability, student academic achievement before admission and performance in public examinations of the schools were also considered.

In Hong Kong, students with better academic results usually enroll in full EMI schools, which are thought more prestigious than CMI/late–partial EMI schools and promise improved prospects for students. This implies that academic performance in most full EMI schools is generally better than that in late–partial EMI schools. For a comprehensive view of the situation of EMI instruction in different types of schools, four full EMI and four late–partial EMI schools with comparable academic ability of the student intake were included. The CMI schools were not chosen because the academic performance of student intake was significantly different from that of the early–full EMI and late–partial EMI schools, and because all teaching and learning (activities, interactions, assessments and teaching materials) was in Chinese. Most of these Chinese medium schools did not change their medium of instruction at senior levels, suggesting limited proficiency of their students.

Figure 3.5 Locations of the responding schools and the eight participating schools



3.5.2 School types—'early–full' EMI versus 'late–partial' EMI schools

With the above sampling criteria, 114 schools in 18 districts were identified in the sampling frame. Among these schools, 4 'early–full' EMI schools (identified as A, B, C, D) and 4 'late–partial' EMI schools (identified as E, F, G, H) participated in this study.

The EMI schools A to D adopted English as the only instruction mode for all grades (grades 7 to 11) and for nearly all subjects except Chinese history and Chinese. Students in these EMI schools had passed the level of English proficiency required by the schools for studying in English. Schools E, F, G, H are late–partial EMI schools. They used Chinese as the MOI for the junior levels (grades 7 to 9), and introduced partial EMI instruction at senior levels (grades 10 to 11) to all content subjects taught in English (including physics, chemistry, biology). Students subsequently took a public examination in English.

Under the government's fine-tuning language policy reviewed in chapter two, schools E to H have been allowed to adopt EMI for senior levels if the students' English proficiency has improved to the threshold level for learning in an English environment (Council, 2009). These late–partial EMI schools used Cantonese as the MOI from grades 7 to 9, and later switched to EMI for grades 10 to 12, with nearly all content subjects being taught in English and public examinations conducted in English. The decision on the MOI was directly related to the academic ability of the students admitted to the schools.

For example, students at Schools E to H were originally categorised as suitable for Chinese instruction before their admission to the schools. These students gradually improved their English proficiency at junior levels, their English ability being assessed through school-based examinations at every grade. If their English proficiency attained the threshold level for EMI, the school decided to allow these students to study in an EMI class at a senior level (i.e. from grade 10).

Typically, students with good academic performance enrolled in EMI schools. With the newly implemented fine-tuning policy, all secondary schools were allowed to select the most appropriate MOI arrangement for their students. For instance, if a class contained 85% of new students who belonged to the top 40%, the Education Bureau would allow flexibility for the school to choose its preferred MOI (Education Bureau, 2009). This suggests that while Chinese students with good academic results were previously only allowed to study in Chinese, they could now opt for an English environment if their late–partial EMI schools had adopted EMI at senior levels.

3.5.3 School background

The background information on the participating schools is summarised in table 3.3. This includes the district within which the school is located, school type, religion, median monthly household income in the school district, proportion of non-student population aged 15 or above with a post-secondary

qualification, academic achievement of intake students at grade 7, and the perceived language ability of intake students (i.e. the medium of instruction). This information was obtained from multiple sources: the school website, the Education Bureau's website, and interviews with the school principals and science teachers.

All eight participating schools were government-funded public schools. All such schools in Hong Kong are operated by the government, charities, or religious groups. Regardless of their school type (Protestant, Catholic or no religion), or the composition of the student population (boys only, girls only or co-ed), these schools deliver the same Hong Kong Secondary Curriculum and are administrated by the same authority, the Education Bureau (equivalent to the Ministry of Education) of the government of the Hong Kong Special Administrative Region. In the eight participating schools, there are five co-ed schools, two girls schools and one boys school. They are located across various districts in Kowloon and the New Territories. There is one full EMI and one late–partial EMI in each of the following districts: two in Kowloon City, two in Kwun Tong, two in Kwai Ching, one late EMI in Yau Tsim Mong and one MOI-switching in Tusen Wan. Most of the schools were located in areas with average monthly household incomes of about HKD$23,000, except for schools A, E and H, which were located in areas with slightly above-average monthly household incomes (HKD$31,000).

All these schools are band 1, meaning that they had admitted a large percentage (70% to 100%) of students categorised as band 1 (see note 6). The academic ability of students in the two EMI schools, C and D, was the highest (all band 1), closely matched by full EMI schools A and B (nearly all band 1 students, 90% to 100%), followed by the two MOI-switching schools F and G (most band 1 students, 80%) and schools E and H (with 70% band 1 and some band 2 students). Although the MOI at grades 10 and 11 was English in all schools, it was assumed that teachers and students in participating schools had diverse experiences of English instruction.

Among the MOI-switching schools, schools F and G were fairly comparable to the EMI schools. Students in school F were slightly more proficient in English than those in school G. Students in schools F and G were generally better at English than the students in schools E. Such observable discrepancies in students' standard of English may help explain the difference in interaction patterns observed after the school switched from Chinese to English for teaching science. Although both early–full and late–partial EMI schools claim their official MOI at grades 10 to 12 to be English, teachers and students had had years of different experiences of English instruction and possessed varied academic abilities and English proficiency.

Schools	A	B	C	D	E	F	G	H
Actual MOI by observation	Mainly Eng.	Mainly Eng.	Mainly Eng.	Mainly English	Mixed, majority Eng.	Mixed, majority Canton.	Mixed, majority Canton.	Mixed
Location (District)	Kowloon City	Kwun Tong	Kwai Tsing	Yau Tsim Mong	Kwoloon City	Kwun Tong	Kwai Tsing	Tusen Wan
Gender; school type (funding);	Co-ed/ Aided[&]	Co-ed/ Aided	Co-ed/ Aided	Girls/ Aided	Boys/ Aided	Girls/ Aided	Co-ed/ Aided	Co-ed/ Aided
Religion	Protestant/ Christian	Catholic	Protestant/ Christian	Protestant/ Christian	Catholic	Catholic	Protestant/ Christian	none
Academic achievement of intake students at grade 7*	90% Band 1	90% Band 1	100% Band 1	100% Band 1	70% Band 1	80% Band 1	80% Band 1	70% Band 1
Perceived MOI of intake students*	Eng.	Eng.	Eng.	Eng.	Eng. & Chin.	Eng. & Chin.	Eng. & Chin.	Eng. & Chin.
Median monthly household income in the district (HKD)^	$31,000	$23,200	$23,600	$30,000	$31,000	$23,200	$23,600	$31,000
Proportion of non-student population aged >15 with a post-secondary qualification	84.6%	75.8%	74.7%	84.1%	84.6%	75.8%	74.7%	83%

Table 3.3 The demographic backgrounds of the eight participating schools

^(median monthly domestic household income in Hong Kong for 2014: HKD 23,500) [&]Aided: schools are subsidized by the Hong Kong SAR government * Sources: Source: 2014 Population and Household Statistics Analysed by District Council District, Census and Statistics Department, Hong Kong SAR Government and school websites, interviews with school principals and science panel heads

3.5.4 The participating teachers

Principals or science panel heads of the sampled schools invited their science colleagues to participate, provided that the teacher was teaching grade 10 or 11 science subjects (physics, chemistry, biology) and agreed to be video or audio-recorded during classroom observation. Only eight schools were studied. These schools provided at least two science classes, both grades 10 and 11, for classroom observations.

3.5.5 The teachers' backgrounds

Nineteen teachers (3 females and 16 males) teaching science subjects (6 physics, 6 chemistry, 7 biology) participated in this study. Each participating teacher was given a pseudonym and a code (T1 to T19), which is used in the data analysis sections. The backgrounds of the participating teachers from each school and their teaching experience are summarised in appendix J and K. Their teaching experience ranged from three to more than 35 years. All teachers graduated from universities in Hong Kong and obtained a BSc degree in a relevant teaching discipline and a postgraduate diploma in education. These academic qualifications are a common requirement for teaching science in local secondary schools. One teacher, T9, had a Master's degree in science education. At present, there is no standardised English assessment for content-subject teachers in Hong Kong to teach at an English medium school.

3.5.6 Teacher qualifications

Based on the responses from the questionnaires and teacher interviews, the self-reported English levels of participating teachers are summarised in appendix L. Almost none of the participating teachers had any formal qualifications in teaching science in English or had participated in any EMI teacher training. Only one teacher, T6, indicated in the questionnaire that she had attended a two-week professional development workshop on language across the curriculum at a local university. All the teachers had passed their English language subject before being admitted to a university, and they had an English proficiency equivalent to score 6 in the International English Language Testing System examination. In the questionnaire, the researcher asked each teacher to rate his or her own English proficiency in listening, speaking, writing and reading on a five-point Likert scale. The self-reported proficiency in English language skills might not, however, truly reflect the actual English language abilities of participating teachers when explaining science to students and delivering teaching materials in English-medium classrooms.

One issue that will be explained later in this thesis is that it was not possible to measure the teachers' English proficiency using a standardised test. The research therefore used direct observation to estimate the teachers' English proficiency. The researcher observed little evidence that teachers' English proficiency did affect their interaction with students. The inability to measure

the teachers' proficiency more formally could constitute a potential limitation on the study. However, the level of the teachers' English proficiency was not related to the study's objectives and did not address, any of the research questions, namely to examine if there was any difference in classroom interactions. In reality, teachers often found it offensive if they thought that their English proficiency was being assessed.

3.5.7 Teaching allocations

From the researcher's view, having the same teacher teaching both grades would have been the most desirable situation. This could have alleviated the potential influence of differences in teaching styles between individual teachers. It would also have been ideal if all participating science teachers had taught the same topics, to minimise any possible teacher effects, but whether this would have been possible is highly dependent on the schools' staffing, teachers' involvement and their own individual teaching schedule. However, in reality it was not always possible to observe the same teacher teaching both grades 10 and 11 in the same school. Only teachers in the early–full EMI school B and late–partial EMI schools G and H were teaching both grades 10 and 11 science classrooms. Teachers in the other five participating schools were only teaching either grade 10 or grade 11 science.

3.5.8 Participating students

A total of 796 students aged 15 to 17 participated in this study: 363 grade 10 students and 428 grade 11 students from 25 classes (physics 6; chemistry 8; biology 11). In most classes, the class sizes ranged between 25 and 40 students.[8] The student questionnaire indicated that nearly all students were born in Hong Kong, with a small percentage of immigrants (10%) from Mainland China. All participating students indicated that they spoke Cantonese as their first language, regardless of the MOI of their schools or their place of birth.[9] Grade 10 and 11 students from the participating schools taking science subjects (physics, chemistry or biology) were selected for observation. In each school, at least one grade 10 and one grade 11 class of the same science subjects were included. In schools B, G, H schools, grade 10 and 11 science classes were taught by different science teachers in each school.

3.5.9 English ability and academic performance of students

Participating students were asked in a questionnaire about their English proficiency, based on their school examination results from the previous academic year. Scores were confirmed with teachers to ensure the reliability of

[8] The number of students in the observed lessons were informed by the participating teachers and confirmed with the actual counting by the researcher during the observation.

[9] Most of the students who migrated to Hong Kong were from the southern cities of Mainland China, e.g. Guangdong province, where they are regarded as Cantonese and speak Cantonese as their first language and Mandarin as their official language in school.

self-reported academic achievements. After I collected all students' questionnaires, I gave the overall scores of the whole class to the teachers and asked whether the scores reflected the students' academic performance at class level. In most cases, the teachers commented that they did. I wanted to find out whether student English achievements were related to their science achievement at school. Thus, the reported results based on their own school assessments could have sufficiently addressed the research question. One might argue that student English proficiency would be more accurately measured using a standardised test. However, assessing individual student English proficiency and science abilities across the eight schools was not the aim of this study, and not practical because many science teachers did not want their students to be assessed in terms of their English and science achievements by the researcher, who was an outsider to the school.

Table 3.4 shows the academic abilities of school graduates in the eight participating schools. The table contains information about student pass rates in English in public examinations, the percentage of students meeting the minimum requirement for university entry, the percentage of students enrolled in a university degree programme, the academic achievement of intake students at grade 7, and the perceived language ability of intake students in each school.

Early–full EMI	A	Engl.	96.9%	78.9%	45.3%
	B	Engl.	96.9%	Not given	Not given
	C	Engl.	100%	93.5%	71.5%
	D	Engl.	99.3%	Not given	Not given
Late–partial EMI	E	Mixed	60%	Not given	Not given
	F	Mixed	93.7%	75.3%	Not given
	G	Mixed	75.1%	57.8%	30.7%
	H	Mixed	51%	40%	14.6%

Table 3.4 Academic ability of the graduates (grade 12) in the participating schools

**^ 78.1% for all secondary schools in Hong Kong. ^ Source: 2014 Population and Household Statistics Analysed by District Council District, Census and Statistics Department, the Hong Kong SAR Government; * Sources: school websites, and interviews with school principals and science panel heads*

This information showed that the students' academic achievements (e.g. science, mathematics) within each of the eight participating schools was generally similar, and this was reflected in a number of ways. First, the school's banding partly indicated students' English proficiency. Students are allocated to a banding based on a standardised school attainment test at grade 6 of their admission to secondary school. Students from band 1 EMI schools had the highest academic attainment and English language proficiency (see note 6 for further elaboration). Thus, the banding of the participating school could indicate the school's general academic ability and the English proficiency of the students admitted to it.

Secondly, the academic performance (including English proficiency) of grade 12 graduates in public examinations provides another indicator of the student's academic ability in each school. The public examination results of graduates from the eight participating schools were above the minimum requirement for university entry in 2014. Student pass-rates in the English language in public examinations (at grade 12 in 2014) ranged from 96.9% to 100% in the EMI schools and 51% to 93.7% in the MOI-switching schools. In all the EMI schools and two of the MOI-switching schools (F and G), the pass-rate was higher than the mean average of all Hong Kong secondary schools (78%).

3.6 Piloting

3.6.1 The pilot study

In order to test the validity and reliability of the instruments, I conducted a pilot study in March and April 2014 in one late–partial EMI School in Hong Kong. Table 3.5 summarises the data collected.

Total	n=22	n=116	n=3
Number of participants	7 science teachers 5 grade 10 science students 10 grade 11 science students	6 science teachers 60 grade 10 science students 50 grade 11 science students	grade 11 physics grade 10 chemistry grade 10 biology
Total time of recordings	4 hours 30 minutes	—	3 hours

Table 3.5 Summary of the pilot study

The following sections discuss the problems I encountered during the pilot study and how some of my research instruments changed as a result of comments from teachers and students in the study. First, in relation to the questionnaire, participating teachers and students expressed difficulty in understanding the terminology of intra- and inter-code switching used during the pilot study. Simpler expressions were used in the pilot study: 'mixing Chinese and English words in one sentence' and 'mixing Chinese sentences and English sentences'. Although participants could distinguish the differences, many students expressed difficulty in determining whether they code-switched at sentence level or within a sentence. In the main study, only three language choices were provided (L1 only, L2 only and code-switching) in trying to establish the participants' previous EMI experiences and their degree of exposure to English in learning science.

Second, in the students' questionnaires, students often left empty the sections on self-reported science achievements and the English language proficiency of students' actual grades in previous examinations. Many students did not remember their scores from previous science examinations or their scores in sub-competencies (listening, speaking, writing and reading) in English subjects. In the main study, I asked for overall average grades for the whole body of students in each class in science and English achievement, instead of their actual grades. For these reasons, I also confirmed verbally with teachers

the overall grade of each class based on the student examination results collected from the student survey.

Third, the last section of the pilot questionnaire asked the respondents to select coping strategies they used and rate their usefulness. Some of the respondents gave a rating even if they did not use the strategy. Clearer instructions were provided in the main study, printed in bold type or with shading, to remind the respondents that they should only provide their ratings for the strategies they used. Although some students were concerned about the length of the questionnaire, many completed the questionnaire in 10 to 15 minutes. The number of questions in the final study was reduced from 130 to 78, across 3½ pages.

For the pilot study, I had prepared a very structured interview protocol, which contained more than 20 questions for teachers and students. Based on advice from the teachers and experienced researchers from the local universities in the pre-test, I reduced the number of questions to six, with a semi-structured interview protocol. In the pilot study these questions were well received by the respondents and proved useful in collecting respondents' views on classroom interactions, perceptions on teaching and learning process, the language challenges, and coping strategies found in EMI science classrooms.

There were also some practical issues with the student interviews. I had originally planned to conduct focus-group interviews with 10 to 15 students in

each session. However, it proved impossible to organise a focus-group interview with students since many of them had other school engagements outside the classroom timetable. Instead, I interviewed a small number of students (three to five students) in a focus group each time. This proved better than one-to-one interviews, because some students were shy about sharing their experience or needed many prompting questions from the researcher to help them articulate their thoughts.

For the follow-up interviews with teachers, I employed the stimuli recall technique: I recalled episodes or scenarios based on my observation notes. In the notes, I marked all of the teaching strategies related to language challenges during the class interactions from the observed lessons. These scenarios I believed were closely related to the aims of this study (e.g. episodes about providing students' L2/English learning opportunities in science through specific questioning techniques, turn-taking and code-switching). I asked the teachers to explain some of these pedagogical acts.

For the classroom observations, I had prepared a structured observation sheet with tables to provide space for recording information about teaching outcomes, learning targets, the nature of interactions and language choices in the classrooms. In my first visit, I could not fill in most of the items because there were many teaching–learning processes going on simultaneously during the lesson. After 10 minutes of the first observation, I decided to use blank paper

to write down what the teacher and students were doing in the lesson. Next to these observed actions, I wrote down my comments. I found this unstructured observation helpful. As all observations in the main study were video-recorded, this allowed me to revisit the observational data and produce a more detailed analysis of the classroom interactions, along with a frequency count of the duration of different classroom languages.

3.6.2 The challenge: the number of possible observations

The experience of my pilot study showed me that it was very important that all my participants—especially the teachers—clearly understood that the study was not intended to evaluate their teaching performance or their students' performance. Making this point clear would minimise anxiety about having me in the classroom with audio equipment or a video camera. If I found unusual behaviour—such as an unnaturally quiet class—I would stop my recording device and use only note-taking techniques for my observations. To avoid 'demonstrative lessons' (Hoare, 2003), where some teachers do not behave as they would usually, I would make it clear to these teachers before the second observation that I was interested in seeing how they normally taught on a daily basis. Interviews with students also included subsequent questions to check whether the observed lesson was noticeably different from their usual lessons in language choices, in various science-learning activities.

In the pilot study, only one single lesson (30–45 minutes) was observed in each class, which limited observation of possible classroom interaction patterns. To obtain a better picture, it was necessary to observe longer lessons, at least of a double-period (60–90 minutes), to allow sufficient time to observe the interactions during a range of teaching topics and learning activities, especially when there was a potential impact of a particular topic or a teacher-led activity on the interaction patterns. For an example, a lab experiment demonstration on exploring factors to affect the process of photosynthesis.

I therefore negotiated with the teachers to allow me to make at least two visits for the main study. For those who did not allow this, I requested that I be permitted to make observations for a double-period lesson. Many school principals and science panel heads expressed their concern about the researcher interrupting the class too often and slowing down their normal teaching schedule, and thus many participating schools allowed me to observe each class only once, in double-period lessons. For example, I observed four double-period lessons by four science teachers in school H during four visits.

In the eight participating schools, there was no observable difference in interaction due to the teaching topics or the classroom activities. The observable difference was the extent of EMI adoption. There was a slight difference when the observed lesson was a laboratory class. To minimise such an effect and to have accurate data of overall science teaching in the school, I negotiated with

every teacher that the observed lessons be mainly lectures, with additional laboratory-practice classes when these were available. I observed only a few laboratory classes simply because the time I visited did not coincide with laboratory schedules. Students in Hong Kong carry out laboratory work only two or three times in the two-year senior science curriculum. In addition to such science classes, I also requested time to observe when the teacher was delivering teaching topics that were similar to those in other participating schools. For examples, most of the chemistry classes I observed included the topic of 'acids and bases' during the time I visited the schools in March and April 2015.

3.6.3 Review of the pilot study

In a review of the pilot study, examiners suggested that the wordings of some of the instructions in the questionnaires needed to be revised. For example: 'Choose the most appropriate [option]'. There was ambiguity over whether this meant 'what you think people should do', 'what you personally would prefer', 'what you have experienced', or 'what you think most people experience'. I discussed this in detail with participating teachers and together we revised all the instructions in the questionnaires before the main data collection. For each instruction, I provided additional background information or circumstances to help the survey respondents understand clearly what they were being asked, and from which point of view they should respond. For instance, '*Based on your experience in your current senior science classroom*, please select the most

appropriate option that reflects your teaching practices' or '*According to your teaching practices in your current senior science classroom*, please indicate to what extent you agree or disagree with the following statements', or '*From your current experience in your current senior science classroom,* how demanding (A) and how important (B) are the following English language skills for your students'. Both my supervisors and I felt confident that the survey respondents could understand clearly what they were being asked in the surveys. In the main data collection, I received no complaints or major requests for clarification at the point of administration of the surveys.

Following the pilot, a pre-observation interview with teacher was added. This was important in order to provide opportunities for the teachers to explain the context of the observed lessons, the rationale behind the teaching planning and to what degree different coping strategies were used. I felt that it was important to conduct pre-observation interviews whenever feasible, for example, during the two to three minutes before the start of each observation. In the main data collection, I was able to ask a few simple questions of each teacher about the teaching content and plan, and the students' background before each observed lesson. Very often, teachers did not have time before the observations because they were teaching another class and only arrived at the classroom two to three minutes before the observation began. I conducted extensive post-observation interviews for each teacher to gather a comprehensive view of what

I had observed and to learn their personal views about teaching science through English.

3.7 Descriptions of research instruments

3.7.1 Classroom observations

The qualitative component consists of detailed unstructured descriptive field notes of the observed lessons. The notes include information on the structure of a lesson, the teachers' pedagogical moves, the flow of interactions, the classroom climate, and other non-verbal behaviour. Observations were of single-period lessons in two visits of 30 to 45 minutes, or (more commonly) of double-period lessons in a single visit. The video-recorded observations were further analysed in terms of the patterns of classroom interactions. The analytical framework and coding procedures are further explained in section 3.8.1. A sample observation sheet used in the data collection is attached as appendix H.

3.7.2 Pre- and post-observation interviews

Pre-observation interviews were conducted with teachers at stage 2, observations and semi-structured interviews were analysed, (in figure 3.3), seeking information on learning outcomes, targets, teaching beliefs, and language issues related to science teaching in EMI classrooms. At the end of each observation, a post-observation interview with teachers and students was conducted at stage 3. These qualitative findings from observation and

interviews informed the content validity of the quantitative survey (in figure 3.3). These interviews investigated participants' reflections on the classroom interactions I had just observed and asked for teachers' comments in relation to the pedagogical function of the interactions in teaching or learning science through the medium of English. Individual language challenges and coping strategies were also explored.

The interview questions had been adopted from previous empirical studies, with validated instruments (Hoare, 2003; Wong, 2012) adapted to meet this study's aims. The questions were aimed at examining teacher and student views on teaching practices, language challenges and the strategies used by the teachers when resolving any language challenges encountered by their students in understanding and communicating scientific ideas in EMI science classrooms. The interview questions were checked by three experienced researchers in the field of classroom research for content validity.

Post-observational interviews were conducted with all science teachers and with a randomly selected small sample of students (15 to 20 at each school) after the observation lessons. The aim of these interviews was to seek clarification and reasons for each teaching or learning episode where I observed language challenges and strategies in EMI science classrooms. I explored the teachers' turn-taking style, interactions, questioning skills, code-switching patterns and use of multimedia for teaching science. Teachers and students were interviewed

in their preferred language, which was Cantonese. I interviewed each teacher separately to enable them to express their opinions. With the students, I formed focus groups of two or three. Respondents were first asked for their comments on the observed lesson—whether they believed the lesson was typical of their previous lessons. This helped to establish the content validity of the observed data, clarifying the extent to which the observed lessons provided evidence of the actual daily experience of teaching science in those students' EMI classrooms. All interviews were audiotaped and later transcribed into Chinese for coding purposes. Only those yielding results were translated into English. The coding framework and procedures are further explained below, in section 3.8.2. All the questions in both teacher and student interviews are listed in Appendix G.

3.7.3 Teacher questionnaire

The questionnaire design was based on a comprehensive literature review of relevant empirical studies, and a careful examination of validated surveys in previous studies of teacher and student perceptions of EMI learning. The modified survey in this study focuses on aspects of significant indicators that might influence the quality of classroom interactions (Lo and Lo, 2013): classroom language use (Evans, 2000), teachers' views and teaching practices about second language teaching in science (Hoare, 2003), and language

challenges and strategies in EMI classrooms (Tatzl, 2011). The following items were covered in the teacher questionnaires:

1. demographic data about the science teacher, teaching qualifications, teaching experiences in EMI; views on English language skills in science; self-reported English language abilities in four language skills (speaking, writing, reading, listening) (15 items)
2. use of different classroom languages in a range of science class activities (12 items)
3. importance and difficulty of different English language skills in science classrooms (17 items)
4. teaching practices (11 items) and teaching belief (11 items) about the use of English in teaching science.
5. language challenges (27 items) and coping strategies (11 items) in EMI science classroom.

3.7.4 Student questionnaire

The same survey was administered to both groups of grades 10 and 11 science students. The only differences were in the background information sought, such as the number of years of learning experience, and the latest language and science achievements.

As with the teacher questionnaire, items were carefully adapted from previous studies with validated instruments after an intensive literature review. Items included classroom language use (Evans, 2000), student self-concepts and student belief in science (Yip, Coyle, and Tsang, 2007) and language challenges and strategies in EMI classrooms (Tatzl, 2011). The following items were covered in the student questionnaire:

6. demographic data, self-reported science achievements and English language abilities in four language skills (speaking, writing, reading, listening) (15 items)
1. use of different classroom languages in a range of science class activities (12 items)
2. importance and difficulty of different English language skills in science classrooms (17 items)
3. reflections on the impact of the medium of instruction on their science learning (3 items) and degree of importance and difficulty of English skills in science (10 items)
4. self-concepts (7 items) and beliefs about instructional activities (9 items) in learning science through English
5. language challenges (27 items) and coping strategies (11 items) in EMI science classrooms.

3.7.5 Development of the questionnaires

Both teacher and student questionnaires were designed to explore individual perceptions of EMI science learning, language use in science, English proficiency, self-concepts, teaching beliefs, language challenges and strategies, and relevant demographic information. All teachers and a small set of student participants were invited for follow-up interviews to obtain clarifications or explanations on challenges and strategies identified in the surveys. Questionnaire results informed my more guided questions for the second-round interviews with teachers and students in stage 3.

For each of the surveyed items, the respondents were asked to indicate their preference on a Likert scale. For example, rating of student self-concepts used a 5-point scale, where 1 = strongly disagree, 2 = disagree, 3 = neutral; 4=agree, 5 = strongly agree. Both questionnaires were developed in English. Only the student version was translated into Chinese. It was checked and proofread for accuracy by a professional Chinese–English translator. Students were provided with a bilingual version to ensure they understood the questions. The questionnaires were reviewed by three experienced researchers in science education, education and linguistics, in order to establish content validity in the categories of typical instructional activities in a science classroom and typical challenges and strategies in learning science through English. The researchers also ensured the construct validity of each survey item, so that the measure of

each variable corresponded to the underlying reality. The procedures for analysing the questionnaire data and the chosen statistical tests are further explained in section 3.8.3. Both teacher and student questionnaires are attached in appendices C and D.

3.8 Data collection

The number of participants at each school and the data collected— video-recorded observations, interviews and questionnaires—are summarised in table 3.6.

Schools	A, B, C, D	E, F, G, H	8
Class	10 (grade 10: 5 grade 11: 5)	15 (grade 10: 7 grade 11: 8)	25
Subjects	6 biology, 2 physics, 2 chemistry	5 biology, 4 physics, 6 chemistry	-
Observed lessons	13	20	33
Teachers	6	13	19
Students (total)	346	450	796
Students (grade 10)	158	210	368
Students (grade 11)	188	240	428
	33 observed lessons in 30 visits 19 science teachers and 796 students were observed in the lesson observations 346 students from full EMI schools and 450 students from late–partial EMI schools 363 students from grade 10 students (3 classes from physics, 4 from chemistry, 5 from biology) 428 students from grade 11 students (3 classes from physics, 4 from chemistry, 6 from biology)		

Table 3.6 Summary of main data collection

3.8.1 The teaching and learning materials of the participating schools

It would have been ideal if the same topic had been taught across all observed classrooms, to eliminate possible confounding variables such as the type of teacher-led activities that could greatly affect the frequency of teacher–student interactions. However, this was an observational study which aimed to avoid altering a teacher's normal teaching and students' learning behaviour. The science topic of the observed lessons was therefore not controlled. In the inclusion criteria, I already controlled for all participating schools to be following a similar teaching timeline. All these schools were based on the same Hong Kong Diploma of Secondary Education science curriculum (CDC and HKEAA, 2007a, 2007b, 2007c). Teachers drew on this curriculum to develop their individual teaching plans. The curriculum outlines topics, teaching hours for each science topic, specific science knowledge expected for each topic, and the science learning activities (e.g. laboratory practices) students are expected to undertake in a specific timeline. From interviews with teachers and science panel heads, I learned that all eight participating schools followed the same teaching timeline, and delivered the same sets of science topics during the data collection period. All science teachers in the schools I visited claimed to follow the Hong Kong Diploma of Secondary Education curriculum when developing their teaching schedule, teacher-led activities and laboratory classes.

All the science classes that I visited used textbooks as the primary source of teaching materials. Nearly all the participating schools used the same publisher for science textbooks. Some teachers used multimedia resources such as PowerPoint slides and videos of laboratory experiments, which were developed by the textbook publishers and which the teachers projected onto a large screen in front of the class when teaching. The projections were the same set of learning materials that students could find in their own textbooks. In Hong Kong, only a few publishers produce secondary science textbooks, and each publisher produces textbooks for only one specific science subject. In the schools I visited, textbooks from the Aristo publisher were used for chemistry; Oxford University Press textbooks were used for physics and biology.

3.8.2 Pre-observations with teachers

Pre-observation interviews were conducted with teachers briefly for two to three minutes at the beginning of each observed lesson to obtain information about the lesson. For instance, the teaching objectives of each lesson, teaching topics, prior knowledge, learning outcomes, types of teaching materials, and students' backgrounds. All teachers participated in the pre-observation interviews and these were audio-recorded in teachers' native language (Cantonese) to allow them to express themselves freely.

All interviews with teachers and students were conducted in Cantonese, the participants' first language, to allow participants to easily recall what they

thought about the observed lessons and to encourage them to provide comments on their perceptions and experiences of teaching and learning science in an English environment more generally.

3.8.3 Video-recorded classroom observations

A total of 33 lessons, mostly in double lesson sessions (40 minutes per lesson), were observed during 30 school visits. All lessons were video-recorded. Each class was observed twice or at least once in double periods. The researcher directly observed the class and took field notes about all teaching materials, class activities, participants' reactions regarding their classroom interactions, and the teachers' questioning skills.

3.8.4 Procedures of video-recorded observation in each school

Here is an example of one observation schedule for each school I visited. First, I met the school principal or science panel head to introduce the aims of the study, explain the research activities involved, negotiate the possible number of classroom visits, and discuss possible dates, times and locations for classroom observation—in most cases, according to the teacher's schedule. During the first visit in each school, I had an informal meeting with the school principal, science subject heads, and science teachers who had expressed interest in participating. In the meeting, I answered their questions and addressed any concerns related to the study. Once I had obtained teacher and student consent, I arrived at the school at an agreed time.

The lessons observed varied according to the day of the week and the time of day (morning or afternoon). To prevent the teacher from altering his or her normal teaching practice, I did not explain in great detail what I would pay especial attention to during my observation.

Sitting at the back of the classroom, I would observe and write detailed notes and comments on classroom interactions, questioning and language issues. The teacher would be given a wireless microphone and the lesson would be video and audio-recorded with the camera at the back of the room. Video-recording would only take place with the consent of both teacher and students and if I had received no objection from any individual in the classroom. If a teacher or any of the students did not wish to be recorded, I would negotiate to audio-record. If this was not acceptable, I would take only handwritten notes without recording, but this did not happen in the eight participating schools in my sample. I ended up observing each teacher for at least one double-period lesson in most schools I visited.

3.8.5 Post-observation interviews with teachers

After all the observations were completed, I invited each teacher to take part in a semi-structured interview, which was audio-recorded and lasted for around 30 minutes. All interviews were conducted in the participants' native language (Cantonese) and transcribed into English by the researcher. The interview was divided into two parts. In the first part the participants were asked about their

overall impression of the observed lessons, and their views about the pedagogical functions of the interactions in the lesson just observed. From time to time, I reminded participants of scenarios from the lesson that I had noted in my observation sheet. These scenarios were mostly related to class interactions and the teachers' questioning skills. I then invited the teachers to comment on their actions or on student behaviour and to explain or justify the observed teaching behaviour (e.g. 'Would you like to comment on why you asked such and such a question at that time?' 'Why did you translate the word 'neutralisation' into Cantonese?).

In the second part of the interview, I asked for the teachers' views on using English to teach senior science classes, possible language challenges, and the individual strategies they used. The aim here was to find out their reflections on the usual practices in the lessons observed, and to understand their views about the MOI practice and language use in English science classrooms. A few teachers shared views on the changes they had observed between the newly implemented six-year Hong Kong secondary curriculum and the old seven-year secondary education.

3.8.6 Interviews with students

Fifty-two students were interviewed from the eight participating schools. Around two to five students for each class that had been observed were randomly selected by the researcher to be invited for a 10-minute focus-group

interview. In the pilot study, I tried one-to-one interviews with students and found that some students were reluctant to express their opinions. In the main study, I invited at least two students to be interviewed at the same time. This greatly encouraged students to give their opinions because they could explain their ideas by building on their peers' responses, providing additional examples. The focus group also allowed a genuine discussion among students, where students did not simply agree with one another but provided counterarguments of their own, supporting ideas on different issues raised in the interview. For example, I asked which language was their preferred MOI in learning science? Some students supported English; others supported Cantonese and a few thought code-switching was preferable.

All the interviews were conducted in Cantonese and audio-recorded without the presence of the teacher. The interview was designed to serve two purposes. Firstly, it was to check if the teacher and students behaved as usual in the observed lesson. Most of the students said that the observed lessons were normal and truly reflected their usual teaching and learning practices, thereby confirming the validity of the collected data. Secondly, the interview was an opportunity to explore student reflections on the observed classroom interactions and to elicit their views about learning science in the English medium and about individual language challenges and coping strategies. Table 3.7 summarises the interview data.

No. of pre- and post-interviews	12	22	34
No. of teachers	6 (5 male, 1 female)	11 (10 male, 1 female)	17
Subjects	3 biology, 2 physics, 1 chemistry	4 biology, 4 physics, 5 chemistry	—
No. of student focus group interviews	8 (grade 10: 4; grade 11: 4)	14 (grade 10: 7; grade 11: 7)	22
No. of student	20 (grade 10: 10; grade 11: 10)	32 (grade 10:17; grade 11:15)	52
Total	19 teachers were interviewed; 6 teachers from the EMI schools; 13 teachers from the MOI-switching schools. 6 physics teacher, 6 chemistry teachers and 7 biology teachers. 43 teacher interviews were conducted, 25 pre-observation interviews (2–3 minutes) and 19 post-observations interviews (15–20 minutes).		
	52 students were interviewed after observation; 19 students from the EMI schools; 33 students from the MOI-switching schools. 27 grade 10 students and 25 grade 11 students. 12 physics students, 16 chemistry students and 24 biology students. 22 student interviews were conducted. 11 Groups from grade 10 and another 11 Groups from grade 11, each group with 2-5 students, (10-15 minutes).		

Table 3.7 Summary of the interview data

3.8.7 Teacher and student questionnaires

Once all observations had been carried out, the teachers and students who participated in the observations were invited to fill in a questionnaire. Respondents only completed the questionnaires after all observations had finished. The researcher was present when the students completed the questionnaires to avoid any possible influence from the teacher. Students were provided with sufficient time to complete the questionnaire and they were allowed to ask questions to ensure they were clear about all the instructions.

Most teachers and students could understand and follow all the questions in the questionnaires. Most classes finished the questionnaire in about 15 to 20 minutes. Overall, 19 teachers and 796 students from the eight participating schools filled in the questionnaires; only 545 students returned their questionnaires to the researcher (a return rate of 68%). All returned questionnaires were checked carefully to ensure every item was filled in. If there were any missing pages or items, the questionnaires would be returned to the school and collected after the items were completed. The questionnaires of 19 teachers and 368 grade 10 students and 428 grade 11 students were collected, together with those of 346 students from the early–full EMI schools and 450 students from the late–partial EMI schools. Table 3.8 summarises the demographic backgrounds of student respondents to the questionnaires. Table 3.9 summarises the demographic backgrounds of teacher respondents.

School Types	Early–full EMI (n=284)	Late–partial EMI (n=261)
Sex		
Male	101(19%)	136 (25%)
Female	182(33%)	125 (23%)
Age		
15	0	40 (7%)
16	56 (10%)	102 (19%)
17	150 (28%)	88 (16%)
18	59 (11%)	24 (4%)
19 or above	19 (3%)	7 (1%)
First language		
Cantonese	282 (52%)	258 (47%)
Mandarin	2 (0.4%)	3 (1%)
Place of primary education		
Hong Kong	282 (52%)	258 (47%)
Mainland China	2 (0.4%)	3 (1%)

Table 3.8 Demographic backgrounds of the student respondents to the questionnaire

School Types	Early–full EMI (n=6)	Late–partial EMI (n=13)
Sex		
Male	5 (26%);	11 (58%)
Female	1 (5%)	2 (11%)
Age:		
20–30 years	3 (16%)	0
31–40	2 (11%)	5 (26%)
41–50	1 (5%)	4 (21%)
51–60	0	4 (21%)
Teaching areas:		
Physics	2 (11%)	4 (21%)
Chemistry	1 (5%)	5 (26%)
Biology	2 (11%)	4 (21%)
Years of teaching experience	Mean (range, median)	Mean (range, median)
at secondary school	10.2 (2–22, 9)	20.8 (6–35, 19)
in English medium of instruction	8.3 (4–15, 5.5)	18.1 (3–40, 17)
in junior levels (grades 7–9)	7.5 (4–15, 5.5)	10.1 (0–35, 3)
in senior levels (grade 10-12)	10.0 (1–22, 9)	20.3 (2–35, 19)
in HKDSE (G10–12) (since 2010)	4.2 (1–6, 5)	4.1 (3–6, 4)
in Cert. Level (G10–11) (until 2010)	5.8 (0–18, 4)	12.5 (2–32, 13)
in A-Level (G12–13) (until 2010)	5.8 (0–18, 4)	15.1 (0–30, 16)
Self-reported English Language skills*	Mean (range, median)	Mean (range, median)
Listening	3.8 (3–4, 4)	3.4 (2–4, 3)
Speaking	3.7 (3–4, 4)	3.2 (2–4, 3)
Writing	3.5 (3–4, 3.5)	3.2 (2–4, 3)
Reading	3.8 (3–4, 4)	3.5 (3–4, 3)
Received EMI training?	Yes: 2; No: 6	Yes: 0; No: 13

Table 3.9 Demographic backgrounds of teacher respondents to the questionnaire

*Note: *Scale=1 (poor) 2 (fair) 3 (moderate) 4 (good) 5 (excellent)*

3.9 Analysis of the data

The following sections briefly discuss how I analysed the qualitative and quantitative data from multiple sources (see figure 3.6).

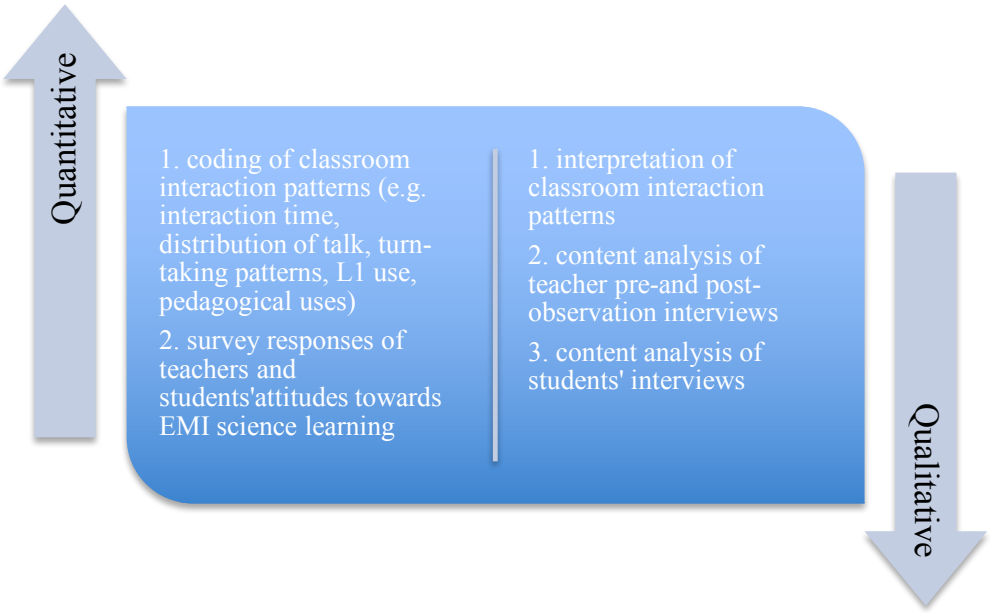


Figure 3.6 Research approaches to analysing multiple datasets

3.9.1 Analysing classroom interaction in a quantitative manner

The procedures in analysing teacher and student talk were based on the methods of Lo and Macaro (2012) with specific attention to the teacher–student interactions, the teachers' questioning types and the teachers' explanations that are related to the aims of this study. The observed classroom interactions were handled in quantitative and qualitative manners. Figure 3.7 summarises the key steps for analysing teacher and student talk.

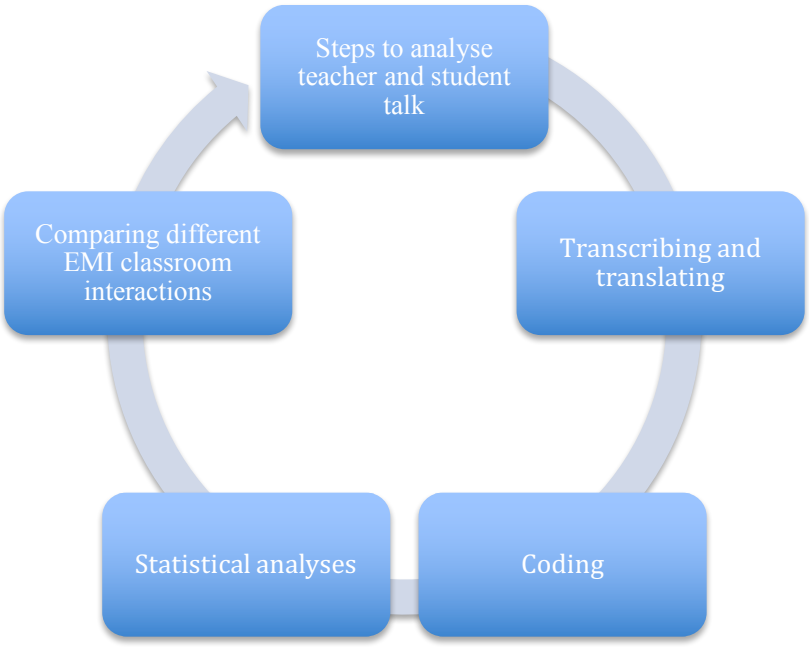


Figure 3.7 key steps for analysing teacher and student talk

i. Transcribing and translating teacher and student talk

The 33 video-recorded science lessons (physics, chemistry and biology) from four full EMI and four late–partial EMI schools were transcribed using the *NVivo* software package (see figure 3.8). The data was transcribed in English and analysed, together with the unstructured observation notes (about the teaching procedures and the researcher's comments). As observed lessons were mainly teacher-centred, only teacher–student interactions and some student–student interactions in whole-class situation were transcribed. Student–student interactions during group work or private conversations that were captured by the recorders were excluded. The lessons were first transcribed into English and supplemented with Chinese transcriptions at the time when participants were

using their first language or code switching. An example of the translation procedure of a lesson transcript is illustrated in appendix N.

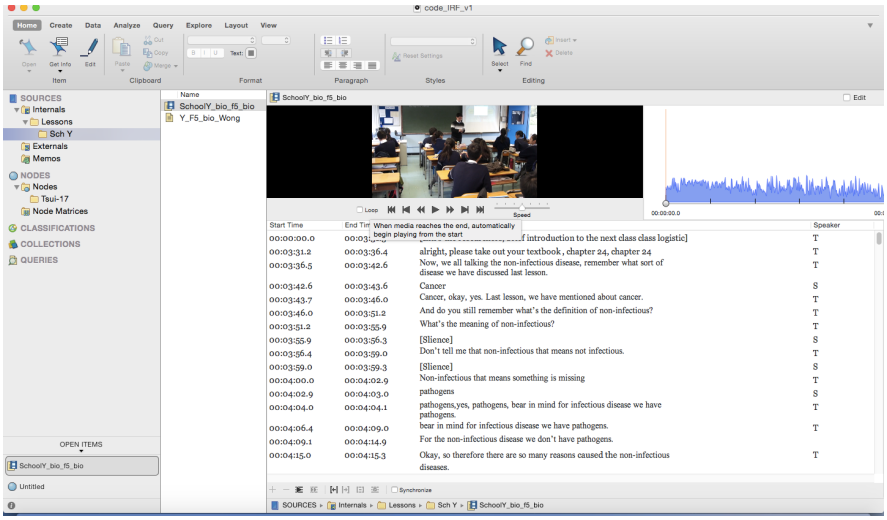


Figure 3.8 The NVivo programme window showing the transcribing process

ii. Coding for teacher and student talk

An initial coding system was adopted from Lo and Macaro's (2012) study, with specific attention to exploring classroom interactions in the science classroom. The coding framework aims to analyse classroom discourse in a quantifiable manner. After the lessons were transcribed and translated, these transcription files and the corresponding video files were loaded into *NVivo* software package for further coding. First, the teachers' and students' turns were defined, identifying different 'acts'.[10] These were then categorised into IRF exchange sequences based on established analytical frameworks (Sinclair and

[10] According to Sinclair & Coulthard (1975, p 27), the units at the lowest rank of discourse are *acts* that carry performative functions.

Coulthard, 1975; Tsui, 1985a). In the *NVivo* programme window (see figure 3.9), the left-hand side shows the hierarchy of different 'acts' and the IRF sequences. The right-hand side shows the length (in seconds) of each act in the video-recorded lesson and the actual talk what the speaker said in each act. After coding all the acts in one lesson, an output file was generated from *NVivo* which summarised the number of occurrences of each coded 'act', their time length, the percentage of time of each 'act' and the pattern of the overall IRF sequence in one observed lesson.

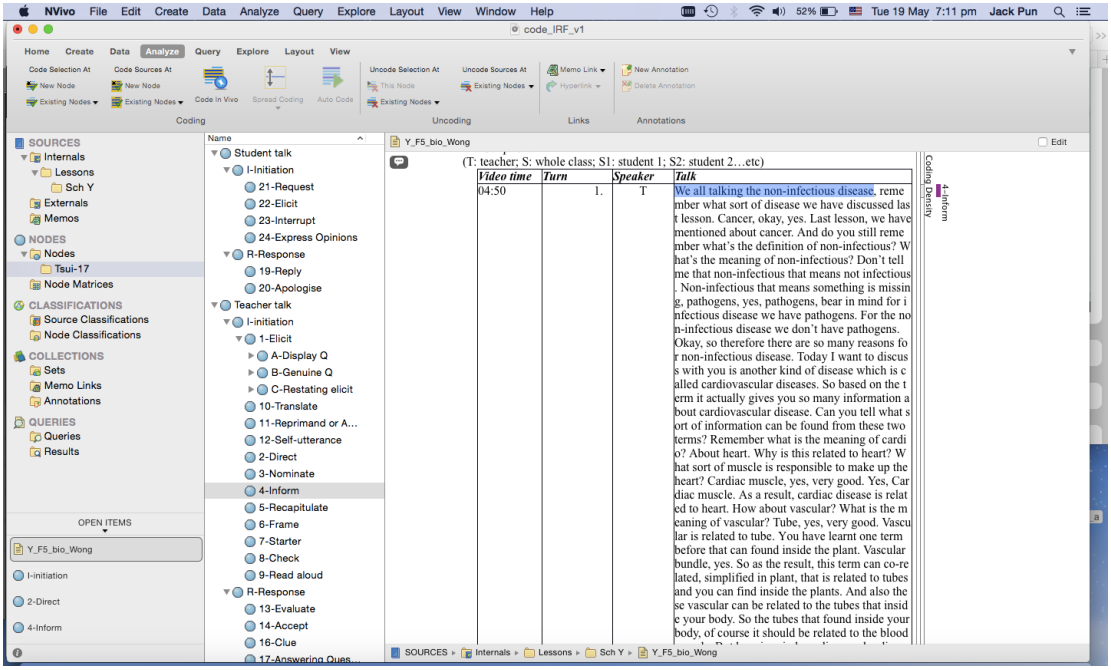


Figure 3.9 The NVivo programme window showing the coding process

With all 33 lessons coded, all the teacher and student talk was categorised. The information generated from *NVivo* helped me calculate the following eight items:

1. overall time interacting within a lesson
2. proportion and length of teacher and student talk
3. number of Initiation–Response–Feedback (IRF) exchange sequence patterns between teachers and students
4. the pedagogical functions of teacher and student talk
5. number of L1 and L2 use
6. L1 use
7. science teachers' questions
8. science teachers' feedback.

The frameworks used in the analysis and the definitions of each category is explained in appendix A.

1. Teaching purposes ***(Mortimer & Scott, 2003)***	*a) Opening up the problem;* *b) Exploring and working on students' views; introducing and developing the scientific story;* *c) Guiding students to work with scientific ideas and supporting internalisation* *d) Guiding students to apply, and expand on the use of, the scientific view, and handing over responsibility for its use* *e) Maintaining the development of the scientific story*
2. Content ***(Mortimer & Scott, 2003)***	*a) Everyday-specific* *b) Description, explanation, generalisation* *c) Empirical-theoretical*
3.Communicative approach ***(Mortimer & Scott, 2003)***	*a) Interactive/ non-interactive* *b) Authoritative/ dialogic*
4. Patterns of interaction ***(Mortimer & Scott, 2003)***	*a) IRF vs extended IRF*
5a Forms of interaction	*a) IRF/E (Initiation-Response-Feedback/Evaluation)* *b) IRFRF (Initiation-Response- Feedback- Response- Feedback)*
5b Functions of interaction	Tsui (1985) The seventeen categories of acts in classifying second-language classroom talk Chin (2006) Taxonomy of teacher's feedbacks to students' responses in science classroom
6. Teaching interventions ***(Mortimer & Scott, 2003)***	*a) shaping ideas; b) selecting ideas; c) marking key ideas; d) sharing ideas; e) checking student understanding; f) reviewing*
7.Teacher's question types ***(Yip 2004)***	*1) Recalling; 2) Explanation; 3)Analysis; 4)Evaluation; 5)Synthesis; 6)Motivation; 7)Eliciting; 8)Challenging; 9)Extending; 10)Application*
8. The choice of instructional language (L1/L2), proportion of teacher/student talk	*Timed analysis (Macaro, 2001)---sampling the interactions every five seconds and then code according to speaker and the language being spoken*
9. The distribution and allocation of teacher/student turns	*Turn analysis (Macaro & Mutton, 2002)---calculating the mean length of each speaker's turn)*
10.Type of code-switching patterns; ***(Myers-Scotton, 1988)***	*a) Intra-sentential (within a sentence); b) Inter-sentential (between sentences)*

Figure 3.10 The coding framework for teacher and student talk

The coding categories summarized in figure 3.10 were then used to compare patterns of interactions in the science classrooms of early–full and late–partial

EMI science classrooms and of grades 10 and 11 in each group. Such analysis addressed the extent to which classroom interactions were similar or different between different groups (RQ2 and RQ3). Table 3.10 summarises each of the definitions and sub-categories. Appendix A provides further discussion of the definitions of each category. This coding frame provides the key elements for analysing teacher and student talk quantitatively.

a. The interaction time	i. Interaction time	Total recorded lesson time, total interaction time and percentages of interaction time
	ii. Proportion of talk	Proportion of teacher talk, students talk and percentages of talk for each observed lesson
	iii. Length of turns	Turn analysis: calculating the mean length of each speaker's turn
	iv. Ratio between L1 and L2 use	Proportion of teacher and student talk in L1 (Cantonese) and L2 (English)
b. The pedagogical functions of interaction		17 pedagogical functions of IRF patterns classifying classroom talk between teacher and students. (Tsui, 1985a)
c. The science teacher questions		Science teacher questions in developing student's science understanding.(Yip, 2004)
D. The science teacher feedback		Classification of science teachers' feedback to students' responses in IRF patterns. (Chin, 2006)
E. The use of L1	type of code-switching patterns	a) Intra-sentential (within a sentence); b) Inter-sentential (between sentences)

Table 3.10 The framework for coding the classroom interaction

iii. Statistical analyses for comparing different groups of classroom interactions

After the basic information about the interaction patterns between grades 10 and 11 was obtained in each type of school, further statistical analyses were

performed to estimate to what extent interaction patterns in each group were significantly different between early–full and late–partial EMI schools.

A number of independent sample *t*-tests (for parametric data) or Mann-Whitney tests (for non-parametric data) were performed to estimate the observed differences in classroom interactions between grades 10 and 11, and between early–full and late–partial EMI schools. First, normality of the distribution of data was examined. The statistical procedure includes calculating the values of 'skewness' and 'kurtosis' of the data and these numbers should fall into the range -2.5 to 2.5 for that the data to be regarded as normally distributed. Second, the appropriate statistical test was applied to the data set. The *t*-test would be used if the data was normally distributed and the Mann-Whitney test would be used if the data was not normally distributed. Third, after applying the *t*-test or the Mann-Whitney procedure, the mean of two groups was then compared, and the results of the differences such as proportion of the teachers' and students' talks, the average time length of the teachers' and students' turns, and the IRF sequences were reported.

3.10 Analysing classroom interaction in a qualitative manner

The quantified analysis outlined above generated numeric accounts of the classroom interactions observed in each group and provided comparable results between early–full and late–partial EMI schools. In a separate analytical phase, I analysed classroom interaction qualitatively, to provide a

comprehensive picture of the actual teaching and learning process in the observed classrooms. In analysing the classroom interactions, I am interested in what the science teachers did in the teaching process and the functions of their turns at talk (science pedagogy), what kind of language the teacher and students actually used for interaction (the language of science); and how teachers and student interacted to construct content knowledge (thematic understanding of science concepts).

This phase of analysis consists of three major components: (1) analysing science pedagogy; (2) analysing the language of science; and (3) analysing how students develop a thematic understanding of science concepts through teacher–student interaction. This combined framework for analysing the language of science in the classroom interactions observed is summarised in figure 3.11. These analyses help to address RQ1, i.e. What is the nature of classroom interaction in a EMI science classroom? Figure 3.11 diagram illustrates the framework used to analyse classroom interactions qualitatively

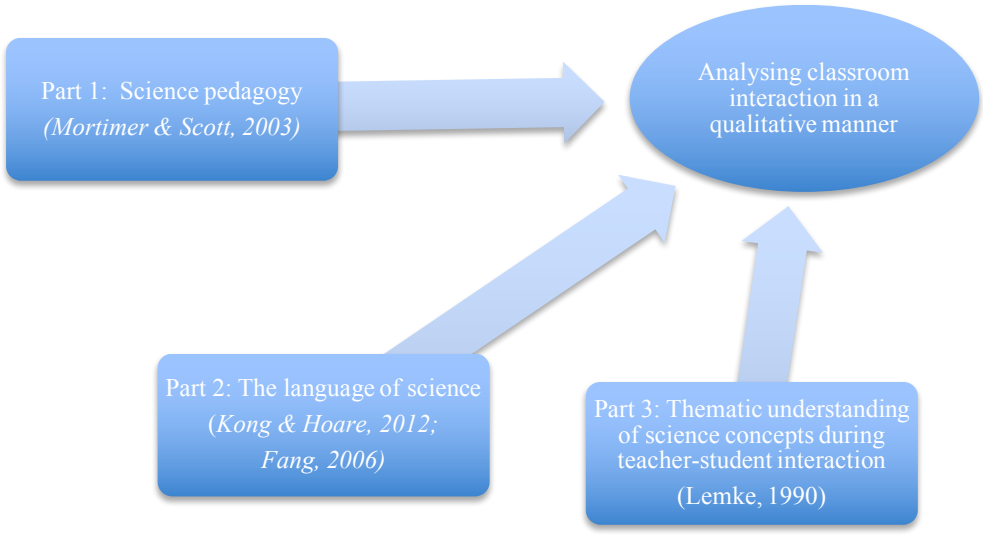


Figure 3.11 Framework used to analyse classroom interactions qualitatively

3.10.1. Science pedagogy

In the qualitative analysis of classroom interaction, I examined the science pedagogy using a frequently used framework (Mortimer and Scott, 2003). Table 3.12 shows the proposed coding frame for analysing science pedagogy. In this analytical framework, specific attention is paid to the following aspects of analysis: (1) teaching purpose; (2) content; (3) communicative approach; (4) patterns of interaction; (5) functions and forms of interaction; (6) teaching interventions.

a. Teaching purposes	Teaching purposes in relation to the science being taught, at each phase of the observed lesson
b. Content	Content of classroom interactions
c. Communicative approach	Ways in which a teacher guides students in addressing science ideas developed in a lesson through frequent or limited interactions.
d. Patterns of interaction	Distinctive patterns of interactions observed between teacher and students: IRF vs extended IRF
e. Teaching interventions	Ways in which teacher intervenes in order to develop the scientific story through addressing students' scientific ideas

Table 3.11 The proposed coding frame for analysing science pedagogy

3.10.2. The language of science

One of the features of relevance in teacher and student talk in an EMI context is the use of academic language. Academic language plays a critical role in interactions between teachers and students as they construct science experiences and shapes the ways in which teachers and students explain abstract science phenomena and express their own scientific ideas. In this part of analysis, I adapted Kong and Hoare's (2012) framework of the characteristics of academic language in science classrooms, reviewed in chapter two. This framework can serve as a tool for analysing the complexity of academic language used in teacher and student talk. It also provides an explanation of how teachers can develop students' academic language through interactions in a EMI science classroom

To provide a comprehensive understanding of the language features used in the science classroom, in addition to Kong and Hoare's framework, I adopted a framework that describes the linguistic features of school science. Fang (2006)

examined US high school students' language use in content-based instruction science classrooms. His framework explains the language of science that science students experience in an English as a second language (ESL) classroom. It also describes language demands and challenges in the ESL context. This framework usefully supplements Kong and Hoare's framework in providing a more extensive list of features of language in science and of possible language challenges for EMI science students. Table 3.12 summarises the two frameworks used to describe the language of science.

Framework describing the language of science in teacher and student talk	Framework describing the language features of science
Use of subject-specific vocabulary	Technical vocabulary
Use of nominalisations (normally are used as grammatical metaphors, when nominalised words can be unpacked)	Ordinary words with multiple meanings
Use of grammatical metaphors (when meaning is expressed in uncommon grammatical forms)	Words with multiple grammatical functions
Use of complex noun phrases (noun phrases with a head plus pre-modification and or post-modification	Grammatical words
High lexical density (measured by the number of content words divided by the total number of words; content words include lexical items such as nouns, adjectives, verbs, adverbs, and functional words include grammatical items such as prepositions, pronouns, auxiliary verbs, conjunctions, demonstratives)	Ellipsis
Use of the language of logical meaning or knowledge relationships (such as classification, definition, cause-and-effect)	Subordinate clauses
	prepositional phrases
	Abstract nouns
	Lengthy nouns
	Complex sentences
	Interruption construction
	Passive voice

Table 3.12 The frameworks adapted to describe the language of science

3.10.3. Developing students' thematic understanding through extended IRF exchanges between teachers and students

Lemke's (1990) concept of thematic development is used to examine how students develop an understanding of science concepts through classroom interactions. This part of the analysis focused principally on how science teachers modify their talk to develop students' understanding in science through interaction. To do this, in each IRF sequence, I analysed how teachers responded to students, by either selecting the students' science ideas in their responses or by modifying the students' answers to formulate further questions in their teacher feedbacks, prompting a meaningful interaction that develops students' thematic understanding of science topics in terms of taxonomic knowledge of related science vocabulary.

I therefore analysed thematic development in teachers' talk, focusing on the selection and modification of students' answers in developing a coherent understanding of science. Linguistically, analysis focused on whether and how teachers paid attention to explain the 1) semantic relations between words and nominal phrases; and 2) logical relations between phrases.

Through the analysis of IRF triadic exchanges, I aimed to see to what extent teachers in these two types of EMI schools are skillful enough to make the science content more accessible to students in L2. The teachers' selection of students' science ideas in their responses and the teachers' modified input are key aspects in producing input that is comprehensible students and that

develops their science understanding and their familiarity with the language of school science.

To achieve this goal, I examined IRF sequences in episodes where teachers are teaching a science concept, particularly when teachers asked a question and provided feedback to students. I paid particular attention to the following dimensions of teacher input:

1) How the teacher selected students' ideas:
    a. When students answered teacher questions, what (aspects of) students' ideas were picked up on by the teacher in subsequent turns by the teacher?
    b. What kind of ideas from the students' talk were chosen by the teacher to become the focus of later exchanges?
2) How the teacher modified his/her talk:
    a. What kind of feedback did the teacher give?
    b. Did the teacher modify the feedback based on students' responses?
    c. What decision(s) did the teacher make in reacting to students' responses (i.e. Did teachers ignore, acknowledge, direct students to the teachers' intended specific view on the science phenomena, or expand on the student's idea?)

This aspect of analysis is in line with how others have analysed science pedagogy. For example, Mortimer and Scott (2003) analyse the four communicative approaches in the science classroom (dialogic vs. authoritative) and teachers' interventions (ways that teachers intervene with students in order to develop the scientific story and to make it accessible to all the students in the lesson).

To conclude, I have summarised several frameworks for examining classroom interaction qualitatively. I have explained each of the categories and their relevance in providing an integrated framework for the purposes of analysis.

3.11 Analysing interview data

All the data from teacher and student interviews was audio-recorded, transcribed with pseudonyms and saved as a text file in *NVivo* software. The interview data were treated with a similar procedure to that of the observation data in *NVivo.* A two-step coding process was used for an in-depth qualitative analysis of the transcribed interview data (Corbin and Strauss, 2008). First, each interview transcript was imported into the software and an initial open coding was developed for each pattern or recurrent theme related to the main focus of the interview questions (i.e. views on EMI, language challenges, strategies). Then, specific parts of the texts in these segments were coded (Mills, Eurepos, and Wiebe, 2010). Called 'axial coding', this is a process of relating categories to

their subcategories, again to represent sub-themes to which the statements belong.

Using a grounded theory approach, the final version of the coding system was gradually developed with major themes drawn from the initial coding list. The final coding list with emerging findings from the major themes in the interview data was used to refine or amend the items covered in the larger scale quantitative questionnaire in stages 2 and 3. The coded interview transcripts were carefully read and repeatedly compared, sorted, recoded and explored for connections among coded segments. About 10% of the data (observations, interviews) were independently coded by two trained raters according to the coding sheet developed, in order to ensure the reliability of the coding framework. The two raters establish an inter-rater reliability of (k>0.8) using Cohen's Kappa coefficient (Robson, 2002).

3.12 Quantitative data: teacher and student questionnaires

The questionnaire data was entered into SPSS software manually and descriptive statistical reports for the teacher and student populations were produced. Mean and standard errors were calculated. Using the inferential statistics (independent *t*-test or Mann-Whitney test), mean scores of the subgroups were calculated (grade 10 vs grade 11; early–full and late–partial EMI schools) and compared statistically. Inferential statistics, including those groups that are statistically significant, were reported.

The first of the two methods of analysis concerns teacher and student views about particular issues—teaching practice and beliefs about English in science, student self-concepts and beliefs. These items can be described with summary measures such as mean and standard deviations of responses for each item.

The second method concerns the underlying factors determining overt teacher and student responses to individual language challenges and strategies. Exploratory factor analysis was used to calculate each factor loading in each item (i.e. challenges and strategies); then the number of factors was decided by admitting factors with eigenvalues greater than 1. A principal components factor analysis was performed to investigate the underlying constructs and identify the major challenges during classroom interaction. Cronbach's *alpha* value were calculated to check the internal consistency. This ensured that the degree of each of indicator variable measuring the same latent construct was correlated (Field, 2013). The factors produced about the language challenges and coping strategies may be interpreted as important indicators of the quality of classroom interactions.

For grade 11 students, self-reported proficiency in English and science achievements were collected through the questionnaire survey. After controlling for the prior MOI background, school type and academic achievement before secondary schooling, the two scores for each student were entered into SPSS to run the Pearson product-moment (if data normally

distributed) or Spearman's rho correlation coefficient (for non-parametric data). This determined whether there was a relationship between student English proficiency and academic achievement in science at grade 11.

3.13 Ethical considerations

3.13.1 Ethical procedures

This project received ethics clearance through the University of Oxford Central University Research Ethics Committee in March 2014. The data collected was subjected to the *Data Protection Act*, which protected the participants' data. The ethical application and approval are shown in appendix D.

Before data collection, all invited teacher and student participants received an information sheet (appendix C) informing them of their rights and of the nature of the study, the objectives, the data collection processes and the use of the findings. I allowed sufficient time for participants to decide whether or not to take part in this study. A Chinese version of the same set of information sheets and consent forms was also available. After reading the information sheet and receiving a verbal explanation from the researcher, teachers and students who expressed interest in participating in the study returned signed written consent forms. They were reminded that their participation was at all times voluntary. They could choose to participate or not to participate, and could withdraw from the study at any time. Participants who did not give their assent

did not take part in any stage of the study. The recorded data of those who withdrew from this study at a later stage were deleted.

All interviews were audio-recorded. All interview data was recorded anonymously and all names were de-identified. At the beginning of each classroom observation, the researcher verbally informed all students and teacher(s) about the purpose of the study and asked if they agreed to be video-recorded during the lesson. Digital audio-recorders were placed only on the desks of students who were willing to take part in the study. Any video-recording applied only to those teachers who agreed to be video-recorded. The camera mainly focused upon teachers. No identifiable images of students were intentionally recorded or stored.

For analysis of students' written artefacts, a sample of their science writings and textbooks was collected from the participating teachers. The analysis did not focus on individual students and was only used to provide a full picture of what was being done in the observed lesson, in additional to the researcher's hand-written observation notes, and not as a record of individual learning. The samples of classwork produced in the lesson were collected from students who gave their consent, and these were de-identified by the teacher before being handed to the researcher.

3.13.2 Confidentiality and anonymity

All participants were assured of confidentiality and anonymity to ensure that neither individuals nor their schools could be identified. The principals or head teachers in participating schools were informed that they would have no access to data regarding on individual teacher or student without permission from the participants. During the project, all video and audio data was stored encrypted on a password protected external hard disk, in a locked cabinet accessible only to the researcher. All data was destroyed at the end of the project.

3.14 Comparsion with Lo & Macacro (2012)

This study has extended the research on EMI classroom interactions in Hong Kong (Lo and Macaro, 2012). Although the research design of my study is similar to Lo and Macaro's study, which also explored differences in classroom interaction, there are several major differences in my study. Firstly, the research context is different. Lo and Macaro's study was conducted in 2008–09, before the implementation of the fine-tuning MOI policy in 2010, and the teachers and students were following a seven-year secondary education programme. My study was conducted five years after the launch of fine-tuning policy, where schools were no longer divided into EMI and CMI streams. Instead, the school MOI situation is completely different as most of these schools are regarded as EMI schools but in fact implement EMI to different degrees, either in full or partial EMI instruction. The teachers and students are following a new six-year secondary curriculum. Secondly, the research focus is different. Lo and

Macaro's study examined the impact of MOI switching on the classroom interaction between EMI and MOI-switching schools. They looked at arts, humanities and science subjects at junior forms (grade 9s and 10). My study examined the similarities and differences in classroom interactions in the two types of EMI schools in the previously unexamined context of senior secondary (grades 10 and 11) science classrooms (physics, chemistry biology). Thirdly, the method of analysis is more comprehensive. Although my study adopted the analytical framework from Lo and Macaro to analyse classroom interaction, I also included several frameworks that are specific for interaction in science classrooms (e.g. Yip's framework on different science question types; Chin's framework on science teacher feedback). I also added IRF analysis to unpack the classroom interaction and describe the kind of language used in science classrooms. In addition, I used factor analysis to summarise the language challenges that students faced in senior secondary science classrooms. I also triangulated with interview and questionnaire data in exploring teachers' and students' perceptions of their EMI experiences and language challenges. Table 3.13 summarises the key differences between the two studies in terms of historical context, MOI policy periods, content/subject focus and method of analysis.

MOI policy	Data collection was done in the end of mother-tongue policy (2009-10)	Data collection was done in 2015, after the implementation of fine-tuning language policy (2010)
MOI situation	EMI; CMI; MOI-switching schools	Early-full EMI (traditional EMI); Late-partial EMI (CMI schools switching into EMI); CMI schools
Secondary Education	7 years, 2 public examinations (HKCE level and HKA-level)	6 years, 1 public examination (HKDSE)
Comparison groups	Group 1: EMI Group 2: MOI-switching schools	Group 1: Early-full EMI Group 2: late-partial EMI schools
When to start switching?	MOI switched from Cantonese to English at Grade 10	MOI switched from Cantonese to English at Grade 9
MOI experience	Cantonese: Grade 7-9 English: Grade 10-13 (No experience before at Grade 10)	Cantonese: Grade 7-8 Switch: Grade 9 English: Grade 10-12 (little experience before at Grade 10)
Student background	Students studied for 7 years in secondary, similar to UK system where they sit for CE (GCSE) at Grade 11 and then for A-level at Grade 13.	Students only studied for 6 years in secondary, and sit for a new secondary education curriculum--HKDSE curriculum – which was implemented in 2009.
Topics	Code-switching patterns in classroom interactions	Classroom interactions, teachers' and students' perceptions towards EMI
Subject	Junior forms: History, geography, Intergraded Science	Senior forms: Science (physics, chemistry, biology)
Population	Grade 9-10 Junior secondary	Grade 10-11 Senior secondary
Design	Observation, interviews, survey	Observation, interviews, survey
Aims	Identify the effect of a change in the MOI on classroom interaction and its potential for learning	Explore the similarities or differences in classroom interactions and teachers', students' perceptions between early-full and late-partial EMI schools

Table 3.13 Comparison with Lo & Macaro's (2012) study

3.15 Summary

In this chapter, I have presented the research design, research questions and different phases of data collection. I have described the population, sampling frame, criteria for selecting participants, the evaluation of pilot study and

process of data collection. The analytical frameworks and procedures of data analysis have been described in order to explain how the research questions will be addressed. The data collected for the present study included 33 video-recorded observations, pre- and post-observation interviews with 19 teachers, focus-group interviews with 52 students, 19 teacher questionnaires and 545 student questionnaires. The analysis of the data will be discussed in the following chapters. ■

Chapter 4

Quantitative analysis of classroom interactions in early–full and late–partial EMI science classrooms

4.1 Introduction

In this chapter I present the analysis of classroom interactions in different EMI science classrooms. I analysed classroom interaction quantitatively by comparing (i) early–full and late–partial EMI schools and (ii) grades 10 and 11 in each school type. In total, 33 lessons were video recorded and 31 hours and 45 minutes of classroom interactions were transcribed and analysed using the *NVivo* software package. Around 22.5 hours of interactions between teachers and students were analysed (8.5 hours were pauses and non-interactions). The observations were transcribed and checked by a bilingual speaker for accuracy, and the interactions were codified according to the integrated framework illustrated in chapter 3 (p.135).

The first part of the analysis compares the similarities and differences in interactional patterns quantitatively between the two types of EMI schools. It includes seven aspects of analysis in terms of classroom interactions:

1. interaction time

2. proportion and length of teacher and student talk
3. number of initiations and responses
4. wait time between teacher and student turns
5. proportion of teacher and student talk in L1 and L2, and L1 patterns
6. pedagogical functions of teacher and student talk
7. teachers' questions

These analyses provide an objective measure of the differences and similarities according to the pedagogical functions (see the integrated framework in the appendix O, p.102). To understand how the teachers and students interacted differently in these schools and the purposes of the interactions, I also coded interactions using frameworks drawn from previous studies.

The second part of the analysis examines three aspects: (1) the pedagogical functions of teacher and student talk; (2) teachers' questions; and (3) teachers' feedback. As a whole, this findings chapter addresses two research questions:

> RQ2: What are the differences and similarities in classroom interaction between early–full and late–partial EMI schools?
>
> RQ3: What are the differences and similarities in classroom interaction between grades 10 and 11 in each group?

The analyses provide a comprehensive account of the classroom interactions between the early–full and late–partial EMI schools.

4.2 Data codification

The coding framework for analysing the classroom interactions in both types of schools was adopted from Lo and Macaro's (2012) study, with specific attention to the classroom interactions in senior secondary science classes. As explained in chapter three (section 3.9), the coding framework allows the researcher to analyse the classroom discourse in a quantifiable manner, based on the following aspects of analysis:

1. interaction time
2. proportion and length of teacher and student talk
3. number of initiations and responses
4. wait time
5. proportion of L1 and L2 use
6. L1 patterns
7. Types of teacher feedback
8. the pedagogical functions of teacher and student talk
9. science teachers' questions
10. science teachers' feedback.

In the following sections, excerpts from the transcripts are included to further explain how the teachers and students interacted in early–full and late–partial

EMI science classrooms. Examples are given to explain how the following four frameworks were used to analyse the classroom interactions: IRF patterns (Mortimer and Scott, 2003); pedagogical functions of acts (Tsui, 1985); science teachers' question types (Yip, 2004) and science teachers' feedback (Chin, 2006). In some of the excerpts, capital letters are used when teachers or students were speaking in L1. The transcription conventions are illustrated in appendix M.

4.3 The quantitative analysis of classroom interactions between early–full and late–partial EMI science classrooms

4.3.1. Checking normality

For inferential statistics, the assumptions of parametric tests were checked for the data. The interaction time, teacher and student talk, and length of teacher and student turns of all of the lessons were calculated as percentages (%) and inserted into the SPSS software package.

Coding covered 12 variables: percentages of interaction time, percentages of teacher talk, percentages of student talk, percentages of average length of each teacher turn, percentage of length of each student turn, percentages of teacher feedback, percentage of wait time, percentages of L1 use and L2 use, percentages of inter and intra-sentential code-switching, percentage of pedagogical functions, percentage of teachers' questions and percentage of science teacher questions. All variables were screened for normality through the histograms, Q-Q plots. I also conducted the Kolmogorov–Smirnov tests and calculated the values of skewness and kurtosis for each variable to check their

normality and their results are shown in Appendix B. All the variables were not normally distributed and thus the Mann–Whitney test was used.

4.3.2. percentage of interaction time

The overall average lesson length,[11] average interaction time per lesson,[12] and percentage of interaction time[13] between school types and between grades in each school group in a total of 32 lessons are presented in table 4.1.

Between school types	Early–full		10	53.55	37.14	69%
	Late–partial		23	60.60	44.22	73%
Between grades	Early–full	10	5	43.93	59.90	73%
		11	5	30.35	47.21	64%
	Late–partial	10	12	47.33	61.11	77%
		11	11	40.83	60.04	68%

Table 4.1 Summary of the average lesson length and interaction time by school and by grade

The percentages of interaction time between the early–full EMI schools (69%) and the late–partial EMI (73%) were similar. In both types of EMI schools, the

[11] Average lesson length is the sum of all the recording time of each lesson divided by the total number of lessons in each type of school. (e.g. early–full EMI school= the sum of recording time of the 10 lessons in early–full EMI school divided by 10)

[12] Average interaction time per lesson is the sum of teachers' and students' talk in all observed lessons divided by the number of lessons in each school type.

[13] Percentage of interaction is the total interaction time divided by total lesson time.

percentages of interaction time in grade 11 was lower than in grade 10. Both types of schools had 9% less of interaction time in grade 11 than in grade 10.

The percentages of interaction between school types and between grades in each school group were compared using a Mann–Whitney test in table 4.2.

Between school types	Early–full		10	86.75% (.26)	0.611 (n.s.)
	Late–partial		23	83% (.25)	
Between grades	Early–full	Grade 10	5	84.4% (.25)	0.754 (n.s.)
		Grade 11	5	89.1% (.31)	
	Late–partial	Grade 10	12	82.75% (.17)	0.667 (n.s.)
		Grade 11	11	83% (.32)	

Table 4.2 Mann-Whitney Test on the percentages of interaction time by school type and grade

Note: n.s.= no statistically significant difference

For the comparison between school types, a Mann–Whitney *U* Test revealed no significant difference in the percentages of interaction time of early–full EMI schools (md= 86.75%, n=10) and late–partial EMI schools (md=83%, n=23) , *U*= 102, *z*=-5.09, *p*=0.611, *r*=0.089.[14]

For the comparison between grades in each group, the percentages of interaction time in the early–full EMI schools did not differ significantly between grade 10 (md= 84.4%, n=5) and grade 11 (md=89.1%, n=5), *U*= 11, *z*=-

[14] r (effect size)= z/ square root of N, where N=total number of cases.

0.313, p=0.754, r=-0.099. In the late–partial EMI schools, the percentages of interaction time also did not differ significantly between grade 10 (md= 82.75%, n=12) and grade 11 (md=83%, n=11), U= 59, z=-0.431, p=0.667, r=-0.090.

Thus, a Mann–Whitney U Test revealed that there was no statistically significant difference between (a) the early–full and late–partial EMI schools or (b) between grades 10 and 11 in each group, in regard to their percentages of interaction time.

4.3.3 Percentages of teacher and student talk

The percentages of teacher talk[15] and student talk[16] in the observed lessons between school types and between grades are presented in table 4.3.

				Average interaction time per lesson *(mins)*	Percentages of interaction time[17]	Average interaction time per lesson *(mins)*	Percentages of interaction time
Between school types	Early–full		10	32.94	62%	4.20	8%
	Late–partial		23	41.36	68%	2.86	5%
Between grades	Early–full	G10	5	36.66	61%	7.27	12%
		G11	5	29.22	62%	1.12	2%
	Late–partial	G10	12	44.31	73%	3.02	5%
		G11	11	38.15	64%	2.68	4%

Table 4.3 Summary of teacher talk and student talk by school type and by grade

[15] Teacher talk is the time taken up by teachers' utterances in an observed lesson.

[16] Student talk is the time taken up by students' utterances in an observed lesson.

[17] Percentages of interaction is total interaction time divided by total lesson time.

A similar distribution of talk between teachers and their students was observed in the two types of EMI schools. For early–full EMI schools, teachers contributed 62% of the talk and students contributed only 8%. For late–partial EMI schools, teacher talk was 68% and student talk was only 5%. The remaining 27–30% of the talk was non-spoken interaction such as class activities.

Compared across grades, we see that in the early–full EMI schools there was more teacher talk (1%) and less student talk (2%) in grade 11. However, in the late–partial EMI schools, there was less teacher talk (9%) and less student talk (1%) in grade 11.

The observed late–partial EMI schools appeared to be slightly more teacher-centred. Teachers contributed over 68% of the interaction time and student talk only contributed less than 5% of the interaction time.

For inferential statistics, the percentages of teacher talk and student talk between school types and between grades in each school group were compared using a Mann–Whitney test in table 4.4.

				Median (SD)	Asymp. Sig. (2-tailed)	Median (SD)	Asymp. Sig. (2-tailed)
Between school types	Early–full		10	65.41% (.25)	.695 (n.s.)	9.18% (.10)	.147 (n.s.)
	Late–partial		23	68.86% (.28)		4.63% (.056)	
Between grades	Early–full	G10	5	65.89% (.26)	.754 (n.s.)	11.45% (.11)	.175 (n.s.)
		G11	5	64.93% (.28)		6.91% (.11)	
	Late–partial	G10	12	73.88% (.18)	.854 (n.s.)	4.97% (.050)	.356 (n.s.)
		G11	11	63.39% (.36)		4.26% (.64)	

Table 4.4 Mann-Whitney test of the percentages of interaction time of teacher talk and student talk by school type and grade

Note: n.s.= no statistically significant difference

4.3.3.1 Percentages of teacher talk

For the comparison between school types, the percentages of teacher talk did not differ between the early–full EMI schools (md= 65.41%, n=10) and the late–partial EMI schools (md=68.86%, n=23) , *U*= 105, *z*= -3.92, *p*= .695, *r*=.682[18]

For the comparison between grades in each group, the percentages of teacher talk in the early–full EMI schools did not differ significantly between grade 10 (md= 65.89%, n=5) and grade 11 (md=64.93%, n=5), *U*= 11, z=-0.313, *p*=.754, *r*=-0.099. In the late–partial EMI schools, the percentage of teacher talk

[18] r (effect size)= z/ square root of N, where N=total number of cases.

also did not differ significantly between grade 10 (md= 73.88%, n=12) and grade 11 (md=63.39%, n=11), *U*= 63, z=-0.185, *p*= .854, *r*=-0.039.

4.3.3.2 Percentage of student talk

For the comparison between school types, the percentages of student talk did not differ between the early–full EMI schools (md= 9.18%, n=10) and the late–partial EMI schools (md=4.63%, n=23) , *U*=78, *z*= -1.449, *p*=.147, *r*=.252.

For the comparison between grades in each group, the percentage of student talk in the early–full EMI schools did not differ significantly between grade 10 (md= 11.45%, n=5) and grade 11 (md=6.91%, n=5), *U*=6, *z*=-1.358, *p*=.175, *r*=.429. In the late–partial EMI schools, the percentage of student talk also did not differ significantly between grade 10 (md= 4.97%, n=12) and grade 11 (md=4.26%, n=11), *U*= 51, *z*=-.923, *p*= .356, *r*=-.192.

Thus, a Mann–Whitney *U* Test revealed that there is no statistically significant difference between early–full and late–partial EMI schools in the percentages of teacher talk and student talk. The same observation was made between grades 10 and 11 in each school group.

4.3.4 The number of initiations and responses

Table 4.5 and 4.6 summarise the number and percentages of initiations and responses by teachers and students in the observed lessons between early–full and late–partial EMI schools and between grade 10 and 11, reflecting the nature of interactive sequences in each type of school.

	Teachers				Students			
	Initiation	Asymp. Sig. (2-tailed)	Response	Asymp. Sig. (2-tailed)	Initiation	Asymp. Sig. (2-tailed)	Response	Asymp. Sig. (2-tailed)
Early–full	1914 (74%)	.389 (n.s.)	369 (14%)	.922 (n.s.)	236 (9%)	.555 (n.s.)	75 (3%)	.652 (n.s.)
Late–partial	4728 (69%)		785 (11%)		804 (12%)		584 (8%)	

Table 4.5 Mann-Whitney test of the percentages of initiations and responses by teachers and students between early–full and late–partial EMI schools

Note: n.s.= no statistically significant difference

		Teachers				Students			
		Initiation	Asymp. Sig. (2-tailed)	Response	Asymp. Sig. (2-tailed)	Initiation	Asymp. Sig. (2-tailed)	Response	Asymp. Sig. (2-tailed)
Early–full	10	1271 (74%)	.251 (n.s.)	240 (14%)	.465 (n.s.)	52 (3%)	.344 (n.s.)	158 (9%)	.347 (n.s.)
	11	643 (74%)		129 (15%)		23 (3%)		78 (9%)	
Late–partial	10	2548 (67%)	.902 (n.s.)	474 (12%)	.518 (n.s.)	442 (12%)	.265 (n.s.)	344 (9%)	.712 (n.s.)
	11	2180 (70%)		311 (10%)		362 (12%)		240 (8%)	

Table 4.6. Mann-Whitney test of the percentages of initiations and responses by teachers and students between grade 10 and 11 in the two types of EMI schools

Note: n.s.= no statistically significant difference

In the early–full EMI schools, there were more teacher initiations and responses but fewer numbers of student initiations and responses. This is different from the late–partial EMI schools, with less teacher initiations and more student initiations and responses. From grade 10 to 11, a similar proportion of initiations and responses between teachers and students were observed in the two types of schools.

Using inferential statistics, the percentages of teacher and students' initiations and responses in the early–full EMI schools did not differ significantly from those in the late–partial EMI schools. For the comparison between grades 10 and 11 in each school group, the percentages of teacher and students' initiations and responses also shows no significant difference.

4.3.5 Length of teacher and student turns

The total number of turns and the average length of teacher and student turns between the early–full and late–partial EMI schools are shown in table 4.7. The table illustrates the total number of turns, the average length of each turn (in seconds), and the range of length for each group.

		Lessons	Total no. of turns per lesson	Average length of each turn per lesson *(s)*	Range of length of each turn per lesson *(s)*	Total no. of turns of per lesson	Average length of each turn per lesson *(s)*	Range of length of each turn per lesson *(s)*
Between school types	Early–full	10	40	49.29	0.1-1,215.1	30	8.48	0.1-1,192.1
	Late–partial	23	59	42.03	0.1-1,169.2	54	3.16	0.1-302.6
Between groups	Early–full	G10	5	36	61.44	0.2-1,192.1	33	13.39	0.1-410.3
		G11	5	44	39.49	0.1-1,215.1	27	2.52	0.1-48.1
	Late–partial	G10	12	69	38.67	0.1-1,169.2	54.8	3.31	0.1-302.6
		G11	11	48	47.24	0.1-823.5	53.6	3.00	0.1-58.5

Table 4.7 The number of teacher and student turns per lesson and their average length of each turn by school types and by grade

Both teachers and students in the late–partial EMI schools took more turns than those in the early–full EMI schools. However, the average length of teacher turns (42.03 s <49.29 s) and student turns (3.16 s<8.48 s) were slightly shorter. In addition, the maximum length of student turns in the late–partial EMI schools was four times shorter (302.6 s<1,192.1 s) than teacher turns.

From grade 10 to 11, the teacher and student average turn lengths were different in the two types of schools. In the late–partial EMI schools, the average length of teacher turns was more in grade 11 than in grade 10 (38.67 s →47.24 s) but the average length of student turns in grade 11 was less than in grade 10 (3.31 s→ 3.00 s). In the early–full EMI schools, the average length of teacher and student turns in grade 11 was less than in grade 10 (61.44 s→39.49 s and 13.39 s→2.52 s). In addition, the maximum length of student turns in grade 11 was less than in grade 10 in both the early–full EMI schools (410.3 s to 48.1 s) and in the late–partial EMI schools (302.6 s to 58.5 s).

Using inferential statistics, the percentages of average length of teacher turns and of student turns between two types of schools and grades was compared using the Mann–Whitney test, as shown in table 4.8.

			Lesson	Median (SD)	*Asymp. Sig. (2-tailed)*	Median (SD)	*Asymp. Sig. (2-tailed)*
Between school types	Early–full		10	2.45% (.054)	.176 (n.s.)	1.85% (.13)	.169 (n.s.)
	Late–partial		23	1.4% (.022)		1% (.011)	
Between grades	Early–full	G10	5	2.1% (.058)	.754 (n.s.)	4.3% (.18)	.116 (n.s.)
		G11	5	2.8% (.055)		6% (.021)	
	Late–partial	G10	12	1.65% (.019)	.579 (n.s.)	1% (.014)	.597 (n.s.)
		G11	11	1.4% (.027)		0.9% (.0047)	

Table 4.8 Mann-Whitney test on the percentages of average length of teacher and student turns by school type and by grade

Note: n.s.= no statistically significant difference

4.3.5.1 Teacher turns

For the comparison between school types, the percentages of average length of teacher turns did not differ between the early–full EMI schools (md= 2.45%, n=10) and the late–partial EMI schools (md=1.4%, n=23), *U*=80.5, *z*=-1.353, *p*=.176, *r*=.236.

For the comparison between grades in each group, the percentages of mean length of teacher turns in the early–full EMI schools did not differ significantly between grade 10 (md= 2.1%, n=5) and grade 11 (md=2.8%, n=5), *U*=11, z=-0.313, *p*=.754, *r*=0.099. In the late–partial EMI schools, the percentage of mean length of teacher turns also did not differ significantly between grade 10 (md= 1.65%, n=12) and grade 11 (md=1.4%, n=11), *U*= 57, z=-0.555, *p*= .579, *r*=0.12.

4.3.5.2 Student turns

Similarly, the percentages of mean length of student turns did not differ between the early–full EMI schools (md= 1.85%, n=10) and the late–partial EMI schools (md=1%, n=23) , *U*=80, *z*= -1.376, *p*=.169, *r*=.240.

Similarly, the percentage of mean length of student turns in the early–full EMI schools did not differ significantly between grade 10 (md= 4.3%, n=5) and grade 11 (md=6%, n=5), *U*=5.0, z=-1.571, *p*=.116, *r*=0.50. In the late–partial EMI schools, the percentage of mean length of student turns also did not differ significantly between grade 10 (md= 1%, n=12) and grade 11 (md=0.9%, n=11), *U*= 57.5, z=-0.528, *p*= .597, *r*=0.11.

Thus, a Mann–Whitney *U* Test revealed that there is no statistically significant difference between early–full and late–partial EMI schools in the percentages of mean length of teacher turns and student turns. The same observation was made between grades 10 and 11 in each school group. This corresponds to the descriptive statistics. In the early–full EMI schools, the average length of teacher turn in grade 11 was much shorter than in grade 10 (61.44 s→39.49 s).

4.3.6. Types of teacher feedback

A framework for analysing science teachers' feedback was adopted from Chin (2006) and is explained in Appendix P. There are four types of teacher feedback in the follow-up or F-move of the IRF sequence identified in Chin's study. In

her analysis of teacher-student interaction in junior (Year 7) science classrooms in Singapore, Chin (2006) has further extended the 'F' in the IRF sequence model by classifying different types of feedbacks that teachers give to students' responses. In Chin's view, teachers' feedback moves in the science classroom are distinctive moves in which teachers engage students in thinking about the conceptual content. Feedback moves can therefore contribute to the construction of scientific knowledge.

A teacher's follow-up or feedback (F) in the IRF sequence can be in the form of a comment or statement followed by either another question or by further statements that expound more scientific content. Chin analysing these four major types of teacher feedback as follows:

1. affirmation–direct instruction
2. extension by responsive questioning: focusing and zooming
3. explicit correction, i.e. direct instruction
4. constructive challenge.

Table 4.9 gives examples of these different types of science teachers' feedback from my data.

Affirmation–Direct instruction	C-Q, C-S	S: Neutralization. T: Neutralization, what else? (C-Q)
Extension by responsive questioning: Focusing and Zooming	C-Q	S: Water. T: you think of water, does the rate of water have an effect? (C-Q)
Explicit correction, i.e. direct instruction	S-Q, S	S: Respiration. T: Respiration? No. Respiration is mitochondria, not ribosome.
Constructive challenge	C-Q, Q	T: Why there is a negative acceleration? Yeah? What produces the negative acceleration?

Table 4.9. Examples of science teachers' feedback

Note: C, teacher comment; Q, teacher question; S, teacher statement.

The percentages of science teacher feedback moves[19] in the observed lessons between early–full and late–partial EMI schools and between grades 10 and 11 are shown in tables 4.10 and 4.11.

Between school types		Early–full	Late–partial	
Correct	Affirmation-Direct instruction	2%	2%	.937(n.s.)
Mixture of correct and incorrect	Extension by responsive questioning: Focusing and Zooming	2.5%	1%	.410(n.s.)
Incorrect	Explicit correction–Direct instruction	3.5%	1%	.780(n.s.)
	Constructive challenge	<1%	2%	.102(n.s.)

Table 4.10 Percentages and the Mann–Whitney Test for the types of teacher feedback by school type

[19] The percentage of the science teacher's feedback is calculated by dividing the number of each type of feedback for a teacher divided by the total of all different types of feedback by that teacher.

Note: n.s.= no statistically significant difference

		Early–full EMI			Late–partial EMI		
		G10	G11		G10	G11	
Correct	Affirmation-Direct instruction	2% (.03)	1% (.05)	p=.819 (n.s.)	3% (.03)	2% (.02)	.070 (n.s.)
Mixture of correct and incorrect	Extension by responsive questioning: Focusing and Zooming	4% (.03)	1% (.07)	p=1.00 (n.s.)	2% (.27)	1% (.04)	.704 (n.s.)
Incorrect	Explicit correction–Direct instruction	5% (.05)	2% (0.4)	p=1.00 (n.s.)	1.5% (.26)	1% (.03)	.527 (n.s.)
	Constructive challenge	<1% (.08)	<1% (.02)	p=1.00 (n.s.)	2% (.45)	2% (.04)	.417 (n.s.)

Table 4.11 Percentages and the Mann–Whitney Test on the types of teacher feedback by grade

Note: n.s.= no statistically significant difference

A similar distribution of teachers' feedback was observed in both types of schools. Their frequency order was: 'affirmation-direct instruction' > 'extension by responsive questioning: focusing and zooming' > 'explicit correction' > 'constructive challenge'. From grade 10 to 11, more 'affirmation-direct instruction' was observed in the early–full EMI schools but this pattern was reversed in the late–partial EMI schools.

For inferential statistics, there is no statistically significant difference between early–full and late–partial EMI schools in regard to the percentages of

teacher feedback. The same observation was made between grades 10 and 11 in each group except in the late–partial EMI schools.

4.3.7 Wait time

The average and percentages of wait time[20] per lesson between teacher turns and student turns across schools and grades are presented in table 4.12.

Between school types	Early–full		10	4.39	2.8% (.19)	.922 (n.s.)
	Late–partial		23	29.83	2.3% (.05)	
Between grades	Early–full	G10	5	6.9	3.8% (.26)	.916 (n.s.)
		G11	5	1.87	1.8% (.06)	
	Late–partial	G10	12	11.46	1.75% (.04)	.406 (n.s.)
		G11	11	19.05	3% (.06)	

Table 4.12 Percentages and the Mann–Whitney Test on the wait time by school type and by grade

Note: n.s.= no statistically significant difference

The percentages of wait time per lesson in the late–partial EMI schools (29.83 mins, 89%) was much longer than in the early–full EMI schools (4.39 mins, 11%). When comparing across the grades, in the early–full EMI schools, there was less average wait time (5.03 mins) in grade 11 than in grade 10. However,

[20] Wait time is defined as the pauses between a teacher finishing speaking and a student starting a turn, and the gap between a student finishing a turn and teacher starting one (Ingram and Elliott, 2014).

in late–partial EMI schools, there was more average wait time (7.59 mins) in grade 11 than in grade 10.

For inferential statistics, there is no statistically significant difference between early–full and late–partial EMI schools and between grades 10 and 11 in percentages of wait time.

The percentage of wait time did not differ between the early–full EMI schools (md= 2,3%, n=10) and the late–partial EMI schools (md=2.8%, n=23), *U*=112.5, *z*= -0.098, *p*=.922, *r*=0.02.

Similarly, the percentage of wait time in the early–full EMI schools did not differ significantly between grade 10 (md= 3.8%, n=5) and grade 11 (gd=1.8%, n=5), *U*=12, *z*=-0.105, *p*=.916, *r*=0.03. In the late–partial EMI schools, the percentage of wait time also did not differ significantly between grade 10 (gd= 1.75%, n=12) and grade 11 (md=3%, n=11), *U*=52.5, z=-.831, *p*= .406, *r*=0.17.

4.3.8 Teacher and student talk in L1 and L2

Table 4.13 summarises the percentages of spoken L1 (Cantonese) and spoken L2 (English)[21] in the observed lessons between early–full and late–partial EMI

[21] The percentage of L1 use is the number of turns in L1 divided by the total number of turns. The percentage of L2 use is the number of turns in L2 divided by the total number of turns. The aim of this counting was to see how frequently teachers and students use L1 or L2 in each turn. Given that the differences between English and Cantonese create challenges for calculating actual use by taking into account by the length of those turns, or by the number of syllables/word, I only performed the calculation based on the number of turns. Some teachers and students code-switched at different levels, some with a full sentence, some with a noun

schools and between grades 10 and 11, reflecting the extent of English medium instruction implemented in each school in reality.

			Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)	Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)
Between school types	Early–full		93.5% (.13)	p<.0001****	6.5% (.13)	p<.0001****
	Late–partial		44% (.25)		53% (.25)	
Between grades	Early–full	G10	<100% (.18)	.665 (n.s.)	<1%(.18)	.665 (n.s.)
		G11	91% (.07)		9%(.07)	
	Late–partial	G10	47.5% (.20)	.268 (n.s.)	52.5% (.20)	.712(n.s.)
		G11	44%(.29)		56% (.30)	

Table 4.13 Percentages of L1 and L2 by school type and by grade

*Note: ****p<.0001; n.s.= no statistically significant difference*

A high percentage of L2 in the interaction was observed in the early–full EMI schools. A more equally distributed percentage of L1 and L2 spoken was observed in the late–partial EMI schools. There was more L1 use and less L2 use in grade 11 than in grade 10 in both types of schools.

For inferential statistics, the percentages of L1 and L2 spoken between school types and between grades in each school group were compared using a Mann–Whitney test. For the comparison between school types, the percentages

phrase, or some with a single grammatical item such as a verb or adverb. This made it difficult to perform the calculation based on the length of turns or the number of words or syllables.

of L2 spoken differed between the early–full EMI schools (md= 93.5%, n=10) and the late–partial EMI schools (md=44%, n=23) , *U*= 11, *z*= -4.079, *p*<.0001, *r*=.71.[22] This is considered a medium effect size using Cohen (1988) criterion (medium effect=0.5).

The same observation is found for the percentage of L1 spoken between the early–full EMI schools (md= 6.5%, n=10) and the late–partial EMI schools (md=53%, n=23), *U*= 19, *z*= -3.768, *p*<.0001, *r*=.66. This is considered a medium effect size using Cohen (1988) criterion.

For the comparison between grades 10 and 11 in each school group, the percentage of L1 spoken and L2 spoken shows no significant difference.

The percentage of L2 spoken in the early–full EMI schools did not differ significantly between grade 10 (md= <100%, n=5) and grade 11 (md=91%, n=5), *U*=10.5, *z*=-.432, *p*=.665, *r*=-.14. In the late–partial EMI schools, the percentage of L2 spoken also did not differ significantly between grade 10 (md= 47.5%, n=12) and grade 11 (md=44%, n=11), *U*=48, z=-1.109, *p*= .268, *r*=-.23.

The percentage of L1 spoken in the early–full EMI schools did not differ significantly between grade 10 (md= <1%, n=5) and grade 11 (md=9%, n=5), *U*=10.5, *z*=-.432, *p*=.665, *r*=-.14. In the late–partial EMI schools, the percentage of

[22] r (effect size)= z/ square root of N, where N=total number of cases.

L1 spoken also did not differ significantly between grade 10 (md= 52.5%, n=12) and grade 11 (md=56%, n=11), U=60, z=-.370, p= .712, r=-.078.

Table 4.14 summarises the percentages of L1 and L2 use by teachers and students between early–full and late–partial EMI schools and between grades 10 and 11.

		Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)	Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)
		Early–full	Late–partial		Early–full	Late–partial	
L1 use		1.5% (.09)	26% (.20)	.001**	1% (.06)	8% (.22)	.079*
L2 use		54% (.09)	42% (.19)	.008*	33% (.10)	7%(.11)	p<.0001****
Between grades		Teachers			Students		
		Early–full		Late–partial	Early–full		Late–partial
		Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)	Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)	Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)	Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)
L1	G10	<1% (.12)	.738 (n.s.)	42.5% (.18)	.388 (n.s.)	<1%(.06)	.448 (n.s.)	6.5% (.15)	.440 (n.s.)
	G11	3% (.04)		21% (.22)		1% (.06)		12% (.28)	
L2	G10	52% (.10)	.834 (n.s.)	41% (.14)	.601 (n.s.)	33% (.13)	.753 (n.s.)	7.5% (.11)	.665 (n.s.)
	G11	56% (.09)		42% (.24)		33% (.07)		6% (.11)	

Table 4.14 Percentage of L1 and L2 use by teachers and students by school type and by grade

*Note:*p<.05; **p<.01; ***p<.001;****p<.0001; n.s.= no statistically significant difference*

4.3.8.1 Teachers' L1 and L2 use

A high percentage of L2 use was observed in the early–full EMI schools. A high percentage of L1 was observed in the late–partial EMI schools.

For inferential statistics, the percentages of L1 use by teachers differed between the early–full EMI schools (md=1.5%, n=10) and the late–partial EMI schools (md=26%, n=23), *U*=29.5, *z*=-3.361, *p*=.001. *r*=.59. This is considered a medium effect size using Cohen's (1988) criterion.

Similarly, the percentages of L2 use by teachers differed between the early–full EMI schools (md= 54%, n=10) and the late–partial EMI schools (md=42%, n=23) , *U*= 47.5, *z*=-2.647, *p*=.008, *r*=.46). This is considered a small effect size using Cohen's (1988) criterion (small effect=0.2).

When comparing across grades, the percentage of L1 use by teachers in the early–full EMI schools did not differ significantly between grade 10 (md=<1%, n=5) and grade 11 (md=3%, n=5), *U*=11, *z*=-.334, *p*=.738, *r*=-.11. In the late–partial EMI schools, the percentage of L1 use by teachers also did not differ significantly between grade 10 (md=42.5%, n=12) and grade 11 (md=21%, n=11), *U*=52, z=-.863, *p*= .388, *r*=-.18.

The percentage of L2 use by teachers in the early–full EMI schools did not differ significantly between grade 10 (md=52%, n=5) and grade 11 (md=56%, n=5), *U*=11.5, *z*=-,21, *p*=.834, *r*=-.04. In the late–partial EMI schools, the

percentage of L2 use by teachers also did not differ significantly between grade 10 (md=41%, n=12) and grade 11 (md=42%, n=11), *U*=57.5, z=-.524, *p*=.601, *r*=-.11.

4.3.8.2 Students' L1 and L2 use

A relatively high percentage of L2 use was observed in the early–full EMI schools. A similar percentage of L1 and L2 spoken was observed in the late–partial EMI schools. From grade 10 to 11, there was similar ratio of L1 and L2 use in both types of the schools.

For inferential statistics, the percentages of L1 use by students differed between the early–full EMI (md=1%, n=10) and the late–partial EMI schools (md=8%, n=23), *U*=70.5, z=-1.754, *p*=.079, *r*=-.31. This is considered a small effect size using Cohen's (1988) criterion.

Similarly, the percentages of L2 use by students differed between the early–full EMI schools (md= 33%, n=10) and the late–partial EMI schools (md=7%, n=23) , *U*= 13, *z*=-4.002, *p*<.0001, *r*=-.70. This is considered a medium effect size using Cohen's (1988) criterion. Thus, the L1 and L2 use by students shows a statisticallyl significant difference between early–full and late–partial EMI schools.

When comparing across grades, the percentage of L1 use by students in the early–full EMI schools did not differ significantly between grade 10 (md=<1%, n=5) and grade 11 (md=1%, n=5), *U*=9, *z*=-.759, *p*=.448, *r*=-.24. In the late–partial EMI schools, the percentage of L1 use by students also did not differ

significantly between grade 10 (md=33%, n=12) and grade 11 (md=33%, n=11), *U*=53.5, z=-.772, *p*= .440, *r*=-.16.

The percentage of L2 use by students in the early–full EMI schools did not differ significantly between grade 10 (md=33%, n=5) and grade 11 (md=33%, n=5), *U*=11, *z*=-.315, *p*=.753, *r*=-.01. In the late–partial EMI schools, the percentage of L2 use by students also did not differ significantly between grade 10 (md=7.5%, n=12) and grade 11 (md=6%, n=11), *U*=59, z=-.432, *p*=.665, *r*=-.09.

			Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)	Median (SD)	Mann-Whitney (Asymp. Sig. (2-tailed)
Between school types	Early–full		<1% (.22)	.002**	23% (.38)	.254 (n.s.)
	Late–partial		48% (.23)		47% (.24)	
Between grades	Early–full	G10	<1%(.20)	.814 (n.s.)	<1%(.37)	.577 (n.s.)
		G11	<1% (.26)		46%(.43)	
	Late–partial	G10	54% (.17)	.185(n.s.)	46% (.17)	.579(n.s.)
		G11	39% (.27)		53% (.30)	

Table 4.15 Percentages of inter- and intra-sentential code-switching by school type and by grade

*Note: **p<.01; n.s.= no statistically significant difference*

Table 4.15 summarises the percentages of inter- and intra-sentential code-switching for both teachers and students between early–full and late–partial EMI schools and between grades 10 and 11. Each percentage refers to the number of occurrence in each speaker's turn. For code-switching patterns, the

intra-sentential pattern means code switching occurs within a sentence, mixing two languages in a sentence. For example, in a chemistry lesson in a late–partial EMI school, the teacher said, '*our focus today is 中和作用* (*translation: neutralisation*) *that we briefly discussed yesterday*'. The inter-sentential pattern refers to code-switches that happen in between sentences, mixing L1 and L2 sentences. For example, the teacher said, '*Neutralisation is a chemical reaction in which an acid and a base react quantitatively with each other to form salts and water.*' She continued with the same expression in Cantonese. She said, '*中和作用是指酸和鹼反應生成鹽和水的反應。*(translation: *Neutralisation refers to the reaction between acid and base, which reacts to form salts and water*).

When comparing schools, a statistical difference was found for the intra-sentential code-switching between early–full (md=<1%, n=10) and late–partial EMI schools (md=48%, n=23), U=38, z=-3.032, p=.002, r=-.52. This is considered a medium effect size using Cohen's (1988) criterion. For other comparison groups, no statistical difference was found for either intra-sentential or inter-sentential code-switching between school types and between grades 10 and 11 in each group.

However, the descriptive statistics show that teachers and students in early–full EMI schools tended to have more inter-sentential code switching (in between sentences). Those in late–partial EMI schools tended to have more intra-sentential code switching (within a sentence) although the difference here

is not large when compared with the early–full EMI schools. From grade 10 to 11, teachers and students tended to have relatively more inter-sentential code switching (within a sentence) in both types of schools.

4.3.9 The pedagogical functions of teacher and student talk

The analytical framework was adopted from Tsui's (1985) 17-category system with the additional seven categories added by Lo and Macaro (2012). These categories were explained in chapter three (p. 135). In this structured-coding scheme (as seen in appendix A, p.22), the pedagogical functions of teacher and student talk were coded and compared between school types and grades. Table 4.16 provides examples of the six most frequent pedagogical functions of acts, based on the seventeen-category system based on Tsui's definitions, in the observed lessons (See the definitions in appendix O, pp.102).

Inform	*T: That is MRSA, very famous bacteria.*
Self-utterance	*T: All are correct? Really? No! (teacher talked to himself)*
Direct	*T: Read the question carefully.*
Reply (Student)	*T: The amount of antibiotic A B C D are they different?* *S: B can kill more bacteria.*
Check	*T: okay? Any questions about this petri dish? Any question?*
Express Opinions	*T: Sir, it is too much water.*

Table 4.16. Examples of different types of science teachers' feedback

	Frequency (n)	Median (SD)	Frequency (n)	Median (SD)	Original p-value	adjusted p-value (with alpha=.008)
Inform	772	2.5% (.02)	1,938	3.4% (.01)	.938 (n.s.)	.156 (n.s.)
Self-utterance	274	3.3% (.02)	686	2.7% (.03)	.543 (n.s.)	.091 (n.s.)
Direct	239	2.8% (.01)	683	3% (.02)	.739 (n.s.)	.123 (n.s.)
Reply	236	4.7% (.0001)	583	4.7% (.0001)	p=1.00 (n.s.)	.167 (n.s.)
Check	224	2.4% (.05)	305	1.9% (.02)	.583 (n.s.)	.097 (n.s.)
Express Opinions	43	0.5% (.01)	535	0.5% (.10)	.608 (n.s.)	.101 (n.s.)

Table 4.17 Most frequently occurring pedagogical functions of talk by school type

Note: n.s.= no statistically significant difference

	Grade 10		Original p-value		Original p-value	adjusted p-value (with alpha=.008)
	Frequency (n)	Median (SD)	Frequency (n)	Median (SD)		
Inform	497	2.8% (.02)	275	1.7% (.02)	.754(n.s.)	.126 (n.s.)
Self-utterance	193	3.4% (.02)	81	1.4% (.02)	.53(n.s.)	.088(n.s.)
Direct	166	3.1% (.01)	73	2.5% (.01)	.675(n.s.)	.113 (n.s.)
Reply	158	4.7% (.0001)	78	4.7% (.06)	p=1.00(n.s.)	.167 (n.s.)
Check	129	2.7% (.05)	95	2.1% (.06)	.917(n.s.)	.153 (n.s.)
Express Opinions	31	1% (.01)	12	0.3% (.01)	.289(n.s.)	.048 (n.s.)

Table 4.18 Most frequently occurring pedagogical functions of talk by grade in early–full EMI schools

Note: n.s.= no statistically significant difference

	Grade 10		Grade 11		Original p-value	adjusted p-value (with alpha=.008)
	Frequency (n)	Median (SD)	Frequency (n)	Median (SD)		
Inform	1036	3.9% (.01)	902	2.3% (.02)	.441(n.s.)	.0735 (n.s.)
Self-utterance	281	2.8% (.02)	405	1.1% (.04)	.295(n.s.)	.0492 (n.s.)
Direct	410	3.4% (.02)	273	3% (.02)	.388(n.s.)	.0647 (n.s.)
Reply	344	4.7% (.0001)	239	4.7% (.0001)	p=1.00(n.s.)	.167 (n.s.)
Check	181	3.3% (.02)	124	1.9% (.02)	.441(n.s.)	.0735 (n.s.)
Express Opinions	280	0.8% (.09)	255	0.5% (.10)	.757(n.s.)	.126 (n.s.)s

Table 4.19 Most frequently occurring pedagogical functions of talk by grade in late–partial EMI schools

Note: n.s.= no statistically significant difference

The frequency, percentages and proportion of interaction time are summarised in above table 4.17. Tables 4.18 and 4.19 summarises the most frequently occurring pedagogical functions of talk by grade in early–full and late–partial EMI schools.

Mann-Whitney test for between-groups comparisons with Bonferroni correction for multiple comparisons (n=6). The corrected alpha value is 0.008. each of the *p*-values were divided by 6 and the corrected *p*-values were listed in the table. No statistical difference is found for the five frequent pedagogical functions between early–full and late–partial EMI schools. However, from the descriptive statistics, the top four most frequent pedagogical functions in teacher and

student talk were the same in both types of schools: inform> self-utterance> direct> reply. The last three pedagogical functions are all fairly close in percentages. However, the fifth most frequent function in the early–full EMI schools was 'check', whereas 'express opinion' was the fifth most frequent function in the late–partial EMI schools. From grade 10 to 11, a similar pattern of ranking was observed. In the early–full EMI schools, 'self-utterance' was more frequent than 'check' in grade 10 but this pattern was reversed in grade 11. In the late–partial EMI schools, 'direct' was more frequent than 'Self-utterance' but this was reversed in grade 11.

4.3.9 Teachers' questions

4.3.9.1 Teachers' questions in content-subject classrooms

The framework for analysing teachers' questions in content-subject classrooms was adopted from Lo and Macaro (2012), as explained in chapter three (p. 136). Table 4.20 illustrates some of the examples of different teacher's questions in content-subject classrooms.

Factual questions	What else do you know about antibiotics?
Yes/No questions	Do we need to rinse the conical flask with sodium hydroxide?
Alternative questions	Net uptake or net release?
Reasoning questions	Why the mitotic cell division have the same genetic material?
Explaining word meaning questions	What is the meaning of saturated?
Opining questions	What do you think about the consequence of combustion?
Information questions	Have you drawn the result?
Restating elicits	Can we find something like this? Where? Any example of the plant without chlorophyll?

Table 4.20 Examples of teachers' questions in content-subject classrooms

		Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)	
Teachers' elicits		Early–full	Late–partial	original	adjusted p-value (with alpha=.006)
Display questions	Factual questions	1.7% (.04)	2.2% (.03)	.953 (n.s.)	.119(n.s.)
	Yes/No questions	0.6% (.02)	2.2% (.05)	.288 (n.s.)	.036(n.s.)
	Alternative questions	1.9% (.04)	1.3% (.04)	.763 (n.s.)	.0954(n.s.)
	Reasoning	1.9% (.06)	0.9% (.03)	.259 (n.s.)	.0324(n.s.)
	Explaining word meanings	<1% (.04)	<1% (.07)	.499 (n.s.)	.0624(n.s.)
Genuine questions	Opinions	<1% (.0001)	<1% (.0001)	p=1.00 (n.s.)	.0125(n.s.)
	Information	4.6% (.05)	<1% (.03)	.033	.00413*
Restating elicits		1.2% (.04)	1.6% (.03)	.937 (n.s.)	.0117

Table 4.21 Types of teachers' questions by school and by grade

*Note:*p<.00625; n.s.= no statistically significant difference*

		Early–full				Late–partial			
Teachers' elicits		Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)		Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)	
		G10	G11	original	adjusted p-value (with alpha=.006)	G10	G11	original	adjusted p-value (with alpha=.006)
Display questions	Factual	1.9% (.03)	1.4% (.05)	.599(n.s.)	.749(n.s.)	2.7% (.02)	1.2% (.03)	.218(n.s.)	.0273(n.s.)
	Yes/No questions	<1% (.02)	1.1% (.02)	.432(n.s.)	.054(n.s.)	2.2% (.06)	1.1% (.03)	.511(n.s.)	.0639(n.s.)
	Alternative questions	1.3% (.04)	2.5% (.05)	.831(n.s.)	.104(n.s.)	2.5% (.04)	1.3% (.03)	.145(n.s.)	.0181(n.s.)
	Reasoning	1.9% (.05)	1.9% (.07)	.832(n.s.)	.104(n.s.)	0.9% (.04)	0.9% (.02)	.655(n.s.)	.0819(n.s.)
	Explaining word meanings	<1% (.04)	<1% (.04)	p=1.00 (n.s.)	.125(n.s.)	<1% (.08)	<1% (.06)	.873(n.s.)	.109(n.s.)
Genuine questions	Opinions	<1% (.0001)	<1% (.0001)	p=1.00 (n.s.)	.125(n.s.)	<1% (.0001)	<1% (.0001)	p=1.00(n.s.)	.125(n.s.)
	Information	1.8% (.06)	7.3% (.04)	.831(n.s.)	.104(n.s.)	0.9% (.04)	<1% (.03)	.453(n.s.)	.0566(n.s.)
Restating elicits		1.9% (.04)	0.3% (.06)	.344 (n.s.)	.043(n.s.)	1.8% (.03)	1.6% (.03)	.829(n.s.)	.0104(n.s.)

Table 4.22. Teachers' questions compared by school type and grades

Note: n.s.= no statistically significant difference

The above table 4.22 summarises the types of teachers' questions in the observed lessons between the early–full and late–partial EMI schools and between grades 10 and 11. The Mann–Whitney test for between-groups comparisons with Bonferroni correction for multiple comparisons (n=8) was conducted. The corrected alpha value is 0.006. each of the *p*-values were divided by 8 and the corrected *p*-values were listed in the table. No statistical difference is found for the five frequent pedagogical functions between early–full and late–partial EMI schools and between grades 10 and 11 in each group.

The only statistical difference is found for the information type of genuine question between early–full (md= 4.6%, n=10) and late–partial EMI schools (md=1%, n=23) , U=63.5, z= -2.132, p<.033, r=-0.37. This is considered a small effect size using Cohen's (1988) criterion.

The descriptive statistics show that the majority of the teachers' questions were factual (over 44%), followed by restating elicits (over 27%) in the two types of schools. Among all the sub-types in display questions, more reasoning questions (11%) were observed in the early–full EMI schools. More yes/no questions (9%) were observed in the late–partial EMI schools.

From grade 10 to 11, the distribution of factual questions and restating elicits in the early–full EMI schools was similar. However, in the late–partial EMI schools, the number of factual questions in grade 11 (43%) was less than in grade 10 (46%) and the restating elicits in grade 11 (26%) was also less than in

grade 10 (31%). One noticeable change in the two groups was that in the early–full EMI schools, there were more percentages of the three types of questions in grade 11 than in grade 10: yes/no questions, alternative questions and information questions but the opposite was the case in the late–partial EMI schools. Both types of school teachers used more reasoning questions.

4.3.9.2 Science teachers' questions

The framework for analysing science teachers' questions in Hong Kong classrooms was adopted from Yip (2004) as explained in chapter 3 (p. 136). Table 4.23 provides examples of science teachers' questions.

Recalling	*What do you know about antibiotics? When you learned liberal studies?*
Explanation	*Would you explain what happen? At that time, what happen to the basketball at t=0?*
Analysis	*In this experiment, which part is experimental setup? Which part is the experimental setup?*
Evaluation	*Do you think Cholesterol is good or not, to be honest?*
Synthesis	*So if this compound is only slightly soluble in water, how we can make a solution that is clear?*
Motivation	*So you can, what can you do for the protection of the environment?*
Eliciting	*When the bacteria is inside the place seems bad, but do you know what are the benefits?*
Challenging	*Can you find some plant that without chlorophyll? Can you find some plant that the whole plant is not green in colour?*
Extending	*How do you know how much chlorophyll is needed in photosynthesis? Do we need comparison?*
Application	*What are the chemicals inside the glass cleaner, or window cleaner?*

Table 4.23 Examples of science teachers' questions

		Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)	
		Early–full	Late–partial	original	adjusted p-value (with alpha=.004)
	Lower order	3% (.05)	2% (.02)	.749 (n.s.)	.0535(n.s.)
	Higher order	2% (.02)	3% (.03)	.520 (n.s.)	.0371(n.s.)
	Motivation	3.5% (.04)	2% (.03)	.576 (n.s.)	.0411(n.s.)
	Conceptual change	1.5% (.05)	2% (.03)	.910 (n.s.)	.0650(n.s.)
Lower order	Recalling	3% (.05)	2% (.02)	.749 (n.s.)	.0535(n.s.)
	Explanation	<1% (.05)	<1% (.04)	.996 (n.s.)	.0711(n.s.)
Higher order	Analysis	1% (.02)	2% (.06)	.897 (n.s.)	.0641(n.s.)
	Evaluation	1.5% (.02)	3% (.03)	.271 (n.s.)	.0194(n.s.)
	Synthesis	2% (.03)	2% (.03)	p=1.00 (n.s.)	.0714(n.s.)
Motivation	Motivation	3.5% (.04)	2% (.03)	.576 (n.s.)	.0411(n.s.)
Conceptual change	Eliciting	<1% (.02)	<1% (.09)	.984 (n.s.)	.0703(n.s.)
	Challenging	<1% (.04)	<1% (.06)	p=1.00 (n.s.)	.0714(n.s.)
	Extending	2.5% (.06)	1% (.04)	.338 (n.s.)	.0241(n.s.)
	Application	2% (.06)	<1% (.04)	.520 (n.s.)	.0371(n.s.)

Table 4.24 Types of science teachers' questions by school type and by grade

Note: n.s.= no statistically significant difference

		Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)	Median (SD)		Mann-Whitney (Asymp. Sig. (2-tailed)
		G10	G11	adjusted p-value (with alpha=.004)	G10	G11	adjusted p-value (with alpha=.004)
	Lower order	3% (.03)	<1% (.07)	.0324 (n.s.)	3% (.03)	2% (.01)	.0084 (n.s.)
	Higher order	2% (.02)	2% (.01)	.0536 (n.s.)	3.5% (.03)	3% (.03)	.0239 (n.s.)
	Motivation	4% (.06)	3% (.03)	.0481 (n.s.)	2% (.03)	1% (.03)	.0555 (n.s.)
	Conceptual change	2% (.04)	1% (.06)	.0654 (n.s.)	1.5% (.04)	2% (.03)	.0554 (n.s.)
Lower order	Recalling	3% (.03)	<1% (.0001)	.0327 (n.s.)	3.5% (.03)	2% (.01)	.0069 (n.s.)
	Explanation	<1% (.05)	<1% (.0001)	.0581 (n.s.)	<1% (.05)	1% (.04)	.0392 (n.s.)
Higher order	Analysis	1% (.01)	1% (.02)	.0654 (n.s.)	1.5% (.06)	3% (.06)	.0696 (n.s.)
	Evaluation	2% (.03)	<1% (.02)	.0273 (n.s.)	4.5% (.03)	2% (.03)	.0217 (n.s.)
	Synthesis	2% (.03)	2% (.03)	.0654 (n.s.)	3.5% (.03)	1% (.04)	.0096 (n.s.)
Motivation	Motivation	4% (.06)	3% (.03)	.0481 (n.s.)	2% (.03)	1% (.03)	.0555 (n.s.)
Conceptual change	Eliciting	<1% (.02)	<1% (.03)	.0366 (n.s.)	<1% (.03)	<1% (.13)	.0299 (n.s.)
	Challenging	<1% (.001)	<1% (.06)	.0097 (n.s.)	<1% (.07)	<1% (.04)	.0226 (n.s.)
	Extending	5% (.05)	<1% (.07)	.0651 (n.s.)	0.5% (.05)	1% (.02)	.0658 (n.s.)
	Application	2% (.06)	4% (.06)	.0279 (n.s.)	<1% (.05)	<1% (.03)	.0557 (n.s.)

Table 4.25 Types of science teachers' questions by school type

Note: n.s.= no statistically significant difference

Tables 4.24 and 4.25 summarise the types of teachers' questions between early–full and late–partial EMI schools and between grades 10 and 11. Mann–Whitney test for between-groups comparisons with Bonferroni correction for multiple comparisons (n=14). The corrected alpha value is 0.004. each of the *p*-values were divided by 14 and the corrected *p*-values were listed in the table.

No statistical difference was found for the science teachers' questions between early–full and late–partial EMI schools and between grades 10 and 11 in each school group. However, for the descriptive statistics, in the early–full EMI schools, more recalling questions were observed than in the late–partial EMI schools. In the late–partial EMI schools, more frequent use of higher-order questions (analysis, evaluation) and motivation questions were observed than in the early–full EMI schools. From grade 10 to 11, there were more lower-order and higher-order questions in the early–full EMI schools in grade 11 than in grade 10. However, there were more higher-order questions in the late–partial EMI schools.

4.4 Summary of the quantitative findings

In this quantitative analysis, I have examined classroom interactions in early–full and late–partial EMI schools and in grades 10 and 11 in each group. The quantitative comparison provides a representative sample of Hong Kong EMI secondary schools using a number of objective, comprehensive and systematic methods. For example, I measured the interaction time, distribution of teacher

and student talk, the average length of teacher and student turns, wait time between teacher and student talk, the ratio of L1 and L2 use between teachers and students, code-switching patterns, the pedagogical function of teachers' and student' turns, and the types of teachers' questions. The following sections summarise the major findings.

4.4.1 Interaction time, teacher and student talk, average length of teacher and student turns

There was no statistically significant difference between the two groups or between grades 10 and 11 in each group regarding to the interaction time. In grade 11, the interaction time was slightly less than in grade 10. Interaction times in early–full and late–partial EMI schools were similar. The majority of the interactions consisted of teacher talk, at nearly 63% (table 4.3), with a small percentage of student talk in both types of schools. There was more student talk in the early–full EMI schools but less teacher talk in the late–partial EMI schools.

There was no statistical difference in the average length of teacher talk and student talk in the two types of schools. However, teacher talk contributed to the majority of the interactions in the two types of schools. When I examined teacher talk, I measured the average length of teacher talk in each turn. The results showed that although there were more teacher and student turns in the late–partial EMI schools, the turns were shorter. The student turns were much shorter (3.16 s<8.48 s). The maximum length of student turns in the late–partial

EMI schools was four times shorter (302.6 s<1,192.1 s). However, this observation did not hold for grade 11 as compared to grade 10. There were more teacher turns and less student turns in grade 11 in both types of EMI schools. The maximum length of student turns was shorter in both groups. In addition, the average length of teacher and student turns was much shorter in the early–full EMI schools but this was not observed in the late–partial EMI schools.

4.4.2 L1/L2 use

Analyses showed that despite the fact that all participating schools claimed to be EMI schools, there was a diversity in the actual amount of English spoken in the classrooms. In regard to the percentages of L2 and L1 spoken, there was a statistically significant difference between the early–full EMI schools and the late–partial EMI schools with a large effect size. A high percentage of L2 was observed in the early–full EMI schools. A more balanced percentage of L1 and L2 was observed in the late–partial EMI schools. But there was no statistically significant difference between grades 10 and 11 in each school group. There was more L1 use and less L2 use in both types of schools.

Teachers and students in the early–full EMI schools used a high percentage of L2 during interaction. With more L2 use (87%), the percentages of L2 use suggested that early–full EMI schools were genuine EMI schools. There was more L1 use in grade 11 than in grade 10. The transcriptions indicate a few

occasions when teachers and students used L1 to supplement their English explanations, for a quick translation of technical vocabulary or to give examples of daily experiences related to science. In late–partial EMI schools there was a similar ratio of L1 and L2 use between teachers and students. There was a slightly more L1 use in grade 11 than in grade 10 (46% →54%).

To examine code switching, I measured two types of code-switching patterns: between sentences (inter-sentential) and code switching within a sentence (intra-sentential). A statistical difference was found for the intra-sentential code-switching between early–full and late–partial EMI schools. The data showed that early–full EMI schools had more inter-sentential code switching (between sentences) (61% >49%), suggesting that teachers and students with more experience in EMI instruction produce more complete sentences in English. They used English as the matrix language, embedded with Cantonese translations. However, the late–partial EMI schools had more intra-sentential code switching, suggesting that teachers and students tended to use Cantonese as the matrix language, embedded with English technical terms. Teachers and students interact socially about non-academic items in complete Cantonese discourse.

4.4.3 Pedagogical functions of the interactions

The results showed that the four most frequent pedagogical functions in the interactional data were similar in both types of EMI schools. The ranking was:

teachers' informs, teachers' self-utterances, teachers' directs, and teachers' replies. The fifth most frequent pedagogical function was different in the two types of schools: 'check' (early–full EMI) and 'express opinion' (late–partial EMI). In the early–full EMI schools, in grade 11 there is more 'check' than 'self-utterance' but this pattern was reversed in grade 10. In the late–partial EMI schools, in grade 11, there was more 'self-utterance' than 'direct' but the pattern was reversed.

4.4.4 Teachers' questions

The majority of the teachers' questions were factual-type questions in the two types of schools. Adopting Yip's (2004) taxonomy of teacher questions in science lessons, I analysed the number of questions used by the science teachers in the different EMI schools and categorised these questions according to their pedagogical uses in science teaching, namely, lower-order, higher-order, motivational and conceptual change questions.

The result shows that there were more lower-order questions (e.g. recalling questions) in early–full EMI schools. Teachers used lower-order questions to recall students' previous learned science concepts. In the late–partial EMI schools, however, teachers used more higher-order questions. These questions aimed to prompt students to use higher cognitive skills in terms of analysing relationships, evaluating the value or implications of materials, and synthesising new scientific ideas based on existing concepts. When comparing grades 10 and

11, there was a tendency to use a larger number of lower-order questions in grade 11 in the early–full EMI schools. Conversely, there was more use of higher-order questions in grade 11 in the late–partial EMI schools. The only statistical difference was between early–full and late–partial EMI schools for the number of information type questions. In late–partial EMI schools, the only statistical difference between grades 10 and 11 was found for the number of recalling in the lower order questions.

4.4.5 Teacher's feedback and wait time

There was no statistically significant difference between early–full and late–partial EMI schools in the percentages of teacher feedback. The only statistically significant difference was the number of affirmation–direct instruction feedback moves between grades 10 and 11 in the late–partial EMI schools. Both types of schools had a similar distribution of teacher feedback. The frequency order was: 'affirmation-direct instruction' > 'extension by responsive questioning: focusing and zooming' > 'explicit correction-direct instruction' > 'constructive challenge'. From grade 10 to 11, more 'affirmation-direct instruction' was observed in the early–full EMI schools but this pattern was reversed in the late–partial EMI schools.

Although there was no statistically significant difference between the two types of schools and across grades in their percentages of wait time, there was nonetheless a difference. In the late–partial EMI schools, the wait time was

much longer than in the early–full EMI schools. From grades 10 to 11, there was a shorter wait time in the early–full EMI schools, but a longer wait time in the late–partial EMI schools.

To conclude, interaction time and the distribution of teacher and student talk were similar in early–full and late–partial EMI schools. In summary: 62–68% of the interactions were teacher talk, with very little student talk (5-8%), and the average length of teachers' turns was longer than students' turns. Teachers in both types of schools used a similar set of pedagogical functions during interaction (e.g. teachers' informs, teachers' self-utterances, teachers' directs, and teachers' replies) and offered similar types of feedback (e.g. 'affirmation-direct instruction' > 'extension by responsive questioning: focusing and zooming' > 'explicit correction-direct instruction' > 'constructive challenge').

However, similarity in the interactions between early–full and late–partial EMI schools was limited to the macro level. When I examined the interactions at the micro level in terms of the average length of teacher and student talk, the ratio between L1 and L2 use, and the patterns of code switching (inter- and intra-sentential), types of teacher questions and wait time, a number of subtle differences across the two types of schools were found. In the early–full EMI schools, the average length of teacher talk and student talk was greater. Teachers and students used relatively more L2 than L1 in the interactions, with the majority of interactions spoken in English. Teachers and students tended to

code switch between English and Cantonese at sentence level (inter-sentential). Teachers used a larger number of lower-order questions to recall students' previous learning of science concepts, and thus the wait time between teachers' initiations and students' responses was shorter.

In the late–partial EMI schools, teacher and student talk was shorter. For example, the maximum length of student talk was four times shorter than those in the early–full schools. Teachers used a greater number of higher-order questions to prompt students to use higher cognitive skills, and thus the wait time was much longer than in the early–full EMI schools. There was a tendency to use higher-order questions in grade 11. Teachers and students used relatively less L2 in interactions, with a similar ratio between L1 and L2 use in both teacher and student talk. Teachers and students tended to insert English technical terms into Cantonese interactions.

Compared by grades 10 and 11, both types of schools shared similarities. For instance, similar patterns were observed in L1 and L2 use. More code switching between sentences (inter-sentential) was observed in grade 11 in both types of schools. However, there were a number of differences between the two types of schools. In the early–full EMI schools, the difference in the mean length of teacher turns was statistically significant; there was more teacher talk but less student talk in the early–full EMI schools. In the late–partial EMI schools, the

average length of teacher and student turns was much less than in the early–full EMI schools, with more L1 use.

When I examined the pedagogical functions of the interactions, the function of interactive moves and the choices of teachers' questions were the two key indicators marking the differences between early–full and late–partial EMI schools. The four most frequent pedagogical functions in the interaction sequences—inform, self-utterance, direct and reply—appear to reflect the nature of science teaching in Hong Kong. They suggest classrooms that are teacher-centred and authoritative, with very few opportunities for students to negotiate meaning with teachers at the lexical level. These subtle differences suggest that the interactions in early–full and late–partial EMI schools were different in nature, which will be further explained in the discussion chapter.

4.5 Summary

In this chapter, I have analysed the classroom interactions quantitatively and compared the interactions I observed in early–full and late–partial EMI schools, and in grades 10 and 11 in each group.

The statistics indicate that early–full and late–partial EMI science classrooms are characterised by similar interaction patterns (percentages of interaction time, distribution of time between teacher and student talk, frequency of pedagogical functions) but the nature of the interactions is different.

Key findings include the greater amount of L2 used in the early-full schools than in the late-partial schools, the greater use of intersentential code-mixing in the early-full schools and the greater use of intra-sentential code-mixing in the late-partial ones and the greater use of higher order questions in the late-partial schools than in the early-full schools. Particularly, in late–partial EMI schools, there were more (but shorter) student initiations and responses, with more higher-order questions from the teachers in Cantonese but less direct feedback to students. In addition, both teachers and students tended to use more L1.

In both types of schools, there was less interaction time in grade 11 than in grade 10. There was more use of L1 in Grade 11 than in Grade 10. This is presumably because Grade 11 is more cognitively challenging. The maximum length of student turns in grade 11 was also less than in grade 10.

The next chapter will further examine the subtle differences in classroom interactions between the two types of EMI schools. Drawing on a case study of four EMI classrooms transcripts, the chapter will explore the nature of classroom interactions qualitatively and identify the features of language used in EMI science classrooms. The analysis will show how these interactions are similar and different in teaching science between early–full and late–partial EMI schools and the pedagogies implied by these interactive sequences. ■

Chapter 5

Qualitative analysis of classroom interaction in EMI science classrooms

5.1. Introduction

In the previous chapter, I analysed the classroom interaction quantitatively, comparing and contrasting early–full and late–partial EMI schools for the variables of interaction time and the pedagogical functions. The results showed that while the two school types display similar interactional patterns (percentages of interaction time, distribution of time between teacher and student talk, frequency of pedagogical functions), the nature of the interactions differs across the types of school. In particular, subtle differences emerged in the ratio between L1 and L2 use and the patterns of code switching (inter- and intra-sentential). Specifically, from grade 10 to 11, in both types of schools, results indicated a small decrease in the percentage of interaction time, a decrease in the maximum length of student turns and a small increase in L1 use.

In this chapter, I further examine the differences in classroom interactions between the two types of EMI schools by analysing the patterns of classroom

interaction qualitatively. I present transcribed data drawn from four biology lessons. Two lessons are from early–full EM and two from late–partial EMI schools, with a grade 10 lesson and a grade 11 lesson from each type of school. These transcripts were chosen because these lessons were dealing with similar science topics and can provide a homogenous dataset for exploring the nature of classroom interaction.

The analysis in this chapter includes a descriptive analysis of the science pedagogy using Mortimer and Scott's (2003) framework. First, I summarise the teaching purpose, communicative approaches, pattern of interaction and form of interaction of each of the four lessons. Next, I identify the language choices the science teachers and students made in these EMI science classrooms using the frameworks of Fang (2006) and Kong and Hoare (2012), as explained in chapter three. Finally, I analyse interactive sequences in the data in order to show how an EMI science teacher interacts with his students to develop their thematic understanding of science in two of the biology lessons. This final part of the analysis illustrates the teacher's use of IRF patterns to develop students' science understanding of the topic through interaction. The analysis in this chapter addresses my research question: *What is the nature of classroom interaction in the EMI science classroom?* The chapter aims to elucidate how interactions are enacted differently in teaching science in early–full and late–partial EMI classrooms and to probe the nature and implications of the teaching pedagogies

underpinning the interactive sequences observed in the different classroom contexts.

5.2 An integrated framework for analysing classroom interaction qualitatively

As explained in chapter three (section 3.10), the integrated framework I am drawing on in this analysis pays attention to the three dimensions relevant to classroom interactions: science pedagogy, the language of science and the understanding of science concepts. Figure 5.1 illustrates this framework.

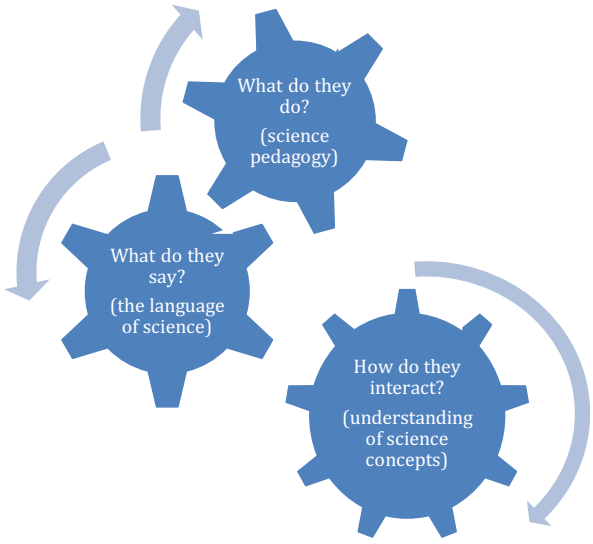


Figure 5.1. Conceptual framework of the three elements to analyse classroom interactions

For the first dimension, science pedagogy, the aim of analysis is to understand what teachers and students do in their classroom interaction to achieve the purpose of learning science. Thus, I use Mortimer and Scott's (2003) framework as my fundamental framework to analyse the classroom interaction. It provides an analytical frame within which to categorise the aspects of classroom

interactions related to science pedagogy: teaching purpose, teaching content, communicative approach (non-interactive vs interactive; authoritative vs dialogic), teachers' interventions, the pattern of interactions and the form of interactions.

To describe the language of science—the second dimension in the conceptual model in figure 5.1—I have adapted Fang's (2006) and Kong and Hoare's (2012) frameworks. Both frameworks provide a method for analysing what language features the teachers and students use in EMI science classrooms. Kong and Hoare examined teachers' talk and classroom interactions in EMI content-subject classrooms. They provide an analytical framework based on a detailed discourse analysis of classroom data (transcriptions of teacher and student talk, teacher interviews, direct observations, lesson plans and teaching materials) in a Hong Kong EMI secondary science classroom. As in Kong and Hoare's study, my study also investigates how teachers develop students' academic language proficiency, analysing the specific language features students use to construct academic knowledge in an EMI classroom, for example through the use of nominalisation (e.g. nominal phrases). From Fang's study (2006) I have adopted the comprehensive review of the specific language features that high school science students encounter when learning science through English.

To capture how students develop an understanding of science concepts through interaction—the third dimension in the conceptual model in figure 5.1—I have based my analysis on Lemke's (1990) concept of semantic relations. As the primary goal of content classrooms is to develop students' content knowledge, it is particularly important to understand how science learning takes place through interaction. Lemke's (1990) concept of semantic relations provides a framework for describing how science teachers modify their talk to provide comprehensible input in order to develop students' understandings of science through interaction.

Table 5.1 summarises the three aspects of analysis in the integrated framework. As I will show in the following sections of this chapter, by using this three-layered integrated framework, I have been able to understand how science teachers in EMI classrooms interact with their students differently and how teachers modify their talk to provide comprehensible input to help develop students' understandings of science concepts through interaction.

Science pedagogy	Mortimer and Scott's framework (2003)	Analysis of the science pedagogy (teaching topic, communicative approach, patterns of interaction (IRF), teachers' interventions)
The language of science	Kong and Hoare (2012)	The use of academic language through teacher and student talk in science classrooms (lexical density, subject-specific vocabulary, grammatical metaphors, complex noun phrases, language of knowledge relationship)
	Fang (2006)	The language of science in teachers' talk and interaction with students (vocabulary, grammar, forms)
Thematic development in science	(Lemke, 1990)	How teachers develop students' understanding of technicality and logical reasoning in science through interactions. (Unpacking nominalisation, making connections between different taxonomic knowledge)

Table 5.1. Three-layer integrated framework used in this study

The following discussion presents the qualitative analysis of classroom interaction for each of the three different dimensions in turn.

5.3. Analysis of classroom interactions in four biology lessons

5.3.1 Early-full EMI biology grade 10

This lesson extract is from a grade 10 early–full EMI biology classroom. The students have been using EMI for three years and have just started to study the senior science curriculum.

In this lesson, the teacher introduced students to the concept of photosynthesis. He explored with students the possible factors that affect the rate of photosynthesis. As excerpt 1a shows, the teacher and his students

explore the factors involved in photosynthesis through lively but systematically structured interaction. Interaction is described in the form of IRF sequences. In excerpt 1a there are five IRF sequences in 20 turns, two of which are the extended IRF sequences. The teacher initiates the interaction by asking students to suggest possible factors that affect the rate of photosynthesis. Students give their answers and the teacher evaluates their responses. If the answer is correct, the teacher acknowledged the student's answer and moved on to the next factor. If the answer was inconsistent with the teacher's view, the teacher provided extensive feedback to the students. The IRF sequence is then repeated as the teacher moves on to further explore with the students how these factors (light intensity, concentration of CO_2, oxygen, amount of chlorophyll, source of water) affect the rate of photosynthesis.

Excerpt 1a. The lesson transcript of early–full EMI grade 10 EMI Biology

Topic: Photosynthesis

Sub-topic: Factors that affect the rate of photosynthesis (light intensity, concentration of CO2, oxygen, amount of chlorophyll, source of water)

Medium of instruction (MOI): English only

Turn	Speaker	Text	IRF sequence	Science topic
1	T	Can you tell me what sort of factors may also affect photosynthesis? What sort of factors may also affect photosynthesis?	I (Open Q)	photosynthesis
2	S1	Amount of chlorophyll	R	Amount of chlorophyll

Turn	Speaker	Text	IRF sequence	Science topic
3	T	Amount of chlorophyll, yes. Okay?	F (acknowledge)	
4	T	Amount of chlorophyll will have an effect. And besides that? Remember the equation of photosynthesis. You have CO2, and you have what? CO2 plus what?	I (Open Q)	equation of photosynthesis; Carbon dioxide (CO2)
5	S1	Water	R	water
6	T	Water, okay. Addition of water.	F (acknowledge)	
7	T	Together with the chlorophyll and also what sort of things?	I (open Q)	
8	S1	Light energy.	R	Light energy
9	T	Light energy. What is the product of the photosynthesis? Oxygen together with what?	F (ignore)	
10	S1	Starch or food.	R′	Starch
11	T	Okay, so light we've mentioned here already.	F′ (ignore)	
12	T	And your classmate talked about whether it is due to the limit of chlorophyll. Anymore things that limit photosynthesis?	I (open Q)	
13	S1	Water	R	
14	T	Water, yes. Can you tell me the source of water of the plants? Where does it come from? Where does it come from?	F (acknowledge +expand)	source of water
15	S1	Soil	R′	Soil
16	T	Soil, yes. So if inside the soil, the amount of water in the soil is very low, then it will be a very great limiting factor.	F′ (acknowledge+ Expand)	
17	T	Anymore? Very straightforward, we have	I (open Q)	

Turn	Speaker	Text	IRF sequence	Science topic
		mentioned chlorophyll, we have mentioned water. And the last one should be … ?		
18	S1	CO2	R	
19	T	Why is CO2 a limiting factor?	F (expand)	

Excerpt 1a shows that the teacher also uses a number of teacher interventions (Mortimer & Scott 2003) in the form of extended IRF sequences. These interventions include: focusing on a particular student's idea by zooming into a particular student response; expanding on what a student has said; further exploring the ideas; asking for clarification of student ideas; and reviewing student responses with the whole class. For example, in turn 19, (see excerpt 1b below), the teacher asks the students to elaborate on why carbon dioxide is a limiting factor for photosynthesis. Then, from turn 20 to 25, the teacher builds on the student' answers to discuss the role of stomata in the process of gas exchange. In this period of interaction, the teacher intervenes by developing the students' understanding of the scientific story. The teacher pays attention to a particular student response (*stomata* in turn 20). The teacher marks the key idea by enacting a confirmatory exchange with the student (*because it comes from the stomata* in turn 23). Then the teacher checks the students' understanding by asking for clarification about the role of the stomata in plants (in turn 23). Finally the teacher returns to and revises the idea again (in turn 25) by

summarising the actual function of stomata in gas exchange. Excerpt 1b below is a continuation of the same lesson.

Excerpt 1b. Lesson transcript of early–full EMI grade 10 EMI biology (cont'd)

Turn	*Speaker*	*Text*	*IRF sequence*	*Science topic*
17	T	Anymore? Very straightforward, we have mentioned chlorophyll, we have mentioned water. And the last one should be … ?	I (open Q)	chlorophyll
18	S1	CO_2	R	Carbon dioxide (CO_2)
19	T	Why is CO_2 a limiting factor?	F (expand)	
20	S1	Stomata	R′	
21	T	Limited by stomata. Why will it be limited by stomata? Can you tell me?	F′ (acknowledge +expand)	Stomata
22	S1	Because it comes from the stomata	R′′	
23	T	Because it comes from the stomata. What is the role of the stomata in plants?	F′′ (acknowledge +expand)	
24	S1	Gas exchange	R′′′	Gas exchange
25	T	Yes, it is the site of gas exchange. They allow the CO_2 from outside to go into the leaves. So the number of stomata will have an effect. It will be one of the possible reasons.	F′′′ (acknowledge +expand)	

In excerpt 1b we can see that the teacher makes several interventions from turns 20 to 25, including sharpening ideas, selecting ideas, marking key ideas, sharing ideas, checking student understanding, and reviewing. These efforts appear

designed to help the students to develop scientific reasoning by making explicit and clear the fact that stomata are a controlling factor in the amount of carbon dioxide intake during gas exchange. This may help students to understand the reason why carbon dioxide could affect the rate of photosynthesis. Table 5.2 summarises the number of turns and turn types in the complete lesson.

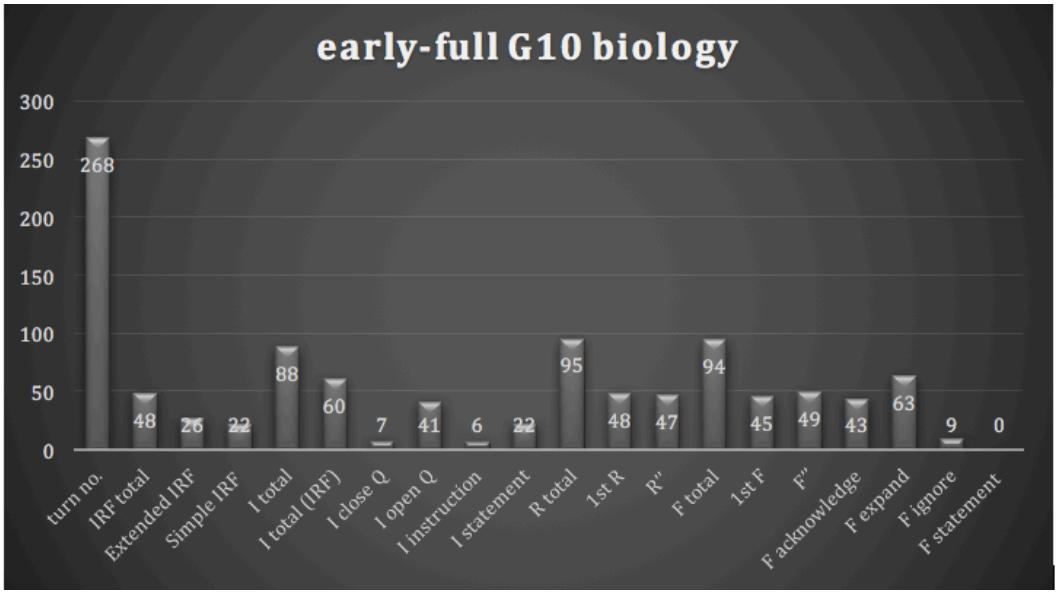


Table 5.2. The number of turns, IRF in the whole lesson

From table 5.2 we can see that in this example of early–full EMI grade 10 biology, there are 268 turns by teachers (173 turns) and students (95 turns) and 48 IRF sequences: 26 are extended IRF and 22 are simple IRF. There are more open questions (41) than closed questions (7). Students provided 95 responses and the teacher made 94 feedback moves. A relatively high ratio of IRF[23] (18%)

[23] Each of the lesson transcripts was analysed and coded into Initiation-Response-Feedback (IRF) sequences. Each IRF sequence can be categorised as a simple IRF or extended IRF pattern. The extended

in the interaction, with more extended IRF sequences, suggests that there were opportunities for the students to interact and respond and for the teacher to give feedback to the students.

Excerpt 1c below is a simplified version of excerpt 1 that highlights only the science topics discussed in the interaction. We can see that the teacher made attempts to elicit students' further responses on the possible factors of photosynthesis by asking questions in his feedback moves. After the students answered topics A, B, and C, the teacher worked with the students together to explore different views, by responding and providing feedback to each student's response, to generate new meaning and co-structure understandings of different views about the scientific phenomenon. Excerpt 1d below summarises the kind of language students produced in the classroom interaction. Students predominately produced incomplete sentences consisting of nouns or noun phrases referring to scientific items when responding to their teacher. In these exchanges, the teacher did not encourage students to produce complete sentences, or make any attempts to correct any students' language mistakes or provide any feedback to students about how to acquire the language of science in L2 context.

IRF pattern consists of a simple IRF pattern prolonged by more responses from students and subsequent teacher feedback. The ratio of IRF is the total number of IRF patterns divided by the total number of extended IRF patterns.

Excerpt 1c. Science topics in excerpt 1a and 1b

Turn	*Speaker*	*Text*	*IRF sequence*
1	T	***factors** may also affect photosynthesis?*	I
2	S	**Amount of chlorophyll**	R
3	T	*Amount of chlorophyll will have an effect, and besides that?*	F (acknowledge)
5	S	**Water**	R
6	T	**Addition of water.**	F (acknowledge)
7	T	*Together with the chlorophyll and what sort of things?*	I (open Q)
8	S	**Light energy.**	R
9	T	**Product of photosynthesis**	F (ignore)
10	S	**Starch or food.**	R′
12	T	*Any more things that limit it?*	I (open Q)
13	S	**Water**	R
14	T	Where does it come from?	F (expand)
15	S	**Soil**	R′
16	T	Anymore? We have mentioned chlorophyll, we have mentioned water. *And the last one should be… ?.*	F′ (acknowledge)
18	S	CO_2	R
19	T	Why is CO_2 a limiting factor?	F(expand)

Excerpt 1d. Students' language output in excerpt 1

Turn	*Speaker*	*Text*	*IRF sequence*	*Turn*
2	S	Amount of chlorophyll	Noun phrase	R
5	S	Water	Noun	R
8	S	Light energy	Noun	R
10	S	Starch or food.	Noun	R′
13	S	Water	Noun	R
15	S	Soil	Noun	R′
18	S	CO_2	Noun (technical vocabulary)	R

In both excerpts 1a and 1b, the teacher uses a range of teacher interventions to develop students' understanding of the factors that affect photosynthesis. In

excerpt 1a, the teacher takes account of his students' points of view on the factors. In excerpt 1b, the teacher explores different views with his students to co-construct understanding about how carbon dioxide is a limiting factor for photosynthesis.

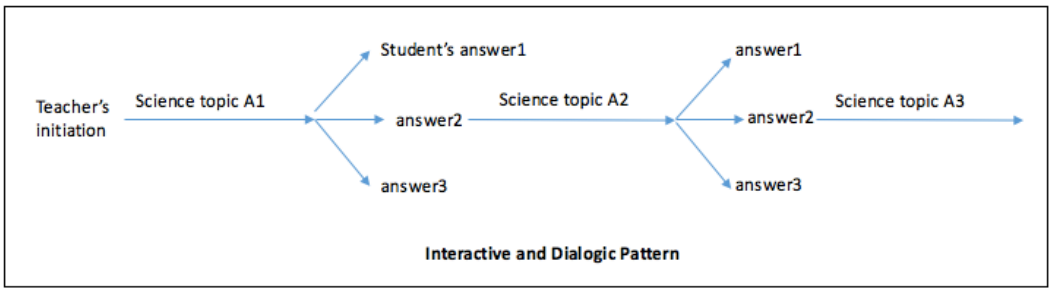


Figure 5.2. Conceptual diagram of the interactive and dialogic pattern

This example of early–full EMI grade 10 EMI biology can be related to Mortimer and Scott's (2003) framework as an example of an interactive and dialogic science lesson, as it contains a number of long sequences made up of rapid turn-taking, with substantial teacher questions and feedback. Excerpts 1a and 1b are highly interactive, with both IRF and extended IRF sequences. Students' answers are long and their ideas are acknowledged by the teachers, followed up by the teacher's feedback. The teacher initiates frequently, realised by open questions, to promote students' extended answers, which in turn enables the teacher to explore meaning and encourage students to practise their English. Science ideas offered by students that are inconsistent with the teacher's planned ideas are further explored, and discussed, showcasing how the teacher and students are in the process of co-constructing knowledge

together through IRF exchanges. In this process, the teacher expanded the science ideas from students to help them understand abstract scientific knowledge. The teacher discusses with students what has been explored in the lesson. The interaction provides opportunities for students to learn content and to practise or learn the language.

5.3.2 Early-full EMI grade 11 biology

In the excerpts presented above, from a grade 10 early–full EMI science classroom, the students have just started to study the senior science curriculum and have been using EMI for three years. I now turn to a classroom interaction by grade 11 students from the same school. These students have studied in an EMI context for four years and have had one more year studying the senior science curriculum. This extract of a lesson is from a grade 11 early–full EMI biology classroom. In this lesson, the teacher introduces the concept of cell division. He checks students' understanding of cell division in bacteria at the microorganism level.

Excerpt 2a shows a considerable amount of interaction between the teacher and his students as the teacher checks students understanding of the key concepts related to cell division (e.g. bacteria, fungi, yeast, genetic variation). There are two extended IRF sequences in 12 turns. In these IRF sequences, the teacher initiates by asking students what microorganisms there are. Then students gave their answers (e.g. fungi) and the teacher asks the student to give

an example (e.g. yeast). Instead of exploring the student's answer, the teacher provides an explanation of how yeast is related to cell division (in turn 5). Later, the teacher jumps to another topic about genetic materials and asks students to give a reason to explain why the genetic materials are the same as those in the cell colony (in turn 6). Students answer quickly, saying it was due to mitotic cell division. The teacher then asks for the reason and students reply by saying that there is no genetic variation. In these exchanges we do not see the teacher expanding on students' answers or providing any feedback to students.

Excerpt 2a. Lesson transcript of early–full EMI grade 11 EMI biology

Topic: cell division

Sub-topic: mitotic cell division

MOI: English only

Turn	*Speaker*	*Text*	*IRF sequence*	*Science topic*
1	T	What do you think? What microorganisms can also grow here? Apart from bacteria. You have learned	I [open Q]	microorganisms; bacteria
2	S1	Fungi	R	fungi
3	T	Fungi? Yes, can you give me an example of fungi? You have learned a very small, okay, unicellular fungi. What's that?	F [acknowledge + expand]	unicellular fungi
4	S1	Yeast	R''	yeast
5	T	Yeast, yes. We can grow yeast here okay? This microorganism, this colony, is derived from the division, the repeated cell division of one cell okay, into many	F'' [statements]	colony; asexual reproduction; mitotic cell division

Turn	*Speaker*	*Text*	*IRF sequence*	*Science topic*
		many cells by mitotic cell division. It is the asexual reproduction of the bacteria. And the bacterial colony almost contains this number of bacteria, this amount that means about millions of that bacteria, okay, in this colony. So that you can know directly, use your naked eye, to observe this, okay?		
6	T	And the genetic materials of the bacteria in this colony should be the same. Why?	I [open Q]	genetic materials of the bacteria in agar plate
7	S1	Because of mitotic cell division	R	
8	T	Why does mitotic cell division produce the same genetic material?	F [acknowledge + expand]	
9	S1	No genetic variation	R''	genetic variation
10	T	No genetic variation. Okay? Genetic variation is very important this term. No genetic variation in mitotic cell division, okay?	F'' [acknowledge]	
11	T	Any questions about this petri dish? Any questions?	I [close Q]	petri dish
12	S1	No	R	

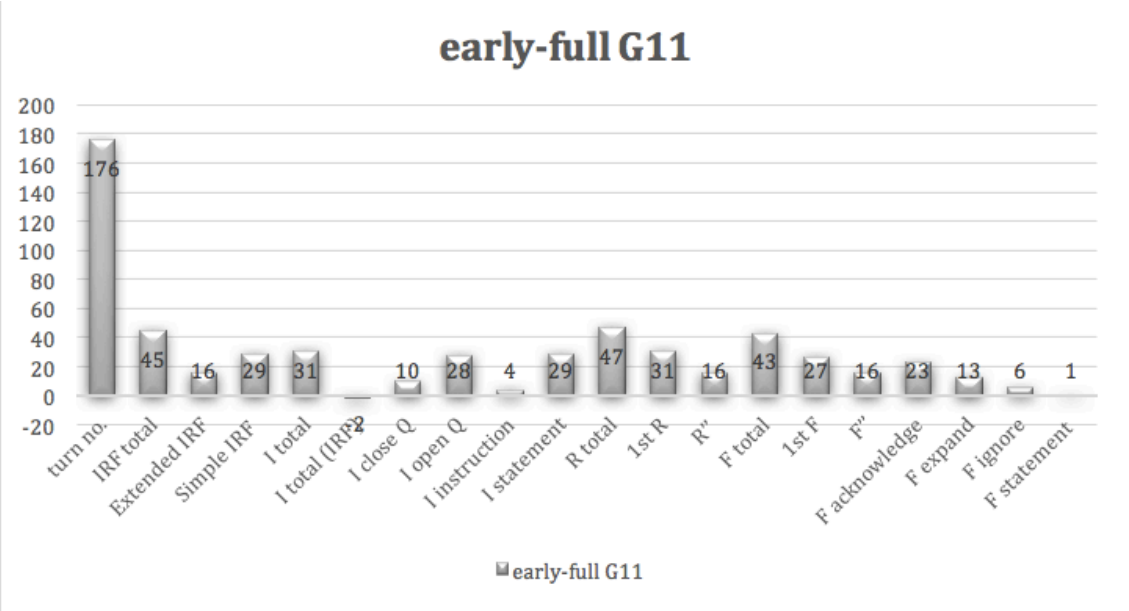


Table 5.3. The number of turns and IRF sequences in the lesson

As table 5.3 shows, in this example of early–full EMI grade 11 EMI biology, there were 176 turns taken between teacher and students and 45 IRF sequences: 16 are extended IRF and 29 are simple IRF. The high ratio of IRF (26%) in the interaction, with more simple IRF sequences, suggests there was less opportunity for the students to respond and for the teacher to give feedback to the students. There are more open questions (28) than closed questions (10). Students made 47 responses and the teacher produced 43 feedback moves.

Excerpt 2b is a simplified version of excerpt 2a, highlighting the science topics discussed in the interaction. In turn 1, the teacher first asked the students a question by reminding them what they learned in the previous lesson. From turns 2 to 5, the students said 'fungi' which was not the answer the teacher expected. The teacher did not address the student's answer and continued to

provide more hints to help the students arrives at the answer 'yeast'. Once the students said 'yeast', the teacher started to elaborate in a sustained turn (5). Similarly, in turn 6, the teacher asked students to explain why the genetic materials are the same as the colony of cells. The teacher did not address the students' answer in turn 7 until the students said 'no genetic variation' in turn 9. The teacher responded by making a claim about there being no genetic variation in cell division.

Excerpt 2c summarises the kind of language students produced in the classroom interaction. It shows that students at grade 11 are similar to the grade 10 students in producing a number of incomplete sentences consisting of nouns or noun phrases referring to scientific items when responding to their teacher. In these exchanges, teacher again did not encourage students to produce a complete sentence, make any attempts to correct the students' language mistakes or provide any feedback to students about how to acquire the language of science in the L2 context.

Excerpt 2b. Science topics in excerpt 2a

Turn	Speaker	Text	IRF sequence
1	T	What do you think? What microorganisms can also grow here? Apart from bacteria. You have learned	I [open Q]
2	S1	**Fungi**	R
3	T	**Fungi?** You have learned a very small, okay, unicellular fungi. What's that?	F [expand]
4	S1	**Yeast**	R''

5	T	**Yeast,** yes. We can grow yeast here okay? This microorganism……	F'' [statements]
6	T	And the **genetic materials** of the bacteria in this colony should be the same. Why?	I [open Q]
7	S1	Because of **mitotic cell division**	R
8	T	Why does mitotic cell division produce the same genetic material?	F [expand]
9	S1	No genetic variation	R''
10	T	No genetic variation. Okay? **Genetic variation is very important** this term. No genetic variation in mitotic cell division, okay?	F'' [acknowledge]

Excerpt 2c. Students' language output in excerpt 2a

Turn	Speaker	Text	Grammatical categories	IRF sequence
2	S1	Fungi	Noun (technical)	R
4	S1	Yeast	Noun (technical)	R''
7	S1	Because of mitotic cell division	Noun phrase (technical)	R
9	S1	No genetic variation	Noun phrase (technical)	R''
12	S1	No	Discourse marker	R

In these examples, turn 1-5 and turn 6-9, after the student gave different answers for science topics (Fungi, Yeast, mitotic cell division and genetic variation), the teacher decided which was consistent with his planned science explanation, and focused on it by asking more questions.

In relation to Mortimer and Scott's (2003) framework, the transcript of early–full EMI grade 10 EMI biology is an example of an interactive and authoritative science lesson.

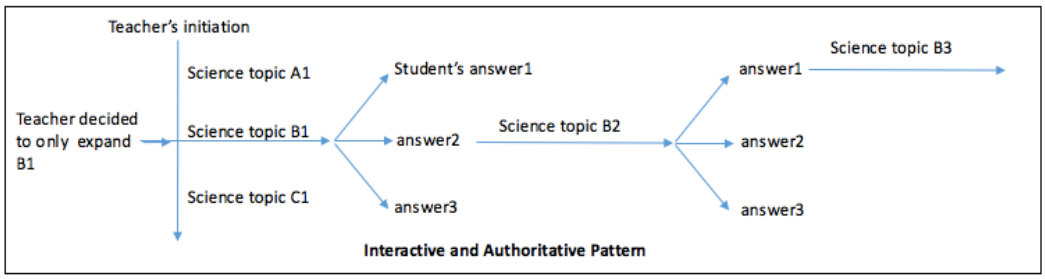


Figure 5.3. Conceptual diagram of the interactive and authoritative pattern

It is characterised by a number of long periods of teacher's initiations, with many statements, indicating the power of the teacher to control the lesson. However, there was still a considerable amount of interaction between teacher and students, in the form of IRF sequences, largely simpler IRF sequences. There were many teacher's initiations, realised by closed questions, or statements, which seemed aimed at only to present the teacher's views of the planned science topic or checking comprehension and which produced short answers from the students. There were some forms of students' responses, followed by teacher's feedback to acknowledge students' answers in the direction of the teacher's planned explanation. Although the teacher sometimes considered students' answers, none of these students' ideas were further explored or followed up. The teacher directed the students towards his planned idea, without exploring scientific meaning and the language of science in the interaction. In the process of interacting, the teacher only unpacked abstract scientific knowledge. The teacher asked for students' ideas but transferred the teacher's way of interpreting the science topic to the students without much

engagement with the students' interpretation of the topic. There were some opportunities for students to learn content, but limited opportunity for them to practise the language.

5.3.3. Late-partial grade 10 biology

The previous two science lessons were from an early–full EMI school. These students have been using EMI for three or four years. In this section, I present data from students with no or very little EMI experience at the same secondary level. These students have just started to study the senior science curriculum. Excerpt 4 below is an extract from a grade 10 late–partial biology classroom. In this lesson, the teacher introduces the concept of immunity, and helps students to distinguish specific immune responses from a general immune response. The teacher asks students to provide explanations of specific immune responses.

Excerpt 4 shows a considerable amount of interaction between the teacher and students in the form of IRF sequences, in exploring their understanding of specific immunity responses. This is achieved by extensive use of Cantonese throughout the interaction. The teacher used a significant amount of Cantonese (the shared L1) when explaining difficult science concepts, asking higher-order questions (e.g. in turn 2, 'Why do we call these specific?') and only used English when referring to technical vocabulary, highlighted in italics. Students were able to understand the teacher's higher-order questions and answered the

questions in Cantonese. However, students' responses are limited and are usually a single word rather than a complete sentence.

From turn 4 to 16, there are three simple IRF sequences, where the teacher asks the students to describe the characteristics of specific immunity responses. For example, various students say target (in turn 5), antigens (in turn 8) and pathogens (in turn 11). The teacher provides feedback on the students' responses in the form of an open question. In turn 13, the teacher summarises what he has discussed with students about 'pathogens and antigens' and creates a causal relation between the two terms, saying 'a pathogen has this type of antigen'. Finally he introduces a new term, 'leukocytes', which is the type of cell that recognises a pathogen in order to initiate the specific immune response. The teacher does not make this link explicit to the students.

Excerpt 3a. The lesson transcript of late–partial grade 10 EMI Biology

Topic: immunity

Sub-topic: specific immune response

MOI: Cantonese as the matrix language, embedded with English vocabulary (*Italics: Cantonese*; non-italics: English)

Turn	*Speaker*	*Text*	*IRF sequence*	*Science topic*
1	T	*First, we are talking about the 首先，我地會講概係有關* specific immune response; *this is not 這個唔係* a general immune response. *It is* a *這個係* specific immune response. *When we talk about 當我地講* skin, saliva, tears, gastric juice, *we call these 我地講這些叫* general.	I (statement)	specific immune response

2	T	*Why do we call these* 點解我地叫 specific? *Anyone remember* 有無人記得? *Why would these be regarded as* 點解這些叫 specific?	I (open Q)	
3	T	*Previously we talked about* 之前我地講 inflammation *and* 同 blood clotting.	I (statement)	inflammation, blood clotting
4	T	*Why do we call these* 點解我地叫 non-specific? *Why would we we call them like this* 點解我地咁樣叫？*This would be* 這樣叫 specific? 什麼叫 *What is* specific?	I (open Q)	non-specific
5	S1	Target.	R	
6	T	Target. *That's right 對呀*. Targeting the **pathogens.**	F (expand)	**pathogens**
7	T	*Why would we say that it has the ability of* 點解我地講佢有能力去 targeting? *You can find a very important word here 你可以在這找到重要的字。*	I (open Q)	
8	S2	**Antigen**	R	
9	T	**Antigen**. *What does it mean?* 點解？*You need to know what it means rather than copy it 你需要知道點解重要過抄寫.*	F (expand)	**Antigen**
10	T	Whose antigen belongs to? *Does it belong to our body or* 係唔係屬於身體定 pathogen?	I (open Q)	
11	S3	**Pathogen.**	R	Pathogen.
12	T	An antigen is a type of protein.	F (ignore)	
13	T	*If the* 如果 pathogen *has this type of* 係有這種 antigen, 這種 *this type of* protein, **leukocytes** 係我地身體入面會認得這些野唔屬於身體 *inside our body would recognise that these are not something belonging to the body. 當佢認到這個唔係 When it can identify that this is not some* substance *屬於身體 belonging to the body, this 佢* antigen 就會當作認到 *would be regarded as recognised. When I say* 當我講 non-specific, 當 *when the* skin *要拒*	I (statement)	**Leukocytes**; non-specific

		絕唔俾 needs to resist, not allowing the bacteria *或者外來物質進入身體 or foreign substances to come inside the body,*		
14	T	*will the 咁* skin *會認得邊一種物質同唔俾進入 recognise which substance and not allow its entry*?	I (close Q)	
15	S1	No.	R	
16	T	*So it is* 所以就叫 non-specific. *There is no* 佢無 recognition, 所有野入唔到 *everything cannot go in. No* 唔需要 recognition *is needed.*	F (acknow)	recognition

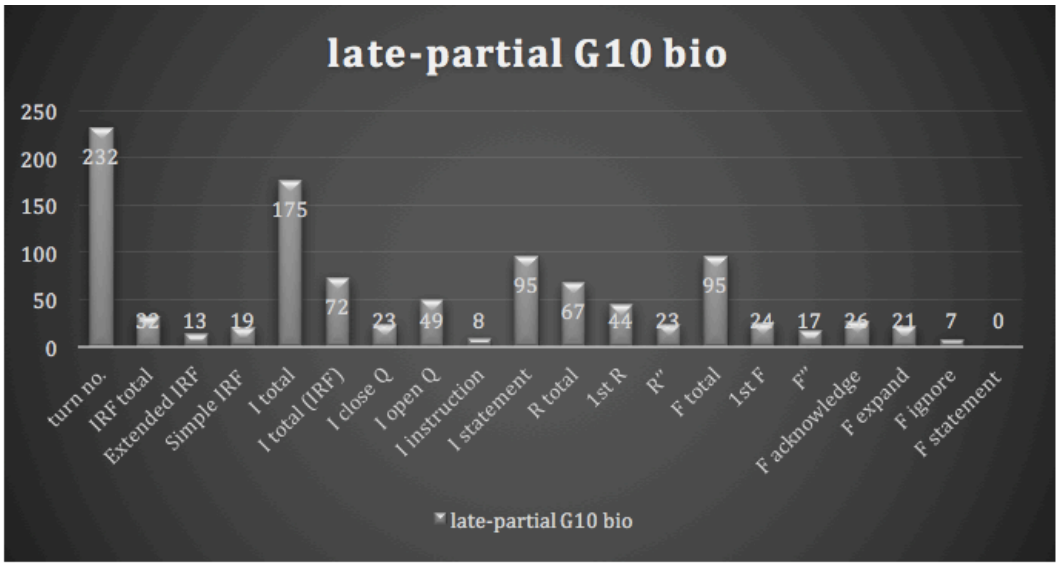


Table 5.4. The number of turns, IRF in the whole lesson

As table 5.4 shows, in this example of late–partial grade 10 EMI biology, the teacher and students take 232 turns, in 32 IRF sequences: 13 are extended IRF and 19 are simple IRF. There are more open questions (49) than closed questions (7). Students' responses number 67 and teacher's feedback 95. There is a medium ratio of IRF (14%) in the interaction, with more extended IRF

sequences, suggesting that there were opportunities for the students to respond and the teacher to give feedback to students.

Excerpt 3b below is a simplified version of excerpt 4a, highlighting the science topics discussed in the interaction. We can see that the teacher made attempts by asking questions in the feedback move to elicit students' further responses on the characteristics of specific immune responses from turns 4 to 11. Students provided answers (e.g. target, antigen, pathogen). In turn 13, the teacher summarised what he discussed with the students.

Excerpt 3c below summarise the kind of language students produced in the classroom interaction. The data shows that students from late–partial schools are very similar to the students from early–full EMI schools, as seen in previous examples, in that they predominately produced incomplete sentences consisting of nouns or noun phrases referring to scientific items when responding to their teachers. But students in this lesson, as seen in excerpt 3a, could only respond to their teachers using the technical items were mentioned in previous interactions. In the excerpt 3a, teacher again did not encourage students to produce a complete sentence, or make any attempt to correct students' language mistakes or provide any feedback to students about how to acquire the language of science in the L2 context.

Excerpt 3b. Science topics in excerpt 3a

Turn	Speaker	Science topics	IRF sequence
4	T	*Why do we call these* non-specific*? Why do we call them like this? This would be* specific*? What is* specific*?*	I (open Q)
5	S1	**Target.**	R
6	T	Target. *That's right*. Targeting the **pathogens.**	F (expand)
7	T	*Why do we say that it has the ability of* targeting*?*	I (open Q)
8	S2	**Antigen**	R
9	T	**Antigen**. *What does it mean?*	F (expand)
10	T	Whose antigen belongs to? *Does it belong to our body or* pathogen?	I (open Q)
11	S3	**Pathogen.**	R
12	T	An antigen is a type of protein.	F (ignore)
13	T	*If the* pathogen *has this type of* antigen*, this type of* protein*, the* **leukocytes** *inside our body would recognise that these are not something belonging to the body. When it can identify that this is not some* substance *belonging to the body, this* antigen *would be regarded as recognised. When I say* non-specific*, when the* skin *needs to resist, it does not allow the* bacteria *or foreign substances to come inside the body,*	I (statement)
14	T	*Will the* skin *recognise which substance it is and not allow its entry?*	I (close Q)
15	S1	No.	R
16	T	*So it is* non-specific. *There is no* recognition*, everything cannot go in. No* recognition *is needed*.	F (acknow)

Excerpt 3c. Students' language output in excerpt 3a

Turn	Speaker	Text	Grammatical categories	IRF sequence
5	S1	Target.	Noun (technical)	R
8	S2	Antigen	Noun (technical)	R
11	S3	Pathogen.	Noun (technical)	R
15	S1	No.	Discourse marker	R

So we can see that after the students gave different answers for science topics A, B, and C, the teacher decided which is consistent with his planned science

explanation, and focused on it by asking more questions. According to Mortimer and Scott (2003), this example of early–full EMI grade 10 EMI Biology is an example of an interactive and authoritative science lesson. The observed interactive features were similar to lesson 2.

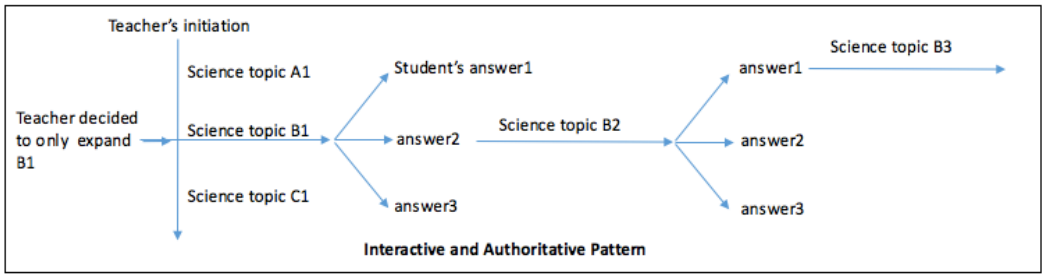


Figure 5.4. Conceptual diagram of the interactive and authoritative pattern

5.3.4 Late-partial grade 11 biology

The examples in this section are from students with little EMI experience and who have been studying the senior science curriculum for one year. Excerpt 4a is from a grade 11 late–partial biology classroom. In this lesson, the teacher introduces the concept of chromosomes. The teacher asks the students to guess the number of pairs of chromosomes in humans and the number of chromosomes in each pair from the father and mother. She used the analogy of counting postage stamps to help students to understand the total sets and the number of chromosomes in a set. She then helped students to distinguish between diploid (two sets of chromosomes, 2n) and haploid cells (one set of chromosomes, 1n) in sexual reproduction.

In excerpt 4a, there are three extended IRF sequences in 35 turns. One of the extended IRF sequences has more than three students' responses and teacher's feedback (from turn 191). There is a considerable amount of interaction between the teacher and students in the form of IRF sequences, in exploring students' understanding of how to count the number of chromosomes in human cells. Across the interaction, the teacher used a number of technical terms, (e.g. homologous chromosomes in turn 171; diploid cells and haploid cells in turn 183; paternal chromosome and maternal chromosome in turn 191 and 193). On numerous occasions the teacher uses Cantonese (highlighted in italics in the transcript) to explain these abstract technical terms and to provide hints to help students understand these terms (e.g. in turn 195).

Excerpt 4a. Lesson transcript of late–partial grade 11 EMI biology

Topic: immunity

Sub-topic: specific immune response

MOI: Cantonese as the matrix language, embedded with English vocabulary (*Italics: Cantonese*; non-italics: English)

Turn	Speaker	Text	IRF sequence	Science topics
164	T	*How many* chromosomes *come from your* father's sperm?	I (open Q)	father's sperm
165	S1	23.	R	
166	T	*How many come from your* mother?	I (open Q)	
167	S1	23.	R	
168	T	23. *So for* each pair, *why does one come from the* father *and one come from the* mother?	F (expand)	

169	T	*Because you are formed from* fertilization, *i.e. the* fusion of the sperm and egg nuclei.	I (instatement)	fusion of the sperm and egg nuclei.
170	T	*Okay, one comes from the father, the* paternal chromosome, *the blue one, for example here, and one comes from your mother,* the maternal chromosome.	I (instatement)	
171	T	*So in each pair, there are blue and red long* chromosomes, homologous chromosomes, homologous chromosomes. *That means they have the* same size and same shape. *One from the* father, *one from the* mother. Homo *means the same.*	I (instatement)	*blue and red long chromosomes;* homologous chromosomes; 'Homo' means the same.
172	T	*Here, how many pairs are there? How many pairs of* homologous chromosomes *are there?*	I (open Q)	
173	S1	Two.	R	
174	T	Two pairs.	F (acknow)	
175	T	*You can see that each contains a special set. For example, homologous chromosome, we have stamps of 10 cents, 20 cents, $1.7, $2.4, this is one set. If we have two sets, we double it.*	I (statement)	
176	T	*How many sets are there?*	I (open Q)	
177	S1	*Two.*	R	
178	T	*Two. Our cells have two sets? How many sets do sperms and eggs have?*	F (expand)	
179	S1	*One set.*	R'	
180	T	*One for each type.*	F (acknow)	
181	T	*If there are 5 types of stamps, and I have one for each type, I have 1 set. If I have two, I have two sets. Two sets, we call it*	I (statement)	diploid cells; haploid

		diploid cells. *If there is only one,* haploid.		
182	T	Diploid two, haploid one. *Okay?*	I (close Q)	
183	T	Diploid cells, haploid cells. *How many* haploid cells *are there in humans?*	I (open Q)	
184	S1	*Only two kinds.*	R	
185	T	*Which kind of* haploid cells?	F (expand)	
186	S1	Sperm and Egg.	R′	
187	T	*Other cells, skin, bones, hair, are all* diploid cells.	F′ (ignore)	
188	T	Understand what I mean?	I (close Q)	
189	T	*Why is it called* diploid cells*?*	I (open Q)	
190	T	*Because when you find a* chromosome*, it always has a partner. Always in a pair. They are called* diploid cells.	I (statement)	*partner*
191	T	*If it comes from the father, what is the name of the* chromosome?	I (open Q)	
192	S1	Paternal chromosome.	R	Paternal chromosome.
193	T	*Right, For mother?*	F (expand)	
194	S1	Maternal chromosome.	R′	
195	T	*Okay, For the same size* chromosomes *paired together, what are they called?*	F′(expand)	
196	S1	Homologous chromosomes	R′′	
197	T	Homologous chromosomes. `	F′′(acknow)	Homologous chromosomes
198	S1	Homologous chromosomes. `	R′′′	
199	T	*That means the* chromosomes have the same shape and size, *or sometimes you say the same structure and size.*	F′′′(ignore)	

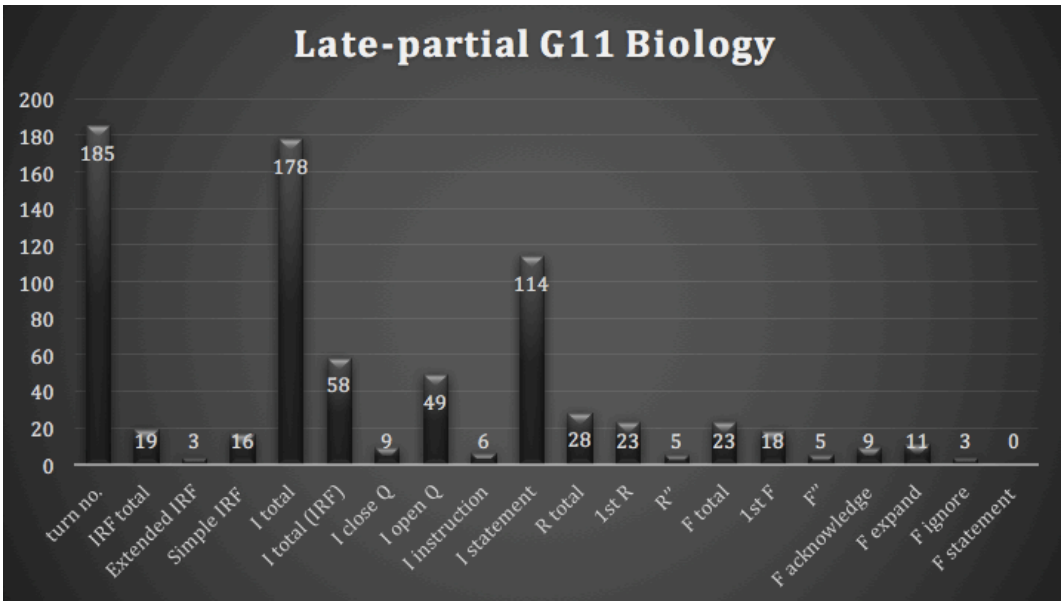


Table 5.5. The number of turns and IRF sequences in the whole lesson

As table 5.5 shows, in this late–partial grade 11 EMI biology classroom, there are 185 turns taken between teacher and students and 19 IRF sequences: three are extended IRF and six are simple IRF. There are more open questions (49) than closed questions (9). Students' responses number 28 and there are 23 teacher feedback moves. There is a relatively low ratio of IRF (10%) in the interaction, with more extended IRF sequences, suggesting that there were fewer opportunities for the students to respond and the teacher to give feedback to the students.

Excerpt 4b is a simplified version of excerpt 4a, highlighting (in bold) the science topics discussed in the interaction. We see that from turns 164 to 188, the teacher asked a number of questions about the number of chromosomes and the number of haploid cells and diploid cells. The teacher only responded to

students' answers if they were consistent with the teacher's view. She only acknowledged what students said if their answer was similar to her views. There was no effort made to elicit students' further responses or to explore students' views. In turn 188, the teacher tried to transfer her understanding to her students by saying 'understand what I mean'. Then in turns 190 and 199, the teacher provided her own definition of diploid cells and homologous chromosomes.

Excerpt 4c—a summary of the students' language—shows that students predominately produced a number of incomplete sentence consisting of nouns or noun phrases referring to scientific items. One noticeable difference in this example compared to the previous ones is that students produced technical English terms when responding to their teacher in Cantonese (L1). In the earlier examples presented above, teachers predominately used English for instruction. In these exchanges, the teacher again did not encourage students to produce a complete sentence, or make any attempts to correct any students' language mistakes or provide any feedback to students about how to acquire the language of science in L2 context.

So we can see that after the students gave different answers in science topics A, B, and C, the teacher decided which was consistent with her planned science explanation, and focused on it by asking more questions. Applying Mortimer and Scott's framework (2003), this example of early–full EMI grade 10 biology is

characterised as an interactive and authoritative science lesson. The observed interactive features were similar to lesson 2.

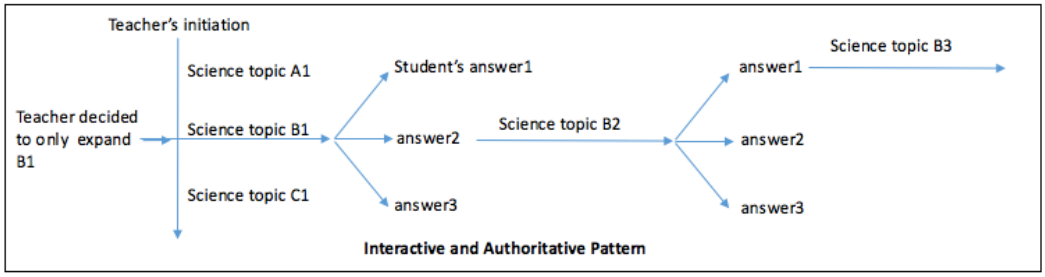


Figure 5.5. Conceptual diagram of the interactive and Authoritative pattern

Excerpt 4b. The science topics in excerpt 4a

(science terms **in bold**)

Turn	Speaker	Text	IRF sequence
164	T	*How many* **chromosomes** (father's sperm)?	I (open Q)
165	S1	23.	R
166	T	*How many* (mother's)?	I (open Q)
167	S1	23.	R
168	T	23. *So for* each pair, *why does one come from the* father *and one come from the* mother?	F (expand)
172	T	*Here, how many pairs are there? How many pairs of* **homologous chromosomes** *are there*?	I (open Q)
173	S1	Two.	R
174	T	Two pairs.	F (acknow)
176	T	***How many sets*** *are there?*	I (open Q)
177	S1	*Two.*	R
178	T	*Two. Our cells have two sets?* ***How many sets do sperms and eggs have****?*	F (expand)
179	S1	*One set.*	R'
183	T	**Diploid cells, haploid cells.** ***How many*** **haploid cells** ***are there in humans****?*	I (open Q)

184	S1	*Only two kinds.*	R
185	T	***Which kind of*** **haploid cells?**	F (expand)
186	S1	Sperm and Egg.	R′
187	T	*Other cells, skin, bones, hair, are all diploid cells.*	F′ (ignore)
188	T	**Understand what I mean?**	I (close Q)
189	T	***Why is it called*** **diploid cells*?***	I (open Q)
190	T	*Because when you find a* chromosome*, it always has a partner. Always in a pair. They are called* diploid cells.	I (statement)
195	T	*Okay,* ***For the same size*** **chromosomes** ***paired together, what are they called?*** *[Cantonese]*	F′(expand)
198	S1	Homologous chromosomes. `	R′′′
199	T	*That means the* chromosomes have the same shape and size*, or sometimes you say the same structure and size*.	F′′′(ignore)

Excerpt 4c. Students' language outputs in excerpt 4a

Turn	Speaker	Text	Grammatical categories	IRF sequence
165	S1	23.	Number	R
167	S1	23.	Number	R
173	S1	Two.	Number	R
177	S1	*Two.*	Noun phrase (Cantonese)	R
179	S1	*One set.*	Noun phrase (Cantonese)	R′
184	S1	*Only two kinds.*	Noun phrase (Cantonese)	R
186	S1	Sperm and Egg.	Nouns	R′
192	S1	Paternal chromosome.	Noun (technical)	R
194	S1	Maternal chromosome.	Noun (technical)	R′
196	S1	Homologous chromosomes	Noun (technical)	R′′
198	S1	Homologous chromosomes. `	Noun (technical)	R′′′

5.3.5. Summary: analysis of classroom interactions in the four biology lessons

Tables 5.6 and 5.7 summarise the overall count of the IRF patterns in the four biology lessons in early–full and late–partial EMI schools and in grades 10 and 11.

To arrive at the figures I calculated the overall distribution of the IRF pattern, the ratio between different forms of IRF (simple IRF and extended IRFRF), the percentage of the teacher's initiations, question types in the teacher's initiations (closed question/open question), the percentage of students' responses and teacher feedback moves.

The data shows that there are more IRF patterns (22%) in the classroom interaction from the early–full EMI lessons than in the late–partial EMI lessons, with a higher ratio of extended IRF (45%) and simple IRF (55%). There is a relatively lower percentage of teacher's initiations (25%), with closed questions (4%) and open questions (16%), but slightly more students' responses (31%) and teacher's feedback (30%). In the late–partial EMI schools, there are fewer IRF patterns (12%), with a higher ratio of simple IRF (72%), and extended IRF (45%). There are significant numbers of teacher's initiations (86%), with closed questions (7%) and open questions (24%), but slightly fewer students' responses (22%) and teacher's feedback (27%).

There are similarities between grades 10 and 11 in both types of schools in the four biology lessons. Regarding the similarities, there are more extended IRF

sequences in grade 10 and more simple IRF sequences in grade 11. There are more students' responses in grade 11.

There are also differences between grades 10 and 11: there are more IRF sequences in grade 10, more closed questions and open questions in grade 11 in teacher's initiations, and more feedback in grade 11 for the early–full EMI schools. However, the opposite is true in the late–partial EMI schools. They show fewer IRF sequences in grade 10, fewer closed questions and open questions in grade 11 in teacher's initiations, and less feedback in grade 11.

In terms of the kind of language students produced in the classroom interactions, students from both early–full EMI and late–partial EMI schools predominately produced a number of incomplete sentences consisting of short, technical and abstract nouns or noun phrases referring to scientific items when responding to their teachers. In most of these exchanges, teacher did not encourage students to produce a complete sentence, or make any attempts to correct students' language mistakes or provide feedback to students about how to acquire the language of science in L2 context. These patterns suggest that the science classroom is not providing students with an opportunity to deepen their English skills, or their science knowledge, through interaction with teachers.

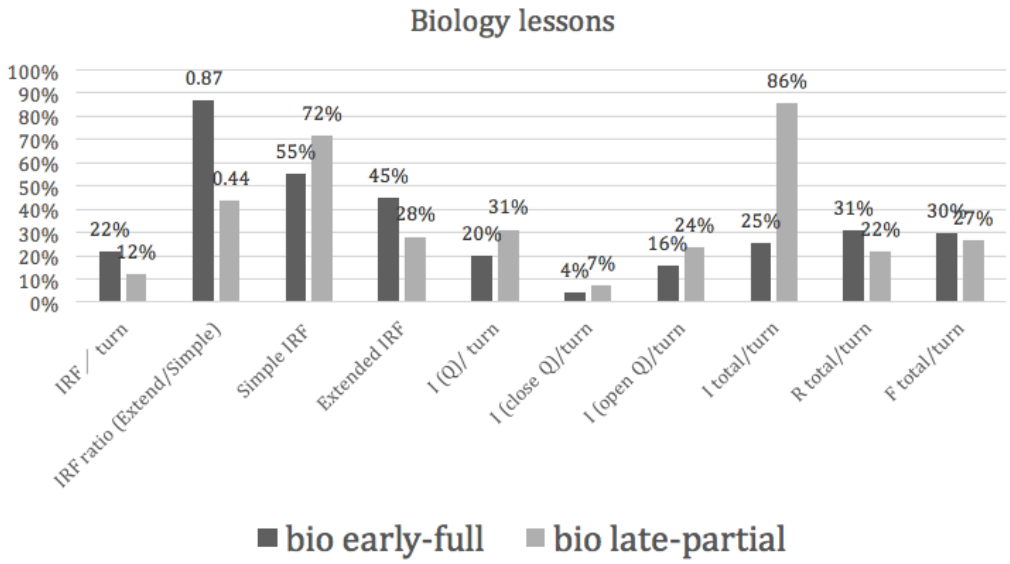


Table 5.6. Distribution of IRF patterns between early–full and late–partial EMI schools

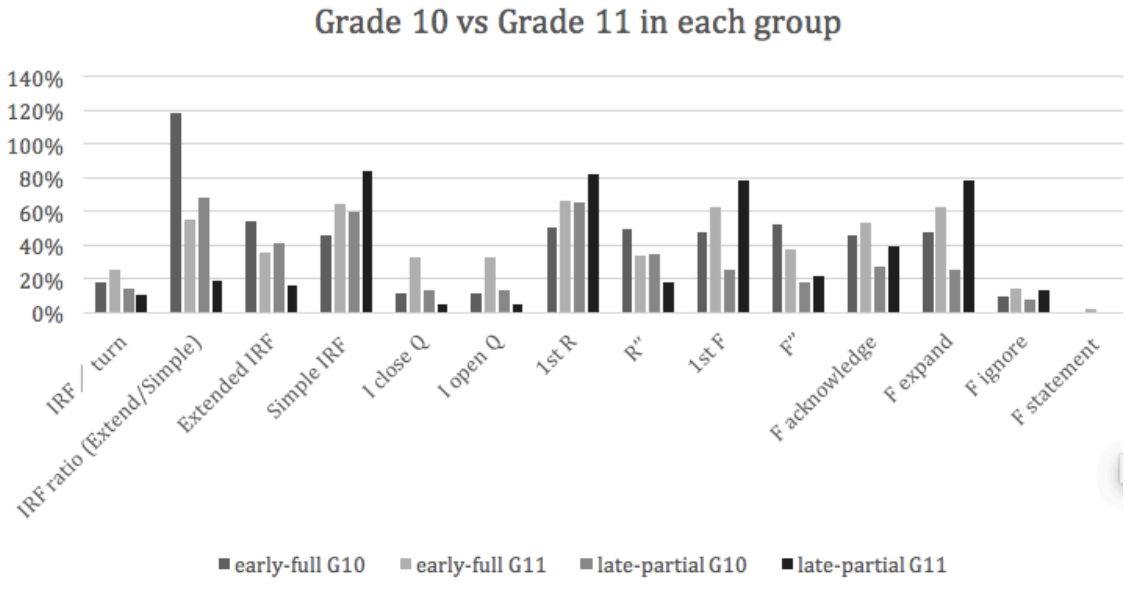


Table 5.7. Distribution of IRF patterns between grades 10 and 11 in each school group

5.3.6 The relationship between IRF patterns and the communicative approaches in science classrooms

Mortimer & Scott's (2003) four communicative approaches in science classrooms categorises science teaching and interaction along two continua: (1) from non-interactive to interactive; (2) from authoritative talk to dialogic talk. The end points of these continua give four categories, i.e. four types of teaching interactions:

- non-interactive–authoritative
- non-interactive-dialogic
- interactive–authoritative
- interactive-dialogic

Although this framework help us to categorise the nature of the interactional sequences in different EMI science classrooms, the approach does not provide a comprehensive account of the nature of interaction at the micro level. In particular, it does not explain the subtle differences in the interaction, for example, whether the science teacher interacted with the students or not, or whether the teacher considered the students' ideas as the lesson proceeded through interaction. Mortimer and Scott's model perhaps only takes a synoptic view to categorizing interaction as a finished product without further providing explanation of the dynamic unfolding of the interaction whether the teacher

take advantage of opportunities in interaction to help the students learn science content and language.

To complement Mortimer and Scott's (2003) categories, I also analysed features of the dynamic unfolding in IRF interaction at the micro level, to provide a comprehensive account of how the teacher interacted with the students at the micro level to try to make the scientific ideas more accessible to students, and to provide students with opportunities to learn the content and language. Based on the qualitative analysis to this point, table 5.8 lists the features in terms of IRF patterns from the four biology EMI science classrooms. This analysis supplements Mortimer and Scott's framework. Table 5.9 summarises the relationship between IRF patterns and Mortimer and Scott's categories. Table 5.10 and 5.11 provides a comparison of the interactional features of the lessons that had simpler and more extended IRF sequences in the early–full and late–partial EMI biology lessons.

Mortimer & Scott's definition	In a non-interactive and authoritative lesson, the teacher only presented a specific view of the science phenomena without any interactions with students.
The IRF analysis supplement to Mortimer & Scott	• long period of teacher's initiations, with lots of statements, • less or nearly no interactions, absence of IRF, particularly extended IRF • only a few comprehension checks, realised by closed Qs • no students' responses • no teacher's feedback built on students' answers • science pedagogy, the teacher simply introduces his own way of understanding scientific phenomena, without considering students' ideas, with no exploration of meaning and language of science in the interaction, • the teacher did not unpack or repack the abstract scientific knowledge • the teacher insists on transferring his way of interpretation of the science topic → no opportunity for L2 learning

Table 5.8 (1) The observed interaction features for non-interactive and authoritative lesson in supplement to Mortimer & Scott's framework

Mortimer & Scott's definition	In non-interactive and dialogic lessons, the teacher considers different points of view, guiding students to explore, work on different views of a science phenomenon without any turn-taking interactions with the students.
The IRF analysis supplement to Mortimer & Scott	• long period of teacher's initiations, with lots of statements, • but a limited amount of interaction between teachers and students, only in the form of IRF, particularly more simple IRF • many teacher's initiations, realised by closed Qs, or statement to only inform the teacher's voice or sometimes to promote students' short answers, mainly for comprehension checking • limited students' responses, followed by teacher's feedback to acknowledge students' answers in the direction of the teacher's planned explanation • while students' answers are rarely considered, none of the students' ideas were explored or followed up. • the teacher only directed students toward his or her planned idea, and encouraged students to consider different points of view, but without any turn-taking interaction with the students • limited exploration of meaning and language of science in the interaction • the teacher only unpacked the abstract scientific knowledge but also worked on different views of a science phenomenon • the teacher asked for students' ideas but transferred his way of interpretation of the science topic, without much engagement by the student in their own science interpretation → some opportunities for understanding content learning, but not much opportunity to practise the language

Table 5.8 (2): The observed interaction features for non-interactive and dialogic lesson in supplement to Mortimer & Scott's framework

Mortimer & Scott's definition	In an interactive and authoritative lesson, the teacher leads students through a great deal of turn-taking by a sequence of questions and answers to achieve one specific view on a science phenomenon.
The IRF analysis supplement to Mortimer & Scott	• long sequence of short periods, with lots of teacher's questions and statements • but a considerably large amount of interaction between teacher and students, in the form of IRF, particularly more simple IRF • short students' answers • students' ideas were acknowledged by the teacher, followed up, with teacher's feedback. • many teacher's initiations, realised by closed Qs, or statement to promote students' short answers, mainly for comprehension checking, rephrasing what students could not understand (perhaps due to students' limited English ability) and topic shift to explore students' ideas • a great deal of students' responses, followed by teacher's feedback to acknowledge students' answers in the direction of the teacher's planned explanation • views inconsistent with the teacher's planned ideas were further explored and discussed • the teacher discussed with students what had been explored in the lesson, with the exploration of meaning and language of science in the interaction • the teacher only unpacked the abstract scientific knowledge → lots of opportunities for understanding content learning, but not much opportunity to practise the language

Table 5.8 (3) The observed interaction features for interactive and authoritative lesson in supplement to Mortimer & Scott's framework

Mortimer & Scott's definition	In an interactive and dialogic lesson, the science teacher listens to and takes account of his or her students' points of view. Then, the teacher explores different views with students in order to generate new meanings, ask real questions, and work on different points of view on a science phenomenon.
The IRF analysis supplement to Mortimer & Scott	• long sequence of short periods, with lots of teacher's questions and feedback • but a considerably large amount of interaction between teacher and students, in the form of IRF, particularly more extended IRF • extended students' answers • students' ideas were acknowledged by the teacher, followed up, with teacher's feedback. • A great deal of teacher's initiations, realised by open Qs, to promote students' long answers, mainly for exploration of meaning and practising the language (perhaps due to students' adequate English ability) • a great deal of students' responses, followed by teacher's feedback to acknowledge students' answers • students' ideas inconsistent with the teacher's planned ideas were further explored and discussed • teacher and students constructed knowledge • the teacher unpacked and repacked the abstract scientific knowledge with the students • the teacher discussed what had been explored in the lesson with the students, with the exploration of meaning and language of science in the interaction → lots of opportunities for understanding content learning, and many opportunities to practise the language

Table 5.8 (4) The observed interaction features for interactive and dialogic lesson in supplement to Mortimer & Scott's framework

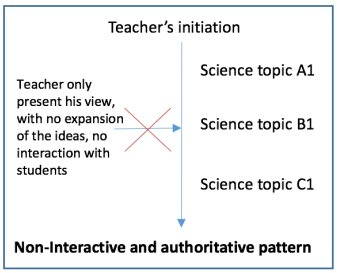
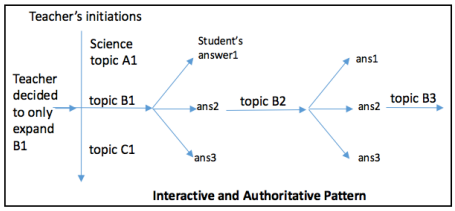
Teacher presents only one specific view of a science phenomenon without any interaction with the students	*Teacher leads students through a great deal of interaction, by a sequence of questions and answers to achieve one specific view on a science phenomenon*
	
-Long period of teacher's turns -Nearly no or absence of IRF -No students' responses -Mainly comprehension checks, by closed Qs -No teachers' feedback	-Long period of teacher's turns -A considerable amount of IRF, (more simple IRF) -Many teacher's initiations, realised by closed Qs to promote student's short answers -Students' responses were acknowledged if in line with the teacher's views in the teacher's feedback -Ideas inconsistent with the teacher's planned ideas were NOT explored and discussed
Example of lesson (Chemistry): T: Last time we stopped at the Fractional Distillation of Petroleum [Topic 1]…. S: ….. T: Today we will start at part 4. The users of the petroleum fractions [Topic 2]…. S: ….. T: Hydrocarbon is a compound made up of hydrogen and carbon atom [topic 3]… S… T: For incomplete reaction, the oxygen supply is poor. For the products, water produced, for the incomplete reaction, water is also produced [Topic 4]…. S:…..	Example of lesson (Chemistry): T: *do you remember the two types of isomers we have learnt?* S: Structural isomers and stereoisomers. T: Right, Structural isomers *have 3 sub-types, do you remember?* *S: what is the daily implication? [ignored by teacher]* *T: What is the* definition *of* isomers? T: *Just to remind you, their* molecular formulas *are the same.* Molecular formulas *are the same.* *S: 3 carbons, 5 H 1 O. In fact 5* isomers *have the same* molecular formulas.

Table 5.9. The relationship between IRF patterns and the four communicative approaches in Mortimer & Scott's (2003) framework

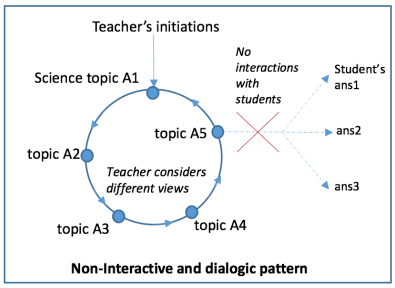
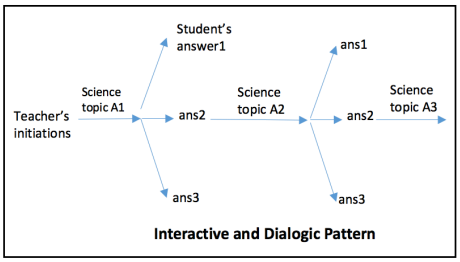
Teacher considers different points of view, guiding students to explore, work on different views of a science phenomenon without any turn-taking interactions with the students	*Teacher listens to, takes account of the students' points of view. Together with the students, he/she explores different views, generates new meanings, asks real questions, and works on different points of view on a science phenomenon.*
	
-Long sequence of short periods of teacher's turn -Minimal IRF -Short students' answers -Students' ideas were not acknowledged by the teacher, nor followed up, with teacher's feedback. -Many teacher's initiations -Realised by closed Qs, or statement mainly for comprehension checks	-Long sequence of short periods, with lots of teacher's questions and feedback -A considerably large amount of IRF (more extended IRF) -extended students' answers -Students' ideas were acknowledged by the teacher, followed up, with teacher's feedback. -A great deal of teacher's initiations, realised by open Qs, to promote students' long answers, mainly for exploration of meaning and practising the language -Ideas inconsistent with the teacher's planned ideas were further explored and discussed
Example of lesson (Chemistry): T: Today we will look at Haloalkane first. From our syllabus, we have only one reaction for our haloalkane, in between alcohol. We look at our book. It is on page 12. S: OKAY. T: This is the haloalkane. Haloalkane is, there is a halogen atom bonded to the carbon. And then, we look at this structure first. S: Yes T: For halogen atom, which is electronegative, it tends to draw the bonded electrons towards itself. So X, Halogen atom, carry partial negative. S: Yes T: And then the carbon become electron deficient.	Example of lesson (Chemistry): T: Last time we are talk about the four reactions of alkalis, four chemical reaction, do you still remember which four chemical reaction are there? S: Neutralization. T: Neutralization, very good. Neutralization. So what is being reacted for neutralization? Alkalis react with what? Alkalis react with what we will call it neutralization? S: Alkali react with acid T: Yes, good. Alkali react with acid, so this is called neutralization. And then for the second one, what is the second reaction we have learn? S: Non-metal oxide T: Non-metal oxide, what is the non-metal oxide we talk about? S: Carbon dioxide T: Carbon dioxide, yes CO2, reaction with CO2.What is the main product that will given out? What is the main product? S: Carbonate ion T: Yes. It will form some carbonate ion. So this is the carbonate ion: Especially for the calcium carbonate, it is insoluble in water, so remember this one.

Table 5.9 (Cont'd). The relationship between IRF patterns and the four communicative approaches in Mortimer & Scott's (2003) framework

Observed features	short period but long sequence more closed Qs, teacher's feedback students' input, for less in-depth exploration of meaning and more practising of language	long period, but short sequence more open Qs, teacher's feedback the role of L1 in interactive classrooms→higher Qs, translation, daily examples, students' input, for more in-depth meaning exploration and not much practising of language

Table 5.10 Comparison of the observed interaction features between a lesson with more extended IRF in early–full and late–partial EMI classrooms

Observed features	long period, short sequence more closed Qs, check for comprehension teacher's acknowledgement mainly in feedback	long period, short sequence more closed Qs, checks for comprehension teacher's acknowledgement mainly in feedback L1, more translation for ensuring understanding of technical terms

Table 5.11 Comparison of the observed interaction features between a lesson with simpler IRF IRF in early–full and late–partial EMI classrooms

5.4 Science pedagogy

The four biology lessons from early–full and late–partial EMI schools were analysed in terms of the presented science pedagogy according to Mortimer and Scott's (2003) framework. It was found that there were some differences in the nature of content addressed in the four lessons. Drawing the data from the pre- and post-observation interviews with the teachers and the lesson transcripts, I analysed the purpose of teaching in the four biology lessons. This appears to suggest that the purpose of teaching was different. For example, lesson 1 (excerpt 1a) aimed to guide students to work with scientific ideas of conducting a lab experiment on understanding the process of photosynthesis. The lesson content was mainly to establish the empirical descriptions of different factors in the process of photosynthesis.

Lesson 2 (excerpt 3) aimed to open up a science problem on the topic of cell division, then explored the issues and worked on students' views. The content was mainly to establish a descriptive understanding of the necessary steps in cell division and make generalisations.

Lesson 3 (excerpt 4) was similar to lesson 2, which was also to explore and work on students' views on their understanding of the mechanism of the immune system in the human body. The content was to establish an empirical explanation related to the immune system.

Lesson 4 (excerpt 6) aimed to introduce and develop a scientific story of specific types of cell division. The content was again to establish an empirical description of the two specific types of cell division (mitotic and meiotic division).

In Mortimer and Scott's (2003) framework, overall all four lessons can be described as authoritative. The teachers of the four lessons used an interactive communicative approach to collect students' ideas, but the teachers tended to be non-interactive and authoritative in selecting which students' response to respond to, follow up or ignore. Although the teachers controlled the discourse, and therefore how the students developed a scientific perspective, there were several incidents in excerpt 3 where the teacher both provided opportunities for the students to express their science stories and provided feedback on their ideas. This suggests that some of the teachers with adequate language competence are able to move along the authoritative-dialogic dimension during the interactions if they wish to or consider it appropriate.

For the pattern of discourse, most of the sequences between teachers and students were in the form of IRF exchanges. In both excerpt 1 and 4, the teachers introduced and guided students to work with scientific ideas. Thus, IRF patterns were dominant in these lessons. But in both excerpts 2 and 3, the teachers began with an exploration of students' views, often selecting and then working on these views to develop the scientific account. Thus, more extended

IRF patterns were observed in these lessons. In addition, there were very few occasions of students volunteering an answer for any teacher question and thus the teacher mainly pursued his or her scientific account and only selected the students' responses that he or she wanted to follow or give feedback on. The more extensive use of the extended IRF (or IRFRF) sequences in excerpt 2 and 3 suggest that these teachers had the linguistic and scientific competence to be more welcoming of students' ideas and chose to respond to each of the students' ideas.

In terms of the forms of teacher's intervention employed, there were no major differences in the teacher's choice of science activities. The teachers mainly checked students' understanding, shared students' ideas, and emphasized key ideas that matched the teacher's scientific views. In both excerpts 2 and 3, the teachers used more extended IRF sequences and this provided opportunities for teachers to review and comment on students' ideas with the whole class.

The analyses of key features of the five aspects of science pedagogy (teaching content, content, approach, pattern of interaction and forms of interaction) and their differences are summarised in table 5.12. A more detailed version of all the observed 32 science lessons in early–full and late–partial EMI schools are attached in appendix R.

Science topics	*Teaching purpose*	*Content*	*Approach*	*Patterns of interaction*	*Forms of interaction*
The process of photosynthesis [Teacher's Lab demonstration]	Guiding students to work with scientific ideas and supporting internalisation	Establishing the empirical descriptions	Interactive/ authoritative	I-R-F	Checking student understanding; sharing ideas; marking key ideas
Lesson 2: early–full EMI grade 11 biology					
Cell division	Opening up the problem; exploring and working on students' views	Establishing descriptive generalisations	Interactive/ authoritative	I-R-F and I-R-F-R-F	Checking student understanding; selecting and sharing ideas with the whole class; reviewing and marking ideas with the whole class
Lesson 3: late–partial EMI grade 10 biology					
The mechanism of the human specific immune system	Exploring and working on students' views	Establishing the empirical explanation	Interactive/ authoritative	I-R-F and I-R-F-R-F	Marking key ideas; checking student understanding; reviewing and marking ideas with the whole class
Lesson 4: late–partial EMI grade 11 biology					
Cell division (*mitotic and meiotic cell division)*	*Introducing and developing the scientific story;*	Establishing the empirical descriptions	Non-Interactive/ authoritative	I-R-F	Checking student understanding

Table 5.12. Summary of the science pedagogy in the four biology lessons from early–full and late–partial EMI schools (adapted from Mortimer & Scott (2003)

5.5. Analysing the language of science in EMI science classrooms

In this section, I analyse the language of science used between teachers and students during the classroom interactions. The language of science is the language choices that teacher and students use during interactions to develop their scientific knowledge. In this section, I focus on the language of science from the two biology lessons between early–full and late–partial EMI schools in order to elucidate the language choices that are made in EMI science classrooms. Using the integrated framework from Kong and Hoare (2012) and Fang (2006), explained in chapter three (section 3.10.2), these language of science features are classified according to grammatical categories.

5.5.1. The language of science

5.5.1.1 Early-full EMI biology lesson

This lesson was about antibiotics. Students learned the basic concept of antibiotics and about the historical development of penicillin (Alexander Fleming). In this lesson, the teacher drew on students' daily experiences with antibiotics and related science concepts (bacteria, pathogens, penicillin) to explain the treatment of and biological mechanism for protecting humans from bacterial infection. At the end of the lesson, the teacher reminded students of the correct use of antibiotics. Table 5.13 summarises the language of school science used in the teacher's talk.

a) Subject-specific vocabulary	Technical vocabulary	bacteria; virus; pathogens; penicillin; physiology; agar plate; petri dish; pipette; spreader; fungi (sg. fungus); yeast; cell division; genetic variation; nucleic acid; protein synthesis; respiration; H7N9; bacteriophage (a virus which parasitizes a bacterium by infecting it and reproducing inside it); membrane; DNA (deoxyribonucleic acid); RNA (ribonucleic acid); host cells; influenza; Ebola; black death 黑死病 (the most devastating pandemic in human history); Staphylococcus Aureus 金黄葡萄球菌 (a gram-positive coccal bacterium that is a member of the Firmicutes, and is frequently found in the respiratory tract); Methicillin-Resistant Staphylococcus aureus, MRSA 耐抗生素金黄葡萄球菌; Multimorphemic words with Latin or Greek origins: microorganisms= mirco+organ+ism+s antibiotics= anti+biotic+s; antigens=anti+gen; mitotic=mito+tic; antitoxin (an antibody that counteracts a toxin) =anti+toxi(c)+in; ribosome= ribo+some
	2. Ordinary words with non-vernacular meaning and usages	temperature n. (body temperature; the degree or intensity of heat present in a substance) incubate v. (keep bacteria at a suitable temperature so that they develop) (be developing an infectious disease before symptoms appears) bacterial colonies n. (a community of animals or plants of one kind living close together) (country under full political control) words with multiple grammatical functions: culture n. (cultivation of bacteria; plants); culture v. (maintain cells in conditions suitable for growth)
	3. words with multiple grammatical functions/ grammatical words with multiple usages	'or': a) denotes choices or alternatives: e.g. we will incubate them in an incubator for a certain time like 24 hours **or** 48 hours at a certain temperature b) introduce words/phrases that define, paraphrase or synthesise a preceding term, usually preceded by a comma, e.g. for example 0.1 mL, using dropper, **or** we call it pipette for advanced tools.

Table 5.13. The language of science: subject-specific vocabulary

	5. Subordinate clauses (non-finite clauses, elided subordinate clauses)	When *no cell wall is formed*, no reproduction occurs in bacteria. When *antibiotic use increases*, the resistance form and the percentage of resistant form will increase. They have some different antibiotics and placed on the agar plate which is spread by a certain kind of bacteria, which means before that, *before adding these antibiotics*, some bacteria are spread here.
	6. With-Prepositional Phrases	Later on if we continue to reproduce, *with the same genetic materials*, it continues to reproduce *with the same genetic materials.*
c) Nominalisations and grammatical metaphors	7. Abstract noun	Infection (infect); contamination (contaminate); incubation (incubate); dilution (dilute); DNA replication (repeat); diffusion (diffuse); reproduction (reproduce); mutation (mutate); formation (form);
d) Language of knowledge relationship	11. Passive voice	Second, how do antibiotics kill bacteria? Only bacteria, okay, *can be killed by antibiotics*, but antibiotics do not kill viruses.
e) Lexical density	71 content words /393 total words x100= 18%	

Table 5.13 (cont'd). The language of science: features other than vocabulary

5.5.1.2 Late-partial EMI biology lesson

This lesson was about the immune system. Students learned the basic concept of the mechanism of the human immune system. In this lesson, the teacher introduced the topic by asking students to consider a number of related concepts (non-infectious disease, pathogens, infectious disease) and later asked the students to distinguish the differences in terms of the biological meanings of these terms. Then, the teacher asked the students to draw on their everyday experiences and explain the mechanism of the human immune system by relating it to the concepts learned. Table 5.14 summarises the language of school science used in the teacher's talk.

a) Subject-specific vocabulary	Technical vocabulary	non-infectious, infectious, pathogens, cardiovascular diseases, cardiac muscle, vascular bundle, coronary heart disease, bypass surgery, cholesterol, plaque, angioplasty, sternum (breastbone), vein, bacterial infection words with Latin or Greek origin: vascular (L); coronary (L); sternum (G);
	2. Ordinary words with non-vernacular meaning and usages	Tube n.; transportation; object - a long hollow cylinder; plaque n.; an ornamental tablet; small raised patch resulting from local damage; Vein n; any of the tubes forming part of the blood circulation system; a fracture in rock containing a deposit of minerals ; distinctive quality, style, tendency in singing words with multiple grammatical functions: clot n; a thick mass of coagulated liquid; clot v; cause to form clots/cover (something) with sticky matter
b) Complex noun phrases	4. Ellipsis	T: … so this definition (cardiovascular disease is not completely related to the heart) telling you that the disease is possibly related to the heart or blood vessels.
c) Nominalisations and grammatical metaphors	7. Abstract noun (verbs→nouns) (product: grammatical metaphor; process: nominalisation)	Infection n. (infect v.)
d) Language of knowledge relationship	11. Passive voice	Can you tell me what sort of risk can be found during this kind of surgery?
e) Lexical density	157 content words /509 total words x100= 31%	

Table 5.14. The language of science

5.5.2. Implicit link between learning content and learning language

5.5.2.1 Asking higher-order questions in L1

In this transcript from a late–partial grade 10 Biology lesson (excerpt 3), there is a considerable amount of teacher's input, in teaching both content knowledge and the language of science in L1 (Cantonese). The teacher made several efforts through a sequence of teacher's initiations to explain the concept of immunity and to describe different types of immunity.

The following example illustrates how a biology teacher asked higher-order questions using L1 (Cantonese), in seeking students' understanding of high-cognitive demanding concepts on human defence system (immunity). The biology teacher taught about the immunity in human body. The teacher used L1 through a number of higher-order questions (e.g. why, what) to make the abstract science content more explicit in L1. Through the use of higher-order questioning in L1, the teacher would be able to use extended IRF patterns to elicit students' understanding of abstract scientific terms such as 'non-specific', 'pathogens', 'antigen' 'Leukocytes' and make their semantic relations in biology explicit to students. In excerpt 7, the teacher started an introduction with an extensive explanation at the beginning of the lesson by drawing students' understanding of organisms such as bacteria and virus attacking our human defence system in daily life. This was to provide hints for students to understand of the primary function of our human defence system, and then the teacher further elicited students' understanding on different types of defences

in human body using a number of higher-order questions in L1 such as: "*Why do we call these* 點解我地叫 non-specific? *Why would we we call them like this* 點解我地咁樣叫？*This would be* 這樣叫 specific? 什麼叫 *What is* specific?"

Excerpt 7. The lesson transcript of late–partial grade 10 EMI Biology

Topic: immunity

Sub-topic: specific immune response

MOI: Cantonese as the matrix language, embedded with English vocabulary *Italics: Cantonese*; non-italics: English

1	T	*Why do we call these* 點解我地叫 non-specific? *Why would we we call them like this* 點解我地咁樣叫？*This would be* 這樣叫 specific? 什麼叫 *What is* specific?	I (open Q)	non-specific
2	S1	Target.	R	
3	T	Target. *That's right 對呀*. Targeting the **pathogens.**	F (expand)	**pathogens**
4	T	*Why would we say that it has the ability of* 點解我地講佢有能力去 targeting? *You can find a very important word here 你可以在這找到重要的字。*	I (open Q)	
5	S2	**Antigen**	R	
6	T	**Antigen**. *What does it mean?* 點解？*You need to know what it means rather than copy it 你需要知道點解重要過抄寫.*	F (expand)	**Antigen**
7	T	Whose antigen belongs to? *Does it belong to our body or* 係唔係屬於身體定 pathogen?	I (open Q)	
8	S3	**Pathogen.**	R	Pathogen.
9	T	An antigen is a type of protein.	F (ignore)	
10	T	*If the* 如果 pathogen *has this type of* 係有這種 antigen, 這種 *this type of* protein, **leukocytes** 係我地身體入面會認得這些野唔屬於身體 *inside our body would recognise that these are not something belonging to the body*.	I (statement)	**Leukocytes**; non-specific

		當佢認到這個唔係 When it can identify that this is not some substance *屬於身體 belonging to the body, this 佢* antigen 就會當作認到 *would be regarded as recognised. When I say* 當我講 non-specific, 當 *when the* skin *要拒絕唔俾 needs to resist, not allowing the* bacteria 或者外來物質進入身體 *or foreign substances to come inside the body,*		

In turn 1, the teacher asked three higher-order questions in L1 (e.*g. why do we call these 點解我地叫 non-specific… What is 什麼叫 specific?*) to help students to understand there were two major types of human defences: non-specific and specific. In turn 2-3, the teacher further elicited students' understanding that the primary function of the human defence system is to provide barriers that stop a specific 'target' which was shown in students' response in turn 2. In turn 3, the teacher provided further feedback to correct students' answer in order to show a more appropriated answer 'pathogens' and made the semantic relation clearly by referring to 'target' and 'pathogens'. In turn 4, the teacher continued to ask another higher-order question '*why would we say that it has the ability of 點解我地講佢有能力去 targeting*?" to provoke students' higher-order thinking of what characteristics does the human defence system can contribute such specific defencing mechanism, and the students responded with an answer 'antigen' in turn 5. In turn 6-7, the teacher further expanded the students' answer and asked them where does 'antigen' come from, which helped the students to make sense of 'antigen' is belong to 'pathogen' outside of our body. This helps students to

understand the semantic relation between 'antigen' and 'pathogen' (turn 7-8). To reinforce such semantic relation, in turn 9, the teacher continued to elaborate 'antigen' is one type of protein in order to remind the students about 'antigen' also share the characteristic of protein molecules, (e.g. Similar to Enzyme specificity which is due to their unique 3D strucures), which has been taught in previous chapters. In turn 10, the teacher used L1 extensively to explain how the human defence system works and highlight the roles of 'antigen', ' pathogens', 'leukocytes' in achieving such defencing function with an example. She tried to make all the semantic relations clearly while mentioning each of the introducted scientific terms. The teacher said 'pathogen' had 'antigens' which are a type of protein, using 'leukocytes' as an example, saying that because of these antigens, our human defence system would recognise these substances from outside of the body and thus resist any of these substances to enter our body and prevent their attacks.

From turn 1 to 10, we can see how a biology teacher asked a number of higher-order questions in L1 to help the students understand better the scientific terms and their semantic relations in biology. The teacher used these L1 higher-order questions in an interactive way to provoke students' higher-order thinking through a considerable amount of teacher's inputs, and expand students' answer by follow-up feedback in a number of interactive sequences.

5.5.2.2 Teaching technical terms with similar meanings in L1

In excerpt 8, the same biology lesson continued. The teacher explained four adjectives (natural vs. artificial and active vs. passive) to help students understand four different types of immunity: active natural, passive natural, active artificial, and passive artificial immunity. There was one extended IRF and two simple IRF sequences in 36 turns, used to check students' comprehension of the terms. He compared and used examples to illustrate their differences (Table 5.15) :

natural immunity	no artificial method is used to acquire the immunity (e.g. people recover from infection)
artificial immunity	vaccination
active immunity	antigens inserted to produce antibodies
passive immunity	antibody is made by others (e.g. mother's breast feeding).

Table 5.15 An example of teaching technical terms with similar meanings

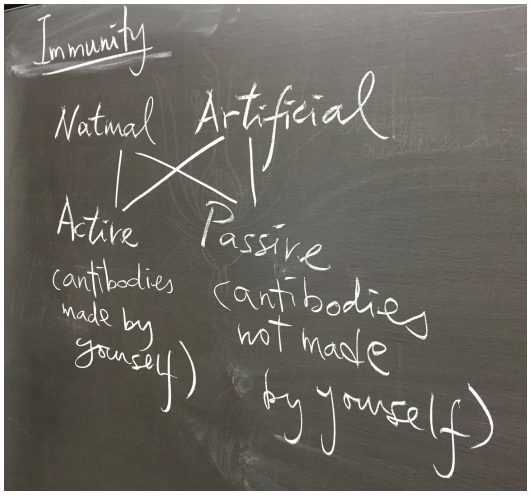


Figure 5.6. A photo of teacher's drawing about teaching technical terms with similar meanings

Excerpt 8. The lesson transcript of late–partial grade 10 EMI Biology

Topic: immunity

Sub-topic: specific immune response

MOI: Cantonese as the matrix language, embedded with English vocabulary *Italics: Cantonese*; non-italics: English

Turn	Speaker	Text	Science topic
23	T	*What is* natural immunity*? It means that no* artificial method *is used to acquire the* immunity*?* (open Q) *It is not achieved by* needle insertion. *Maybe it is because I have had* hepatitis *before. But my* antibodies *are so large in number to kill the* virus. *Therefore, this is* immunity. *However, if a person is afraid of getting* hepatitis *and* gets vaccinated*, this is an* artificial method. *This is* artificial immunity. *So,* needle insertion *must be* immunity. *If you really have that* disease *before, it is* natural immunity. *What is* active immunity*?* (open Q) *Who gives it to you?* (open Q) Antibodies *are valuable. Who is so good to give them to you?* (open Q)	natural immunity, vaccination artificial immunity, natural immunity, active immunity
24	S1	*Mother.* (R)	
25	T	*When will your mother give you* antibodies? (F)	
26	S1	Pregnancy. Breast feeding. (R)	
27	T	*What is the milk?* (F)	
28	S1	*Human Milk.* (R)	Human Milk
29	T	*Yes. Not chocolate milk. Not Vita milk. But human milk.* (F)	
30	T	Active *and* passive immunity. Active immunity *given by* antibodies *produced by our own* plasma cells. *Because it is active, it needs to be produced by ourselves. This can be* active natural *or* active artificial. *Why are you making* antibodies? (open Q) *It is because of natural reasons of you getting the* disease. *Or you insert the* disease *inside your body*. *Having that* disease *is*	Active immunity; passive immunity; active natural, or active artificial.

		natural active. Needle insertion *is* artificial active. *They are different. When your mum* breastfed *you, which category should it belong to?* (open Q)	
31	S	Natural passive. (R)	
32	T	*Is there* artificial passive? *In what situation would it be* artificial active. (F) Artificial *means* needle insertion, *so what do we insert?* (open Q) Inserting antibodies. *Why do we* insert antibodies *instead of* antigens? *It is because you need to wait for 7 days if you* insert antigens. *If you are a doctor without boundary, you can't wait for seven days. You need to have the* immunity *right away. But is it a* primary response *when you insert* antibodies? (closed Q)	
33	S	No. (R)	
34	T	*It doesn't count as a* primary response *because it does not involve* recognition. *In* natural immunity, *people recover from* infection. Artificial immunity *is because there is* vaccination. *But this kind of* immunity *is slow but the advantage is that it is long lasting*. Immunity *given by the* direct transfer of antibodies *from* immune *individuals is called* passive immunity. *We directly get the* antibodies. *How can we know it is* passive *if we can't see the* injection? *How can we know which is* antigens *and which is* antibodies? *What kind of* injection *does not need us to wait?* (open Q) *It's* direct injection *of* antibodies. *So we can tell this is* passive immune. *It is because we don't need to wait. And there is no latent period, no waiting period.* Natural passive immunity. *Mothers give milk to their children.* Antibodies *in the maternal blood pass through the* placenta *and enter the foetal blood*. Antibodies *in mother's milk pass to the baby via* breast feeding. Artificial passive immunity, injection of antibodies. *It is not as useless as it seems.*	Natural immunity; Artificial immunity; passive immunity

5.5.2.2 Teaching synonyms to explain a concept in L1

In the following transcript from a late–partial grade 10 Biology lesson (excerpt 4), there is also a considerable amount of teacher's inputs in L1, in teaching both content knowledge and the language of science. The teacher made several efforts through a sequence of initiations to explain the structure of chromosomes (thin fibres, short stripes, like skein, very fine messily arranged coil), and told students a number of synonyms for describing different parts of DNA: *chromatin, chromatin fibres and chromosomes* (chromatin coils up as a chromosome during cell division). She compared and used examples to illustrate their differences:

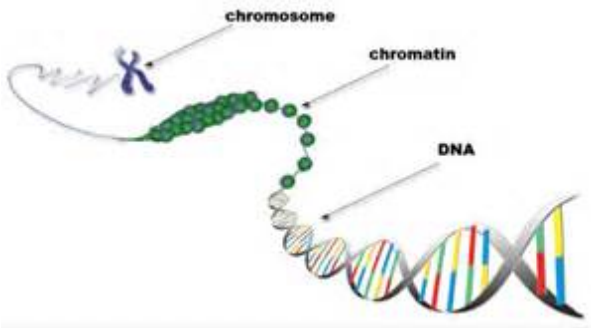


Figure 5.7. A schematic diagram to illustrate the structure of chromosomes

Excerpt 9. The lesson transcript of late–partial grade 11 EMI Biology

Topic: immunity

Sub-topic: specific immune response

MOI: Cantonese as the matrix language, embedded with English vocabulary

Language: Cantonese as the matrix language, embedded with English vocabulary (*Italics: Cantonese*; non-italics: English)

Speaker	***Text***	**IRF sequence**	***Science Topics***
T	*How many* chromosomes *does each cell have?*	I (open Q)	
S1	*Four*	R	
T	*Four, four sets are prepared. Each cell has four* chromosomes after division.	F (acknow)	
T	*Do you understand?*	I (closed Q)	
T	*As the duplicate and original are the same, so we call them* sister chromatids.	I (statement)	sister chromatids.
T	*Do you understand? If not, we will pronounce the nouns.* Chromatid.	I (closed Q)	Chromatid
S1	Chromatid.	R	
T	Chromatin!	F (acknow)	Chromatin
S1	Chromatin	R′	
T	Chromosome!	F′(acknow)	
S1	Chromosome	R′′	
T	Sister chromatids	F′′(acknow)	Sister chromatids
S1	Sister chromatids	R′′′	
T	*The* DNA molecules *are exactly the same, the* protein *is exactly the same, so we call them the* sister chromatids.	F′′′(acknow)	
T	*Usually, they link together by chemicals. The chemicals that stick the two original* chromosomes *and the* uniform chromosome*, that part we call the* centromere. Chromosomes *will have the* centromere *in different positions.*	I (statement)	centromere

5.5.2. Summary of the language of science in EMI biology classrooms

The language of science observed in the four biology EMI science classrooms can be categorised using the integrated framework from Kong and Hoare (2012) and Fang (2006). They include the features: (1) subject-specific vocabulary; (2) nominalisations and grammatical metaphors; (3) complex noun phrases; (4) language of knowledge relationships; and (5) high lexical density. These categories were explained in chapter three (Table 3.12). The measurement of lexical density serves as an indicator of the level of complexity of teacher and student talk in EMI science classrooms. In section 5.5.2.1, I also illustrated this with three examples of biology teachers using L1 (Cantonese) to ask higher-order questions in seeking students' science understanding, teaching words with similar meanings and using synonyms to describe a biological concept.

5.6 Developing students' science thematic understanding through interaction

In this section, I examine how science teachers modify their talk through interaction in developing their students' understanding of the target scientific topic. In this part of the analysis, I analyse how science teachers interact with students in the IRF exchange sequences, focusing on:

- how the teacher initiates the exchange: whether with a statement to give the teacher's view of his interpretation of the science topic or with a closed or open question

- how the teacher elicits responses from students
- what kinds of decision the teacher makes to ignore, acknowledge or expand on the students' answer in feedback or follow-up IRF sequences.

I pay attention to some of the IRF exchanges between teacher and students that leading to further interaction where the teacher is building up students' answers in developing their understanding of the science topic.

These opening IRF exchanges are the critical moments when the teacher could decide to ignore or expand further a student's answer through his or her subsequent talk. By identifying these IRF exchanges, I believe, one can see how students are guided by the teacher's use of modified language to help students' develop the thematic understanding of the science topic, and ultimately acquire the scientific content and language.

In this section of analysis, I conduct an in-depth IRF analysis of the teacher–student interaction and a thematic analysis of the science topics being discussed as the lesson unfolds. The data are from the two biology lessons presented in earlier sections (section 5.3.1—lesson 1 and section 5.3.3—lesson 3). I used one lesson with more extended IRF exchanges, and another one with less organized IRF exchanges in order to illustrate how different science teachers intervene in their students' thinking about science, using modified teacher input in the IRF exchange to help students developing their understanding. Table 5.16 shows the

analysis of a biology lesson with the teacher's modified input and more extended IRF exchanges in developing students' thematic science understanding. Table 5.18 shows the analysis of another biology lesson with less teacher's modified input and less extended IRF.

Table 5.16. IRF thematic analysis of a biology lesson with MORE teacher's modified input and MORE cohesive, extended IRF exchanges in developing students' thematic understanding

Context: early–full EMI grade 10 EMI Biology; *Topic*: Factors that affect the rate of photosynthesis (light intensity, concentration of CO_2, oxygen, amount of chlorophyll, source of water); MOI: English

turn	**Interaction (IRF)**				**Thematic development**	
	Text	*Decisions made (teacher's modified inputs)*	***Teacher***	***Student***	Science topic (thematic pattern)	Semantic relation of the thematic patterns (Lemke, 1990)
1	T: Can you tell me what sort of factors may also affect photosynthesis? What sort of factors may also affect photosynthesis?	Use an Open Q [hints: *What sort of factors?]*	**[Initiation] ↘** **Open Q**		Photo-synthesis	
2	S: Amount of chlorophyll			**[Response]**	Amount of chlorophyll	**Circumstantial relation:** **(Material/Process)** material=chlorophyll process=photosynthesis
3	T: Amount of chlorophyll, yes. Okay? Amount of chlorophyll will have an effect, and besides that?	Acknowledge the student's answer, but no further expansion of the idea	**[Feedback]** **(acknowledge)**			The amount of chlorophyll is involved in the process of photosynthesis

4	T: Remember the equation of photosynthesis. You have CO_2, and you have what? CO_2 plus what?	Use Open Q [hint: fill in the blank—CO_2 plus what?]	**[Initiation] ↘ Open Q**		CO_2	**Logical relation: (item/Addition)** item=chlorophyll addition=CO_2, water
5	S: Water			**[Response]**	Water	CO_2, water and chlorophyll in conjunction affect photosynthesis.
6	T: Water, okay. Addition of water.	Acknowledge the student's answer, no expansion	**[Feedback] (acknowledge)**			
7	T: Together with chlorophyll and also what sort of things?	Use an Open Q [hints: *together with A, what sort of thing?]*	**[Initiation] ↘ Open Q**			
8	S: Light energy.			**[Response]**	Light energy	**Logical relation: (item/Addition)** item= chlorophyll, CO_2, water addition=light energy
9	T: Light energy.	Ignore student's answer	**[Feedback] (ignore)**			Light energy also affects photosynthesis.

10	T: What is the product of photosynthesis? Oxygen together with what?	Use an Open Q [recalling Q]	**[Initiation] ↘ Open Q**			
11	S: Starch or food.			**[Response]**	Starch or food	**Transitivity relation: (Process/ Target)** Process=photosynthesis Target=starch
12	T: Okay, so light we've mentioned here already.	Ignore student's answer	**[Feedback] (ignore)**			Starch is the end-product of the process of photosynthesis.
13	T: And your classmate talked about whether it is due to the limit of chlorophyll. Anymore things that limit photosynthesis?	Use an Open Q	**[Initiation] ↘ Open Q**			
14	S: Water			**[Response]**	Water	
15	T: Water, yes. Can you tell me the source of water of the plants? Where does it come from? Where does it come from?	Acknowledge the student's answer, and further expand it	**[Feedback] (acknowledge and expand)**		Source of water	

16	S: Soil			**[2nd Response]**	Soil	**Circumstantial relation: (Location/located)** Location: soil Located: water
17	T: Soil, yes. So if inside the soil, the amount of water in the soil is very low, then it will be a very great limiting factor.	Acknowledge the student's answer	**[2nd Feedback] (acknowledge)**			The water source for photosynthesis is supplied from soil.
18	T: Anymore? Very straightforward, we have mentioned chlorophyll, we have mentioned water. And the last one should be… ?	Use an Open Q [hints: *recalling Q?]*	**[Initiation] ↘** **Open Q**			
19	S: CO_2			**[Response]**	CO_2	**Circumstantial relation: (Material/Process)** material=CO_2 process=photosynthesis
20	T: Why CO_2 is limit?	Further expand CO_2	**[Feedback] (acknowledge and expand)**			Carbon dioxide also affects photosynthesis.

21	T: Anymore? Very straightforward, we have mentioned chlorophyll, we have mentioned water. And the last one should be… ?	Use an Open Q [hints: *recalling Q?]*	**[Initiation] ↘** **Open Q**			
22	S: CO_2			**[Response]**	CO_2	**Circumstantial relation:** **(Material/Process)** material=CO_2 process=photosynthesis
23	T: Why CO_2 is limit?	Further expand CO_2	**[Feedback]** **(acknowledge and expand)**			Carbon dioxide also affects photosynthesis.
24	S: Stomata.			**[2nd Response]**	Stomata	**Circumstantial relation:** **(Manner/Process)** Manner= limited CO2 from stomata process=photosynthesis
25	T: Limited by the stomata. Why will it be limited by stomata? Can you tell me?	Further expand stomata	**[2nd Feedback]** **(acknowledge and expand)**			The CO2 for photosynthesis is limited by the stomata.

26	S: Because it (CO_2) comes from the stomata			**[3rd Response]**		
27	T: Because it comes from the stomata. What is the role of the stomata in plants?	Further expand the role of stomata in photosynthesis	**[3rd Feedback]** **(acknowledge and expand)**			
28	S: Gas exchange			**[4th Response]**	Gas exchange	**Circumstantial relation:** **(Reason/Process)** Reason=stomata process=gas exchange
29	T: Yes, it is the site of gas exchange. Allows the CO_2 from outside to go into the leaves. So the number of stomata will affect photosynthesis. It will be one of the possible reasons.	Acknowledge students' answer and expand the idea with the teacher's explanation	**[4th Feedback]** **(acknowledge and expand)**			The stomata play a role in gas exchange, allowing CO_2 to enter the leaves.

Table 5.16 illustrates the IRF exchanges in developing students' thematic understanding of photosynthesis from an early–full EMI biology lesson. The analysis includes the IRF exchanges between the biology teacher and his students, the teacher's decisions about expanding students' ideas through his modified input, the science topics being discussed as the lesson proceeds, and the semantic relations among these scientific lexical items.

In this very interactive classroom, there were 268 turns taken between teacher and students and 48 IRF sequences: 26 were extended IRF and 22 were simple IRF. There was a relatively high ratio of IRF (18%) in the interaction between teacher and students, suggesting that there were more opportunities for extended IRF exchanges that lead to develop students' science understanding.

We can see in Table 5.16 that there was a large amount of interaction between teacher and students, in the form of IRF sequences, particularly more extended IRF sequences, suggesting that there were more opportunities for the students to respond and the teacher to give feedback to students. There was a great deal of teacher initiations, realised by open questions, and these questions explored a number of related science topics in a cohesive manner (*photosynthesis, factor to affect photosynthesis, the role of CO2 is a limited factor* …), and prompted students' answers. Most of the students' answers were acknowledged by the teacher, and a number of students' answers were followed up and expanded in

exploring meanings through the teacher's modified inputs in a series of substantial IRF exchanges. In these extended IRF exchanges, the teacher carefully picked up on relevant science concepts in students' answers, and then modified these in subsequent talk by providing comprehensible feedback to the students. This feedback was in the form of questions, to elicit explicitly the semantic relation between the scientific lexical items in the students' answers and the main science concept.

In a number of these extended IRF exchanges, the teacher informed the students about the semantic relations among the scientific topics. The teachers drew on three types of semantic relations, as also noted in Lemke's (1990) analysis: *circumstantial relation, logical relation* and *transitivity relation*. The classification and definitions of these semantic relations can be seen in appendix A. For an example of a *circumstantial relation*, when students responded to the teacher about the factors affecting photosynthesis, the students provided the answers chlorophyll, CO_2, water, and light energy. These three entities can be categorised as circumstantial relation: (material= CO_2, water, light energy, chlorophyll/process= photosynthesis). These semantic relations between these different scientific topics were not made explicit to students until the teacher provided a modified input, further expanding on the students' ideas. He then explained the terms and related them to previous scientific lexical items. We saw the teacher in Table 5.14 produce teacher modified input on several

occasions to connect these scientific lexical items logically in a number of extended IRF exchanges. Table 5.17 summarises the discussed thematic items, and their semantic relations.

Those student's science ideas were further explored, and discussed, indicating that the teacher and students were in the process of co-constructing knowledge together through a number of IRF exchanges. In this process, the teacher unpacked 'CO_2' and further explored how CO_2 is a limiting factor in photosynthesis. The students were then able to relate this to 'stomata' and the role of 'stomata in gas exchange'. Then the teacher repacked it by acknowledging and providing an interpretation in the last sequence of the IRF exchange to help students understand the role of CO_2 in limiting photosynthesis in relation to the stomata.

To summarise, the teacher whose talk is captured in Table 5.14 made use of the opportunities to discuss with students what had been explored in the lesson, and helped students to explore the meaning of different factors in photosynthesis by ignoring, acknowledging or further expanding on in a number of IRF exchanges.

Photosynthesis	Amount of chlorophyll	The amount of chlorophyll involved in the process of photosynthesis	Circumstantial relation:(Material/Process) material=chlorophyll; process=photosynthesis	$\searrow I\ (Open\ Q) + RF$
Photosynthesis	CO_2, water	CO_2, water and chlorophyll in conjunction affect photosynthesis.	Logical relation: (item/Addition) item=chlorophyll; addition=CO_2, water	$\searrow I\ (Open\ Q) + RF$
CO_2, water, amount of chlorophyll	Light energy	Light energy also affects photosynthesis.	Logical relation:(item/Addition) item=chlorophyll, CO_2, water; addition=light energy	$\searrow I\ (Open\ Q) + RF$
Photosynthesis	Starch	Starch is the end-product of the process of photosynthesis.	Transitivity relation: (Process/ Target) Process=photosynthesis; Target=starch	$\searrow F\ (open\ Q)$
Water	Soil	Water source for photosynthesis is supplied from soil.	Circumstantial relation: Location/located) Location: soil Located: water	$\searrow I\ (Open\ Q) + RF$
CO_2	Stomata	The CO_2 for photosynthesis is limited by the stomata.	Circumstantial relation: (Manner/Process) Manner=limited CO_2 from stomata process=photosynthesis	$\searrow F\ (open\ Q)$
Stomata	Gas exchange	The stomata play a role in gas exchange, allowing CO_2 to enter the leaves.	Circumstantial relation: (Reason/Process) Reason=stomata process=gas exchange	$\searrow F\ (open\ Q)$

Table 5.17. Summary of the discussed thematic items, and their semantic relations

Table 5.18. IRF thematic analysis of a biology lesson with LESS teacher's modified input and LESS cohesive, extended IRF exchanges in developing students' thematic understanding

Context: late–partial EMI grade 10 EMI Biology; *Topic:* specific immune response; *MOI*: Cantonese as the matrix language, embedded with English vocabulary

turn	**Interaction (IRF)**				**Thematic development**	
	Text	*Decisions made by teachers/ teacher's modified inputs*	***Teacher***	***Student***	Science topic (thematic pattern)	Semantic relation of the thematic patterns (Lemke, 1990)
1	T: First, we are talking about the specific immune response; this is not a *general immune response*. It is a specific *immune response*. When we talk about skin, saliva, tears, gastric juice, we would call these general.	Use statements to present the teacher's own view on the science topic	**[Initiation] ↘ statements**		Specific immune response	
2	T: Why do we call these specific? Anyone remember? Why would these be regarded as specific?	Use an Open Q	**[Initiation] ↘ Open Q**			
3	T: Previously we talked about inflammation, blood clotting.				Inflammation, blood clotting	

4	T: Why would we call these non-specific? Why would we call them like this? This would be specific? What is specific?	Use an Open Q	**[Initiation] ↘ Open Q**		Non-specific	
5	S: Target			**[Response]**		**Nominal Relation: (Attribute/Carrier)** attribute=specific; carrier=pathogens
6	T: Target. That's right. Targeting the pathogens.	Acknowledge the student's answer, but direct to teacher's planned concept	**[Feedback] (acknowledge)**		Pathogens	Specific is a descriptive characteristic of pathogens.
7	T: Why would we say that it has the ability of targeting? You can find a very important word here.	Use an Open Q	**[Initiation] ↘ Open Q**			
8	S: Antigen			**[Response]**	Antigen	**Nominal Relation:(Attribute/Carrier)** carrier=pathogens; attribute=antigens
9	T: Antigen. What does it mean? You need to know what it means rather than copying.	Acknowledge the student's answer, and further expand it	**[Feedback] (acknowledge and expand)**			Pathogens are bacteria, viruses, or other microorganisms that can cause disease. This is achieved by antigens producing a toxin or other foreign substance which induces an immune response in the body.

Text	*Decisions made by teachers/ teacher's modified inputs*	***Teacher***	***Student***	Science topic (thematic pattern)	Semantic relation of the thematic patterns (Lemke, 1990)
T: Whose antigen belongs to? It belongs to our body or pathogen?		**[Initiation] ↘ Open Q**			
S: **Pathogen**			**[Response]**	Pathogen.	
T: An antigen is a type of protein.		**[Feedback] (ignore)**			
T: If the pathogen has this type of antigen, this type of protein, the **leukocytes** inside our body would recognise that these are not something belonging to the body. When it can identify that this is not some substance belonging to the body, this antigen would be regarded as recognised. I say non-specific, when the skin needs to resist, not allowing the bacteria or foreign substances to come inside the body.	Use statements to present the teacher's own view on the science topic	**[Initiation] ↘ statements**		Leukocytes	

T: will the skin recognise which substance it is and not allow its entry?		**[Initiation]** ↘ **Closed Q**			
S: No			**[Response]**		
T: So it is non-specific. There is no recognition, everything cannot go in. No recognition is needed.		**[Feedback]** **(acknowledge)**		recognition	

Table 5.18 illustrates the IRF exchanges in developing students' thematic understanding of photosynthesis from a late–partial EMI biology lesson. There were 232 turns between teacher and students and 32 IRF sequences, 13 were extended IRF and 19 were simple IRF. There were relatively fewer IRF patterns compared with the previous example of an early–full EMI lesson. A medium ratio of IRF (14%) in the interaction, with few IRF sequences, suggests that there were limited opportunities for extended IRF exchanges that lead to develop students' science understanding.

We can see in table 5.18 that there was a small amount of interaction between teacher and students, and a limited number of IRF sequences, and no extended IRF sequences, suggesting that there were limited opportunities for the students to respond and for the teacher to give feedback to them.

There was a great deal of teacher's initiations, realised by open questions, but these questions were rather less organised, and the science topics were not closely related (*immune response, blood clotting, non-specific, pathogens, antigen, leukocytes*…), suggesting that the teacher seemed to be less organised in his talk. This could perhaps create a challenge for eliciting students' answers and indeed we can see that students' answers were very limited. Although some students' answers were acknowledged by the teacher, a number of students' answers were ignored. For example, the teacher dismissed a student's answer without further exploration by saying '*You need to know what it means rather than copying*'.

There were a few occasions when the teacher only provided a series of statements to present his own view and his interpretation of the science topic hoping that the students could understand. There were few extended IRF exchanges in this lesson in which the teacher selected students' answers and then further expanded them (e.g. target, pathogens, antigens) in exploring the meanings through the teacher's modified inputs in the simple IRF form. Thus, the meaning negotiation process with students ended very quickly as they were not in the form of extended IRF sequences.

In a number of these extended IRF exchanges, the teacher informed the students about the semantic relations among the introduced science topics. Unlike the previous example in table 5.15, we see that few of the lexical items are semantically related. There is one relevant type of semantic relation mentioned in Lemke (1990): *nominal relation*. An example of *nominal relation* is when students responded to the teacher about the ability to target pathogens. Students gave their answer as antigens. These two entities can be categorised as nominal relations: (carrier= pathogens, attribute= antigens). The nominal relation can be explained as follows: ***Pathogens*** are bacteria, viruses, or other microorganisms that can cause disease. *Antigens* produced by pathogens are a toxin or other foreign substance which induces an immune response in the body.

To summarise, although the biology lesson captured in table 5.16 was interactive, the teacher had very limited extended IRF exchanges and thus created few opportunities for his students to explore the meaning through his modified inputs in his talk.

5.6.2 Implications: the skilfulness of science teachers' modified inputs on students' science understanding during interaction

In tables 5.15 and 5.16, I showed two biology lessons (more extended IRF exchanges vs. less extended IRF exchanges) in order to illustrate how different science teachers modify their talk (i.e. by selecting students' answers and expanding them) in the IRF exchanges.

The decision whether to select a student's answer to expand for further discussion or to acknowledge without follow up is controlled by the teacher. This decision is what I would call 'teacher modified input'. The decision on teacher to have extended IRF or simple IRF perhaps is a determining factor to shape the nature of Mortimer & Scott's communicative approaches in science classrooms. The IRF analysis presented above provides some insight into how teachers develop (or fail to develop) their students' thematic understanding in science. This analysis can connect the macro level analysis of Mortimer and Scott (different communicative approach in science classrooms) with the micro level (IRF patterns).

Depending on the communicative approach in science classrooms, teachers in authoritative-and-non-interactive classrooms might only acknowledge a student's answer, provided that the answer is consistent with the teacher's planned views on the scientific topics. Teachers in the dialogic-and-interactive classroom would expand a student's idea even though sometime these ideas are not completely in line with the teacher's views. Teachers would expand these ideas in their feedback to students in order to explore different views of the same topic.

By analysing how science teachers interact with their students, one can see clearly the level of teachers' linguistic competence is relevant to the ways the teachers interact with their students, and how teachers are adept at being interactive or not in providing the necessary comprehensible inputs to students through modification of their talk that leads to students' development of science understanding and the language of science. Table 5.19 summarises the four communicative approaches in Mortimer & Scott's framework at the macro level in a science classroom and relates these to the IRF patterns at micro level that show how teachers interact with their students through modified input in extended IRF exchanges.

A. Interactive-dialogic	Teacher listens to and takes account of the student's point of view. Together with students, he/she explores different views, generates new meanings, asks real questions, and works on different points of view on a science phenomenon.	Selects students' ideas, expand students' ideas, provide a lot of comprehensible feedback based on these ideas to develop different views of interpretations
B. Non-interactive-dialogic	Teacher considers different points of view, guides students to explore and work on different views of a science phenomenon without any turn-taking interactions with the students	Selects students' ideas, provide comprehensible feedback that leads to the teacher's own view on a science topic
C. Interactive-authoritative	Teacher leads students through a great deal of interaction, by a sequence of questions and answers to achieve one specific view on a science phenomenon	Picks up on students' ideas but no comprehensible input to students' ideas, only directing students to their planned specific view on the science topic.
D. Non-interactive-authoritative	Teacher presents only one specific view of a science phenomenon without any interaction with students	Ignores students' ideas and only presents his or her specific view of a science phenomenon without any interaction with students.

Table 5.19. The four communicative approaches in Mortimer & Scott's framework and the ways teachers interact with their students through the modified inputs in extended IRF exchanges

A more adept interactive science teacher with greater competence in English (provides more extended interactions with students' involvement) has numerous extended episodes of interactions where these teachers would select students' ideas, expand students' ideas, provide comprehensible feedback based on these ideas, encourage students to generate new thinking around these ideas, and later work together with students to explore different points of view on the science phenomena. These teachers use a range of teaching strategies to make abstract scientific concepts more accessible in L2. This results

in an *interactive and dialogic* science classroom style, in the terms of Mortimer and Scott (2003).

A less adept interactive science teacher with less competence interacting in English provides less extended interactions with only acknowledgment of students' involvement and has more of these extended episodes of interaction where these teachers select students' ideas, provide comprehensible feedback based on the students' ideas, but neither expand students' ideas, nor work together with students to explore different views on the science phenomenon. These teachers lead students through a great deal of interaction, by a sequence of questions and answers to achieve one specific view on a science phenomenon. This results in an *interactive and authoritative* science classroom style also identified by Mortimer and Scott (2003).

A less interactive science teacher provides few extended interactions with acknowledgment of students' views only if in line with his or her own ideas. The reason why there are less extended interactions is because the teacher would pick up on students' ideas but direct students to the teacher's specific view on the science topic. This results in the *non-interactive and dialogic* science classroom style identified by Mortimer and Scott (2003).

The least interactive science teacher provides no extended interactions and does not use any students' views to have extended interaction because these teachers ignore students' ideas and only present his or her specific view of a

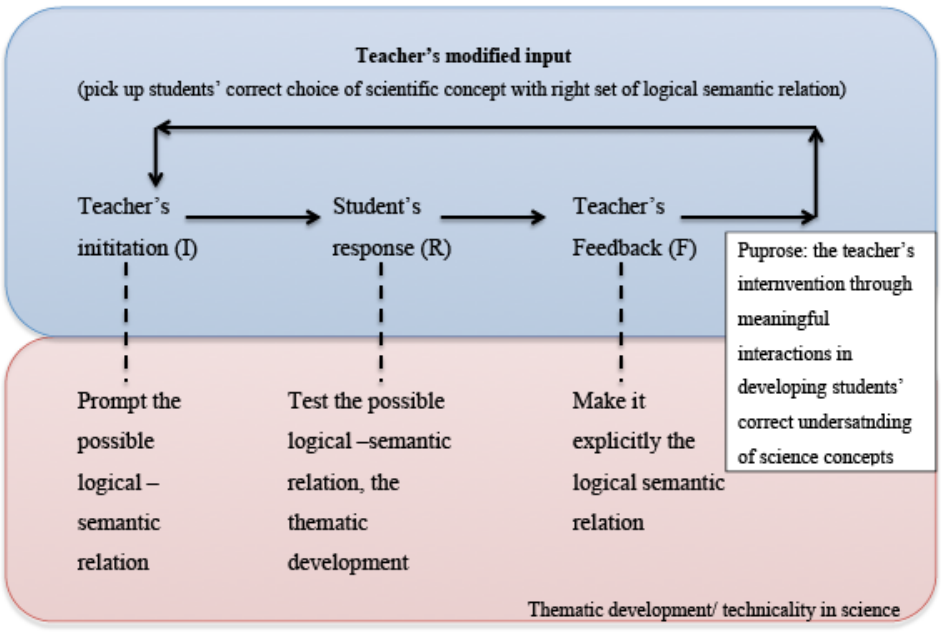
science phenomenon without any interaction with students. This results in the *non-interactive and authoritative* classroom style identified by Mortimer and Scott (2003).

5.6.4 Implication: the role of teachers' modified input in developing students' science thematic understanding

The evidence presented in this chapter suggests that science teachers' modified input is essential to develop students' thematic understanding (or technicality) in science. Science teachers serve as the science expert in science classrooms (Lemke, 1990). The teacher plays an important role in guiding students to develop their thematic understanding of the science topic. To achieve this goal, a teacher provides a modified input in his talk through an extended IRF exchange. In the example of table 5.16, the teacher first makes an initiation, asking what factors affect photosynthesis. This provides a hint to students of the possible semantic relation in preparing their answer. Then students guess that the relation should be a circumstantial relation (material/process) material=chlorophyll; process=photosynthesis.

Then students respond with an answer (CO_2) and this represent their hypothesis. The teacher then plays an important role here, as a science expert, by only selecting the semantically related items from the students' answers to follow up. In the teacher's feedback, the science items in the students' answers are either acknowledged, or further expanded by the teacher in a more extended IRF sequence. This helps students understand the semantic relation between the

science item (CO_2) from the student's answer and the main science topic (photosynthesis) they are learning about. This is an accumulative, cyclic process which is repeated across the lesson. This process will ultimately lead to a comprehensible input for students to master the intended teaching science concept (e.g. all the factors that affect photosynthesis). The teacher will repeat this process again until the teacher feels that the students shares his or her science view. Figure 5.8 visualises the steps in extended IRF exchanges in developing students' thematic understanding through a number of teacher modified inputs.



This accumulative process will ultimately lead to → teacher's comprehensible input

Figure 5.8. A teacher's modified input in the IRF exchange for developing thematic understanding in science

5.6.4.1 What kind of pedagogical function is provided by a teacher's modified input?

A teacher's modified input in a IRF exchange helps students to unpack the complex and abstract science items, usually in the form of grammatical sentences. The type of question in the teacher's modified input leads to the kind of semantic relations of the developing scientific terms. A teacher's modified input in the IRF exchange provides a good opportunity to see how teacher and students co-construct to unpack the semantic relations that lead to the development of students' thematic understanding in science. The IRF exchange provides a valuable opportunity for teacher and students to negotiate science meaning. At this critical moment, students can test their understanding of the science topic in response to a teacher's question. When students give an answer, they hypothesise their understanding of the semantic relation of the science item with other scientific items already encountered.

The implications of these findings are that science teachers should not get their students to only work on lexical input; rather, they should help students to understand and express the hidden semantic relation (Lemke, 1990), more explicitly, at the level between grammar and semantics. This modified input from science teachers can help students to unpack the abstract clause complexes and understand the hidden semantic relations. Only by unpacking the logical semantic relations, mediated by a teacher's modified input, can students learn the language of science through engaging with scientific meanings.

The above two analyses show that a teacher's modified input in a IRF extended exchange is a way to help students engage in science knowledge through extended interaction. As this process continues, students build up the field of knowledge in science through a cumulative cycle of repeated teacher modified inputs across repeated IRF extended exchanges. Teachers in this process also develop students' grasp of the language of science by unpacking the abstract nominal groups and making the hidden semantic relations more explicit and accessible in their feedback to students. Through this cumulative process, teachers ultimately provide a comprehensible input to students in building up students' knowledge in the science topic.

5.7 Chapter summary

In this chapter, I introduced the analytical framework I used to analyse the nature of science classrooms in Hong Kong EMI secondary schools. Drawing from multiple analytical frameworks from science education and applied linguistics, I explored the nature of classroom interactions, presenting examples of authentic transcripts from EMI science classrooms to illustrate the Mortimer and Scott's four communicative categories (e.g. interactive/non-interactive and dialogic/authoritative). The four biology lessons from early–full and late–partial EMI schools revealed some differences in the nature of content addressed in the four lessons. All the four lessons were authoritative. The four lessons used an interactive communicative approach to collect students' ideas, but the teachers

tended to be non-interactive and authoritative in selecting which students' responses to respond to, follow up or ignore. The four lessons generally located at the dialogic-authoritative dimension in Mortimer & Scott's framework which indicates that these science teachers controlled which science ideas from the students to develop. Most of the observed sequences between teacher and students were in the form of simple IRF exchanges.

Students from both early–full EMI and late–partial EMI schools predominately produced a number of incomplete sentences consisting of short, technical and abstract nouns or noun phrases referring to scientific items but teachers rarely encouraged students to produce a complete sentences, or made any attempts to correct students' language mistakes or provide any feedback to students about their L2 language production.

For the language of science, the characteristics of language in teacher and student talk are examined. The specific features of language in science used by science teachers are summarised. The language of science observed in the four biology EMI science classrooms can be categorised as 1) subject-specific vocabulary; 2) nominalizations and grammatical metaphors; 3) complex noun phrases; 4) language of knowledge relationships and 5) high lexical density. The measurement of lexical density serves as an indicator for analysing the level of complexity of teacher and student talk in EMI science classrooms. I also illustrated this with three examples of biology teachers asking higher-order

questions, explaining words with similar meanings and using synonyms to describe a biological concept.

In addition, I provide two IRF analyses to illustrate how science teachers in Hong Kong develop students' thematic understanding in science topics through IRF interactions. Teachers intervene with students' responses at the feedback stage by either expanding, acknowledging, or ignoring students' ideas in developing students' scientific story. Teachers' modified input in their talk during the IRF exchanges serves as an important way of providing extended comprehensive feedback to students in developing their science knowledge.

The nature of classroom interactions in EMI science classrooms in this study is authoritative, very often with teachers controlling the interactions to achieve his or her specific view on the science topic. Teacher and students are very often less interactive, with some noticeable simple IRF patterns. Students seldom initiate interactions and are mainly invited by teachers to give a response to show their understanding of the science topic.

In the next chapter, I present the survey and interview analysis of teacher's perception on their EMI experiences. The interview data shows teachers' views towards science teaching in EMI classrooms, and the possible language challenges and their coping strategies in teaching through English. ■

Chapter 6

Results (III): The science teachers' perceptions of their EMI experiences in science classrooms

6.1 Introduction

In chapter five, I presented the qualitative analyses of the classroom interactions. A comparison of the interaction patterns between full and partial EMI schools indicate that classroom interactions in the EMI science classrooms in this study are authoritative, very often with teachers controlling interactions through their specific view on the science topic. Interaction is limited: students seldom initiate interactions and are mainly invited by teachers to give a response to show their understanding of the science topic.

In this chapter, I report on 19 science teachers' perceptions of their EMI teaching experiences in the observed science classrooms. This part of the analysis draws from two sets of data: the teachers' questionnaire and two semi-structured interviews with each teacher) before and after observation. The questionnaire asked the teachers to reflect on their teaching practices (See Appendix E). Questionnaire items were designed to uncover teachers' beliefs about teaching science in EMI contexts and, more importantly, elicit their views

on language challenges and strategies for teaching science through English. The pre-observation interviews took around three minutes and covered the teaching objectives of each observed lesson (See Appendix G). The post-observation interviews took 20 to 40 minutes. I began by asking teachers for their overall impression of the lessons. I then asked them for their views on using English to teach senior secondary science, the language challenges they faced, and their coping strategies. The results presented in this chapter address research question 4: What are teachers' perception of EMI in science classrooms?

6.2 Science teachers' perception of EMI teaching (questionnaire data)

This section presents a detailed analysis of the data and findings on the teachers' perceptions of their EMI teaching experience in science classrooms.

6.2.1 Demographic characteristics of the teacher respondents

Only 19 teachers returned their questionnaires, with a total response rate of 63%. The questionnaire consisted of six parts: demographic characteristics; the choice of language of instruction in different science teaching activities; the most important and demanding English language skills students needed to study science in English medium; reflections on science teaching practices in the EMI context; the language challenges students faced in learning science in English; and the usefulness and frequency of the teachers' coping strategies. For demographic characteristics, the teacher respondents were asked to report their age range, gender, science subject responsibilities, number of years of total

teaching experience, different curricula taught (e.g. HKDSE, A-Level, CE), self-reported English Language skills and whether they had received any EMI training. These demographic characteristics of the teacher respondents were presented in chapter three (Table 3.8), appendix J (teacher's background and qualifications), appendix K (teacher's teaching experience) and Appendix L (teacher's self-reported English levels).

6.3 Questionnaire results (correlation analysis)

This part of my analysis investigates if there is any correlation between the teachers' background characteristics and the eight scales using Spearman's rho coefficient. Preliminary analyses were performed to check the assumptions of normality, linearity and homoscedasticity. The relationship between different variables of teachers' responses about their perceptions of EMI experience (as indicated by their average total scores for each survey item on a five-point scale) was investigated using Spearman's rho coefficient.

6.3.1 Correlations among the teachers' demographic characteristics

A Spearman's rank-order correlation was run to determine the relationship among the 19 teachers' demographic characteristics. The results are shown in table 6.1.

a. School Type	n.s.	n.s.	-.663**	-.591**	n.s.	n.s.	n.s.	n.s.
b. Sex	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
c. Age	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
d. University degree	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
e. EMI training	n.s.	n.s.	n.s.	n.s.	.462*	n.s.	n.s.	n.s.
f. English scores	-.574*	n.s.	n.s.	.568*	n.s.	n.s.	n.s.	n.s.
g. Listening	n.s.	n.s.	n.s.	.487*	n.s.	n.s.	n.s.	n.s.
h. Speaking	-.610*	n.s.	n.s.	.599**	n.s.	n.s.	n.s.	n.s.
i. Reading	n.s.	n.s.	n.s.	.619**	n.s.	n.s.	n.s.	n.s.
j. Writing	n.s.	n.s.	n.s.	.522*	n.s.	n.s.	n.s.	-.526*
k. Teaching experience (junior)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
l. Teaching experience (senior)	n.s.	n.s.	n.s.	n.s.	-.526*	n.s.	n.s.	n.s.
n. Teaching experience in EMI	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
m. Teaching experience in integrative science (junior)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
n. Teaching science subjects	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
o. HKDSE	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
p. CE	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
q. A-level	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Table 6.1. The correlation among teachers' demographic characteristics (n=19)

*Note: *p<.05; **p<.01; ***p<.001; n.s.=no statistically significance*

The results with statistical significance are as follows:

- When it comes to language choice in activities, teachers' English self-reported overall score (r=-.574, *p*=.01) and their self-reported English speaking skills (r=-.61, *p*=.006) were strongly negatively correlated. This suggests that teachers with lower self-reported English scores, particularly those with poor speaking skills, tend to use Cantonese in science teaching activities.
- When it comes to teachers' views on the importance of English, it was found that the MOI of the schools that teachers were teaching in was negatively correlated with their views towards the importance of English language skills (r=-.663, *p*=.002). This perhaps suggests that teachers from late–partial EMI schools rated the importance of English language skills lower than teachers in the early–full schools.
- On teachers' language awareness, a number of teachers' characteristics were strongly correlated. They included the school MOI (r=-.591, *p*=.008), their overall English scores (r=.568, *p*=.011), their listening (r=.487, *p*=.035), their speaking (r=.599, *p*=.007), their reading (r=.619, *p*=.005) and their writing (r=.522, *p*=.022). This perhaps suggests that teachers from early–full EMI schools, with higher self-reported English scores as well as four individual language skills, have a higher language awareness of teaching science through English than the late–partial schools.

- For teachers' beliefs about teaching in EMI contexts, it was found that EMI training (r=.462, *p*=.046) and the amount of teaching experience at senior levels (r=-.526, *p*=.021) were strongly correlated with teaching belief in EMI context. This perhaps suggests that teachers who reported they had had EMI training, but less teaching experience at senior levels, have a greater belief in teaching through EMI. In addition, teachers with low self-reported writing score in English think that coping strategies are useful.
- There was no correlation between the following three scales with the teachers' demographic characteristics: demanding English skills, language challenges and frequency of coping strategies.
- In sum, teachers with lower self-reported English scores tend to use Cantonese in science teaching activities. Teachers with EMI training, but less teaching experience at senior levels, have a higher teaching belief in EMI. Those teachers with low self-reported writing score in English thinks the coping strategies are useful. Early-full EMI teachers rated the importance of English language skills higher, with higher self-reported English scores as well as higher scores for the four individual language skills, and more language awareness of teaching science through English, as opposed to the late–partial EMI teachers.

6.3.2 Correlations among the eight questionnaire scales

A Spearman's rank-order correlation was run to determine the relationship among the eight scales. The results of the correlations among the eight questionnaire scales are shown in table 6.2.

1. Lang. choice in science activities	n.s.	n.s.	n.s.	-.587**	n.s.	n.s.	n.s.	n.s.
2. English demanding	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
3. English important	n.s.	n.s.	n.s.	n.s.	-.466*	n.s.	n.s.	n.s.
4. Language awareness	-.587**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
5. Belief	n.s.	n.s.	-.466*	n.s.	n.s.	n.s.	n.s.	n.s.
6.Challenges	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
7. Freq. strategy	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	.756***
8. Useful. strategy	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Table 6.2. Summary of the correlations among the eight questionnaire scales

*Note: *p<.05; **p<.01; ***p<.001; n.s.=no statistically significance*

The results with statistical significance are as follows:

- Teachers' language awareness was negatively correlated with their choice of instructional language in different science teaching activities (r=-.587, *p*=.008). This perhaps suggests that teachers who reported higher language awareness tend to use more English in science teaching activities.

- Teachers' views on the importance of English language skills were negatively correlated with their teaching belief in EMI teaching (r=-.466, *p*=.044). This perhaps suggests that teachers who rated the importance of English language skills lower have a higher teaching belief in EMI.
- Teachers' views on the frequency of coping strategies were found to be positively correlated with their views on the usefulness of coping strategies (r=.756, *p*<.0001). This perhaps suggests that teachers who reported that they used more frequent coping strategies also found these strategies useful.
- The scale of teachers' language awareness include statements asking teachers about whether they make necessary steps in teaching to make science more accessible in English. For examples, *I use special teaching methods to help my students understand the English vocabulary I use in my science teaching; I find it helpful to use my knowledge of English grammar to support my students in learning science through English. I use a number of teaching strategies in teaching science through English that I would not use if I taught in Chinese.* In sum, teachers with higher language awareness (i.e. teachers reported that they put more efforts in making science more accessible to students in English) tend to use more English in science teaching activities. Those with a higher teaching belief in EMI tended to

rate lower the importance of English language skills. Those who used more frequent coping strategies also found these strategies useful.

6.4 Questionnaire results (descriptive statistical analysis)

Due to the small number of participants (n=19), I could only perform a descriptive statistical analysis to describe the teachers' responses. The major results of the teacher's questionnaire are presented in tables 6.3 to 6.10. These tables contain the means and standard deviations of each of the survey items. In addition, I performed a correlation analysis using the teachers' responses in both groups (early–full and late–partial) from the eight questionnaire scales (as indicated by their average total scores for each survey item on a five-point scale).

6.4.1 Questionnaire results of the eight aspects of teachers' EMI experience

For the choice of instructional language in different science teaching activities, the teachers in late–partial EMI schools chose to have more Cantonese or code-switching between English and Cantonese in the EMI classrooms. This is seen in table 6.3, which shows that the mean scores of teacher responses from the late–partial EMI schools had a larger value than those in early–full EMI schools. However, the overall sum of scores for the 12 items about the choice of instructional language in science classrooms did not differ between the early–full and late–partial EMI schools. Table 6.3 summarises the teachers' responses to the choice of instructional language in different science teaching activities.

The late–partial teachers believed the English language skills for students to study science in English medium is more demanding. Their views were more than those early–full teachers. This is seen in table 6.4, which shows that the mean scores of teachers' responses from the late–partial EMI schools for items 1, 3, 6, 7, 8, 12, 13 had a slightly larger value than those in early–full EMI schools. Teachers in late–partial EMI schools found that the level of demanding English required by these schools was higher than the level of English required by the early–full schools. For items 2, 4, 5, 9, 10, 11, 14, 15, 16, and 17, teachers in the late–partial EMI schools rated the level of demanding English lower for the same set of English language skills. Table 6.4 summarises the teachers' responses to the most demanding English language skills for students to study science in English.

Teachers were asked about what English language skills are important for students to study science in English medium. The results show that more early–full teachers than the late–partial teachers believed that English language skills are more important for learning science. This is seen in table 6.5, where the mean scores of teachers' responses from the early–full EMI schools rated all the English language skills (except item 8) higher than did teachers in the late–partial EMI schools. Table 6.5 summarises the teachers' responses to the question of which are the most important English language skills for students to study science in English medium.

On the question of teacher language awareness in teaching science through English, the teachers in the late–partial EMI schools had a relatively lower language awareness than teachers in the early–full EMI schools. This is seen in table 6.6, where the mean scores of teachers' responses of their language awareness in teaching science through English from the early–full EMI schools were higher than teachers in the late–partial EMI schools. Table 6.6 summarises the teachers' responses to their language awareness in teaching science through English.

For the reflections of science teaching practices in the EMI context, the late–partial EMI teachers had a higher score for teaching reflection. This is seen in table 6.7, where the mean scores of teachers' responses of their reflections of science teaching practices in the EMI context from the late–partial EMI schools were rated higher than by teachers in the late–partial EMI schools. However, early–full EMI teachers had a higher ranking for items 4 and 8 in relation to expectations of students' English levels. Although these teachers do not believe they have a role in teaching English, they feel strongly about their need to know how their students learn effectively through English. This is seen in their responses to item 4 ('Developing students' English proficiency is not an important part of a science teacher's role in an English medium school') and item 8 ('Knowing how students can learn English effectively through science is useful to science teachers in an EMI school'). Table 6.7 summarises the teachers'

responses to their reflections about science teaching practices in the EMI context.

On questions of language challenges for learning science in English, the late–partial EMI teachers believed their students faced more language challenges. This is seen in table 6.8, where the mean scores of teachers from the late–partial EMI schools were higher than in the late–partial EMI schools. However, teachers in early–full EMI schools rated items 6, 7, 14, 15, 16, 22, 24 and 26 higher. Table 6.8 summarises the teachers' responses to the language challenges for learning science in English.

On the frequency of coping strategies, the early–full EMI teachers reported that they used coping strategies more frequently. This is seen in table 6.9, where the mean scores of teachers from the early–full EMI schools were higher in their responses to the frequency of coping strategies than teacher responses in the late–partial EMI schools. However, teachers in late–partial EMI schools rated items 1, 2, 8 and 5 higher. Table 6.9 summarises the teachers' responses to the frequency of coping strategies.

On the usefulness of coping strategies, the early–full EMI teachers reported these strategies were more useful. This is seen in table 6.10, where the mean scores of teachers from early–full EMI schools were higher in their responses to most of the items on the usefulness of coping strategies. However, teachers in

late–partial EMI schools rated items 1, 5 and 8 higher. Table 6.10 summarises the teachers' responses to the usefulness of coping strategies.

	Early-Full	Partial EMI	Overall
1. Teaching the whole class	1.83(.75)	3 (1.29)	2.63(1.26)
2. Giving instructions to the students	2(1.01)	3.38(1.12)	2.95(1.27)
3. Answering students' questions in front of the whole class	1.83(.753)	3 (1.29)	2.6(1.26)
4. Discussing ideas with the whole class	1.83(.75)	3.08 (1.19)	2.68(1.2)
5. Managing the classroom	2.5(1.05)	3.54(1.33)	3.21(1.32)
6. Talking to individual students about their work	2.83(.75)	4(.82)	3.63(.96)
7. Taking part in teacher-student interactions	2.67(.52)	3.38(1.39)	3.16(1.21)
8. Explaining the definition of scientific vocabulary	2.67(.82)	3(1.16)	2.89(1.05)
9. Explaining a science phenomenon	2.5(.84)	2.92(1.32)	2.79(1.18)
10. Explaining a science phenomenon using everyday experience	2.67(.82)	3.08(1.19)	2.95(1.08)
11. Giving instructions to students for a lab experiment	2.33(.52)	3.08(1.26)	2.84(1.12)
12. Clarifying students' science misconception in a lab experiment	2.83(.75)	3.23(1.09)	3.11(.99)
Overall score of instructional language in current science classrooms	2.38(.6)	3.22(1.09)	2.96(1.025)

Table 6.3. The teachers' responses to the choice of instructional language in different science teaching activities

Notes: 1. The choice of instructional language was rated on a 5-point scale, where 1=(always English), 2=(usually English), 3=(code-switching between English and Cantonese), 4=(usually Cantonese), 5=(always Cantonese);

	Early-full	Late-partial	Both
1. Speaking (dialogue, e.g. whole class interaction between teacher and classmates)	2.67(.82)	2.77(.93)	2.74(.87)
2 Speaking (monologue, e.g. presentation)	2.83(.75)	2.77(.83)	2.79(.79)
3. Writing (scientific reports, with specific purpose, structures, language style)	3.67(1.03)	3.69(1.03)	3.68(1.003)
4. Writing (e.g. daily assignments)	3.83(.98)	3.62(.87)	3.68(.89)
5. Reading (e.g. science textbooks)	4(1.1)	3.31(.75)	3.53(.91)
6. Listening (e.g. science teacher's oral explanations in English)	3.5(.84)	3.31(1.03)	3.37(.96)
7. Understanding the meaning of technical vocabulary (e.g. oxidation, electrolysis, ionic bond, electrochemical series)	3.5(.84)	3.92(.64)	3.79(.71)
8. Understanding the meaning of abstract vocabulary (e.g. inert, displacement, reduction, oxidizing)	3.5(.84)	3.85(.99)	3.74(.93)
9. Understanding the meaning of academic English Vocabulary (e.g. examine, account for, describe, explain)	3.5(1.05)	3.0(1.0)	3.16(1.02)
10. Understanding the style of science writing (e.g. the language style, language choice in a lab report)	3.5(1.05)	2.92(.86)	3.11(.94)
11. Recognizing the organization of a science text (e.g. the format of a lab report, its components, sub-sections)	3.5(1.05)	2.62(.87)	2.89(.99)
12. Writing scientific texts with accurate English grammar	3.17(.75)	2.92(1.26)	3.0(1.11)
13. Writing scientific texts with appropriate English vocabulary	3.0(.63)	3.54(1.2)	3.37(1.07)
14. Choosing the correct technical terms in expressing a science concept	3.5(.84)	3.38(1.04)	3.42(.96)
15. Distinguishing between English Vocabulary for explanation and technical terminology	3.33(.82)	3.31(.86)	3.32(.82)
16. Expressing the right answers in simple spoken English	3.33(1.03)	3.0(.71)	3.11(.81)
17. Expressing the right answers in simple written English	3.67(1.03)	3.54(.88)	3.58(.90)
Overall score of English difficulty in learning science through English	3.41(.75)	3.26(.41)	3.31(.53)

Table 6.4. The teachers' responses to the most demanding English language skills for students to study science in English medium

Notes: The most demanding English skills for learning science through English was rated on a 5-point scale, where 1=(least demanding), 5=(most demanding).

	Early-full	Late-partial	Both
1. Speaking (dialogue, e.g. whole class interaction between teacher and classmates)	4.17(.75)	3.08(.76)	3.42(.90)
2. Speaking (monologue, e.g. presentation)	4.17(.75)	2.85(.99)	3.26(1.1)
3. Writing (scientific reports, with specific purpose, structures, language style)	4.17(.75)	3.62(1.19)	3.79(1.08)
4. Writing (e.g. daily assignments)	4.5(.55)	4.08(.64)	4.21(.63)
5. Reading (e.g. science textbooks)	4.5(.55)	3.54(.78)	3.84(.83)
6. Listening (e.g. science teacher's oral explanations in English)	4.17(.41)	3.46(.78)	3.68(.75)
7. Understanding the meaning of technical vocabulary (e.g. oxidation, electrolysis, ionic bond, electrochemical series)	4.17(.75)	4.00(.71)	4.05(.71)
8. Understanding the meaning of abstract vocabulary (e.g. inert, displacement, reduction, oxidizing)	3.83(.75)	3.92(1.11)	3.89(.99)
9. Understanding the meaning of academic English Vocabulary (e.g. examine, account for, describe, explain)	4.17(.75)	4.00(.71)	4.05(.71)
10. Understanding the style of science writing (e.g. the language style, language choice in a lab report)	3.83(.98)	3.15(1.14)	3.37(1.12)
11. Recognizing the organization of a science text (e.g. the format of a lab report, its components, sub-sections)	4.17(.98)	3.00(1.29)	3.37(1.3)
12. Writing scientific texts with accurate English grammar	3.83(.98)	3.67(.82)	3.16(1.21)
13. Writing scientific texts with appropriate English vocabulary	3.67(.82)	3.5(1.45)	3.53(1.26)
14. Choosing the correct technical terms in expressing a science concept	4.17(.75)	3.46(1.13)	3.68(1.06)
15. Distinguishing between English Vocabulary for explanation and technical terminology	4.17(.75)	3.38(1.04)	3.63(1.01)
16. Expressing the right answers in simple spoken English	3.67(.82)	3.08(1.12)	3.26(1.05)
17. Expressing the right answers in simple written English	4.67(.52)	3.08(1.71)	3.58(1.61)
Overall score of the most important English skills in learning science through English	4.11(.50)	3.39(.49)	3.62(.589)

Table 6.5. The teachers' responses to the most important English language skills for students to study science in English medium

*Notes: The most important English skills for learning science through English was rated on a 5-point scale, where 1=(least demanding), 5=(most demanding). 2.*p<.05; **p<.01; ***p<.001.*

	Early-full	Late-partial	Both
1. I use special teaching methods to help my students understand the English vocabulary I use in my science teaching.	3.83(.75)	3.83(.75)	3.37(1.12)
2. I always pay a lot of attention to the teaching of vocabulary in my science lessons because it is conducted in English.	3.83(.75)	3.23(1.01)	3.42(.96)
3. I regularly ask my students to read their English science textbooks on their own.	3.67(1.21)	2.92(1.32)	3.16(1.30)
4. I regularly ask my students to read other science resources in English.	3.5(1.05)	2.69(1.18)	2.95(1.18)
5. In my science teaching, I pay a lot of attention to help students developing their English while they learn science.	3.33(1.03)	2.38(.77)	2.68(.95)
6. I use a number of teaching strategies in teaching science through English that I would not use if I taught in Chinese.	3.33(1.03)	2.38(1.12)	2.68(1.16)
7. I find it helpful to use my knowledge of English grammar to support my students in learning science through English.	3.67(.82)	2.92(.95)	3.16(.96)
8. I find it helpful to use my knowledge of English vocabulary to support my students in learning science through English.	4.0(.63)	3.77(.93)	3.84(.83)
9. In my science lessons, I try to use English in ways that will help my students to learn English as they learn science.	3.67(.82)	2.85(1.21)	3.11(1.15)
10. In my science lessons, I regularly try to give my students opportunities to talk in English in order to help them learn both science and English.	3.67(1.03)	2.77(1.36)	3.05(1.31)
11. I try to help my students use English when they speak to me (e.g. answering questions) in my science classes.	3.83(.75)	2.46(1.45)	2.89(1.41)
12. I regularly require my students to write long answers in English (one sentence or more) as part of their learning of science.	4.0(1.27)	2.31(1.18)	2.84(1.43)
The overall score of teacher language awareness in teaching science through English	3.69(.64)	2.82(.64)	3.10(.75)

Table 6.6 The teachers' responses to their language awareness in teaching science through English

Notes: The teacher language awareness in teaching science was rated on a 5-point scale, where 1=(untrue of me), 2=(somewhat untrue of me), 3=(neutral), 4=(somewhat true of me), 5=(very true of me).

	Early-full	Late-partial	Both
1. It is important for English medium science teachers to find ways of helping their students to deal with the English vocabulary they meet in science lessons.	1.83(.41)	3.0(1.41)	2.63(1.3)
2. English medium students need specialised help to understand the English vocabulary they used in science learning.	2.67(.52)	3.23(.73)	3.05(.71)
3. Reading the English science textbooks is an important way for students to learn the English they need for studying science.	2.17(.98)	2.85(1.52)	2.63(1.38)
4. Developing students' English proficiency is not an important part of a science teacher's role in an English medium school.	2.83(.75)	2.69(.95)	2.74(.87)
5. Helping students to understand English they use in science is one of the most important responsibilities for a science teacher in an English medium school.	2.33(.52)	3.08(1.19)	2.84(1.07)
6. All English medium science teachers need to know how to support their students in understanding the use of English in a science classroom.	2.17(.41)	2.38(.87)	2.32(.75)
7. It is important for science teachers to have some knowledge about the English language (e.g. grammar, phonology, semantic, genre) in order to support students' learning of science through English.	2.00(.63)	2.38(.87)	2.26(.81)
8. Knowing how students can learn English effectively through science is useful to science teachers in an EMI school.	2.5(.84)	2.38(.96)	2.42(.902)
9. Teachers who speak fluent English will motivate students to improve their uses of English in a science class.	2.17(.41)	2.23(1.17)	2.21(.98)
10. Teachers who write good English will motivate students to improve their uses of English in a science class.	2.17(.41)	2.23(1.09)	2.21(.92)
11. In English medium science lessons, students need regular opportunities to talk about science in English.	1.83(.41)	2.38(.87)	2.21(.79)
12. It is important for students to do learning tasks in science that require them to produce long spoken answers in English.	2.5(.55)	2.92(.76)	2.79(.71)
13. It is important for students to do learning tasks in science that require them to produce long written answers in English.	2.17(.41)	2.46(.66)	2.37(.60)
Overall score of the teachers' reflections on their science teaching practices in EMI context	2.26(.19)	2.63(.63)	2.51(.56)

Table 6.7. The teachers' responses to their reflections of science teaching practices in the EMI context

Notes: The teachers' reflection on their teaching science teaching practice was rated on a 5-point scale, where 1=(untrue of me), 2=(somewhat untrue of me), 3=(neutral), 4=(somewhat true of me), 5=(very true of me).

1. Transmitting content knowledge through English	2.83(1.47)	2.85(1.07)	2.84(1.17)
2. Teaching and explaining abstract scientific ideas in English	3.5(1.51)	4.15(.69)	3.95(1.03)
3. Teaching and explaining complex scientific ideas in English	3.83(1.47)	4.23(.60)	4.11(.937)
4. Teaching students to distinguish vocabulary and technical terminology in English	2.83(1.33)	3.08(.76)	3.0(.943)
5. Making students to answer to my questions in English	3.33(.52)	3.46(.78)	3.42(.692)
6. Making students to discuss themselves in English	4.17(.75)	4.08(1.12)	4.11(.994)
7. Evaluating students' science understating in English	3.17(1.33)	3.08(.95)	3.11(1.05)
8. Transmitting scientific knowledge and skills to students in English	2.67(1.21)	3.15(.98)	3.0(1.05)
9. Providing opportunities for practice and giving corrective feedback for consolidation in English	2.83(1.17)	3.31(.86)	3.16(.96)
10. Using questions to prompt students for higher-order cognitive thinking in English	3.33(1.21)	3.62(.87)	3.53(.96)
11. Developing students' scientific skills for investigation study (testing hypothesis, designing working procedures, gathering data, performing calculation, drawing conclusion)	3.0(1.1)	3.62(1.2)	3.42(1.17)
12. Encouraging students to generate new knowledge through group work by sharing their knowledge in English	3.33(1.03)	3.69(.76)	3.58(1.12)
13. Initiating students to apply existing knowledge to unfamiliar situations in English	3.33(1.03)	3.92(.76)	3.74(.87)
14. Preparing teaching content for presentations in English	2.17(1.47)	2.08(.86)	2.11(1.05)
15. Dealing with different levels of English language proficiency/skills of the students	3.33(1.21)	3.15(1.07)	3.21(1.08)
16. Dealing with different levels of science achievements of the students	3.5(1.05)	3.0(.71)	3.16(.83)
17. Dealing with diversity of existing science knowledge among students	3.17(1.72)	3.54(.66)	3.42(1.07)
18. Choosing appropriate language style for explaining a science concept	2.5(1.38)	3.0(.86)	2.84(1.02)
19. Choosing appropriate text organization for explaining a science concept	2.67(1.37)	2.85(.801)	2.79(.98)
20. Explaining topics after reading materials	2.17(1.17)	3.08(.76)	2.79(.98)

21. Designing a test/an exam with consideration on the English demand for students (e.g. writing, M.C.)	2.17(1.602)	2.31(.48)	2.26(.93)
22. Deciding the science topics and levels of difficulty in a test or an exam	2.5(1.64)	2.23(.44)	2.32(.95)
23. Writing exam questions in English with consideration on students' English level	2.17(1.17)	2.31(.75)	2.26(.87)
24. Assessing English language mistakes in written exams	2.83(1.17)	2.54(.88)	2.63(.96)
25. Assessing students' understanding of the subject content	2.17(1.17)	2.54(1.05)	2.42(1.07)
26. Making a balance between correcting students' mistakes in English and in science concepts	2.83(.98)	2.69(.95)	2.74(.93)
Overall score of language challenges in teaching through English	2.94(1.07)	3.13(.38)	3.07(.66)

Table 6.8. The teachers' responses to the language challenges for learning science in English

Notes: The language challenges for learning science in English was rated on a 5-point scale, where 1=(strongly disagree), 5=(strongly agree).

	Early-Full	Late-Partial	Both
1. Providing Chinese translation of technical vocabulary	2.67(.52)	3.46(1.39)	3.21(1.23)
2. Providing Chinese translation of abstract English vocabulary (not technical, e.g. metaphor)	3.0(.63)	3.38(1.26)	3.26(1.10)
3. Providing more definitions and exemplification of technical words in English but not necessary to translate them into Chinese	3.5(1.05)	3.0(1.08)	3.16(1.07)
4. Providing students with more English language instructions from their current English teachers	3.17(1.17)	1.85(1.28)	2.26(1.37)
5. Providing students with additional English language course	1.33(.52)	1.85(1.41)	1.68(1.20)
6. Science teachers should receive more training on EMI teaching and the knowledge of English language	3.0(1.10)	2.54(.97)	2.68(1.00)
7. Providing additional English explanations and inputs from science teachers	3.5(1.05)	3.0(.91)	3.16(.96)
8. Providing teaching notes to students in both Chinese and English	1.5(.84)	1.77(1.3)	1.68(1.16)
9. Providing students with more feedbacks and corrections on their English use in science	3.5(1.05)	3.31(.95)	3.37(.96)
10. Collaborative teaching between English language teachers and science teachers on the same science topic	2.5(1.05)	1.8(1.36)	2.0(1.29)
11. Students should attend tutorials and seek for study assistants outside school about their science and English	3.17(.75)	2.38(1.33)	2.63(1.21)
Overall score of frequency of coping strategies rated by teachers	4.26(3.57)	3.26(2.50)	3.57(2.81)

Table 6.9. The teachers' responses to the frequency of coping strategies

Notes: The frequency of coping strategies was rated on a 5-point scale, where 1=(untrue of me), 2=(somewhat untrue of me), 3=(neutral), 4=(somewhat true of me), 5=(very true of me).

	Early-full	Late-partial	Both
1. Providing Chinese translation of technical vocabulary	3.17(1.17)	3.23(1.54)	3.21 (1.40)
2. Providing Chinese translation of abstract English vocabulary (not technical, e.g. metaphor)	3.67(.82)	3.46(1.39)	3.53 (1.22)
3. Providing more definitions and exemplification of technical words in English but not necessary to translate them into Chinese	3.67(1.03)	3.08(1.04)	3.26 (1.05)
4. Providing students with more English language instructions from their current English teachers	3.17(1.17)	2.38(1.5)	2.63 (1.42)
5. Providing students with additional English language course	2.17(1.6)	2.69(1.7)	2.53 (1.65)
6. Science teachers should receive more training on EMI teaching and the knowledge of English language	19.5(38.97)	3.0(.82)	3.11 (0.99)
7. Providing additional English explanations and inputs from science teachers	3.83(1.33)	3.08(.86)	3.32 (1.06)
8. Providing teaching notes to students in both Chinese and English	2.33(1.21)	9.69(26.86)	2.26 (1.20)
9. Providing students with more feedbacks and corrections on their English use in science	3.67(1.03)	3.38(.96)	3.47 (0.96)
10. Collaborative teaching between English language teachers and science teachers on the same science topic	3.5(1.64)	2.23(1.59)	2.63 (1.67)
11. Students should attend tutorials and seek for study assistants outside school about their science and English	3.5(.84)	2.69(1.38)	2.95 (1.27)
Overall score of frequency of coping strategies rated by teachers	4.74(3.82)	3.53(2.64)	3.92 (3.01)

Table 6.10. The teachers' responses to the usefulness of coping strategies

Notes: The usefulness of coping strategies was rated on a 5-point scale, where 1=(untrue of me), 2=(somewhat untrue of me), 3=(neutral), 4=(somewhat true of me), 5=(very true of me).

6.4.2 Summary of the questionnaire analyses

The correlations analyses yielded the following findings. Firstly, the teachers with lower self-reported English scores tend to use Cantonese in science

teaching activities. Secondly, teachers with EMI training, but less teaching experience at senior levels, have a higher teaching belief. Those teachers with low self-reported writing score in English believe that coping strategies are useful. The early–full EMI teachers rated the importance of English language skills higher, with higher self-reported English scores as well as higher scores for the four individual language skills, and more language awareness of teaching science through English, as opposed to the late–partial EMI teachers. Finally, the teachers with higher language awareness tend to use more English in science teaching activities. Those with a higher teaching belief in EMI tended to rate lower the importance of English language skills. Those who used more frequent coping strategies also found these strategies useful.

The descriptive analyses of the questionnaire results for the eight aspects of teachers' experiences yielded the following findings. Late-partial EMI teachers believed that their students use more Cantonese than English in science teaching activities. The late–partial EMI teachers rated English language skills as more demanding than did teachers in the early–full EMI schools, but rated the same set of English skills lower in terms of importance than did teachers in early–full EMI schools. This result reflects the same tendency as students in late–partial schools (discussed further in chapter eight). The late–partial EMI teachers also reported lower language awareness in teaching science through

English, suggesting that perhaps teachers in late–partial EMI schools pay less attention to students' language issues.

However, the late–partial EMI teachers had a lower rating in their reflections about science teaching practices in the EMI context. This suggests that EMI has had a negative impact on their teaching. This potentially explains why they rated most of the language challenges higher than the early–full EMI teachers, suggesting that late–partial teachers believed their students encountered a number of language challenges when learning science through English. However, when asked about the frequency and the usefulness of coping strategies, the ratings from teachers in the late–partial EMI schools were lower than those in early–full EMI schools. This suggests that teachers in late–partial EMI schools use coping strategies less frequently and find these coping strategies less useful.

6.5 Semi-structured interviews with science teachers

6.5.1 Background of the teachers interviewed

A total of 19 science teachers were recruited: 6 Physics teachers, 6 chemistry teachers and 7 biology teachers. Two females and 17 male teachers participated in semi-structured interviews after lesson observations on the same teaching day: 5 teachers from early–full EMI schools and 13 teachers from late–partial EMI schools. All the participating teachers had obtained a science degree in their teaching area and held a postgraduate diploma in education (PGDE) from

Hong Kong. One teacher, T9, had obtained a Masters' degree in science education. All identified Cantonese as their first language. Their average teaching experience was 17.47 years (3 to 35 years). Almost none of the participating teachers had any qualifications or had received any training in EMI, nor had they participated in any training related to teaching science through English. Only one teacher, T6, indicated in the questionnaire that she had attended a two-week professional development workshop about language across the curriculum at one of Hong Kong's universities. All the teachers had passed their English Language subject before being admitted to university, meaning that they had demosntrated English proficiency equivalent to a score of 6 or above in the International English Language Testing System examination. Each of the participating teachers was given a pseudonym and a code (T1 to T19) which will be used to in the analysis. The interview and analytical procedures were described in chapter three (section 3.11).

6.5.2 Major themes from the teachers' semi-structured interviews

Each interview consisted of three parts. First, the pre-observation interview aimed to explore the teaching purpose and learning objectives in the lessons that I was about to observe. Second, after the observations, teachers were asked to comment on the lessons. This part of the interview was guided by a list of questions. In particular, I asked the teachers:

1. How did you feel about the lesson? Was the planned learning objective achieved? If yes, how? If not, what needs to be done?
2. What teaching and learning challenges did you experience?
3. Were there any specific events in the lesson that need to be clarified?
4. What has been the impact of EMI on classroom interactions?
5. What has been the impact of EMI on your teaching?

Third, in the second part of the post-observation interview, I asked the teachers for their views on EMI teaching, particularly their opinions on using English to teach senior secondary science, the language challenges they encountered, and the coping strategies that they used. The teachers were given an opportunity to express their views on other relevant topics such as the new science curriculum, comparing the previous seven-year curriculum with the current six-year one.

Teacher interviews were analysed according to seven different areas that related to teachers' views on their EMI teaching experience. The transcripts generated the following themes:

1. Teacher views on teaching experience in EMI science classrooms
2. Language challenges in teaching science through English
3. Coping strategies (in general) and specific coping strategies (examples from a biology class)

4. When to use L1
5. Questioning techniques in EMI classrooms
6. Vocabulary types in EMI science classrooms
7. Other teaching challenges related to the new science curriculum

6.5.3 The results of the analysis of the teachers' interviews

6.5.3.1 Teacher views on teaching experience in EMI science classrooms

Teachers from the late–partial EMI schools strongly believe that the medium of instruction is a just tool for transmitting knowledge rather than a means to prepare students to learn a second language. A late–partial EMI chemistry teacher noted that many science teachers are not good at English. Science teachers do not speak English solely in their classrooms.

Teachers in the late-partial schools generally welcomed a mixed-mode instruction with Cantonese as the matrix language embedded with English scientific terms. The use of L1 in the science classroom allows teachers to easily explain logical relationships, helps them manage students with limited language ability, and also consolidates students' science knowledge as teachers can make the necessary connections with what students have learned previously or what they see in their daily life. A mixed-mode instruction was cited as convenient for both teachers and students, especially weaker students. Mr. Yu, a chemistry teacher at a late–partial school, explained that:

> I generally agree with mixed-mode instruction in class. Cantonese helps consolidate students' knowledge and also it is more convenient for teachers; as you know, many science teachers are not very good at English. In fact, even for EMI schools, I don't think many teachers have completely used English language in class. (T9)

Mr. Chik, a Physics teacher at a late–partial school similarly noted that:

> I think language is a tool to achieve knowledge (in this case, which means Physics), so, it's okay to use any language as long as students understand … Although some students will take English papers, I think using Cantonese to explain physics concepts and the cause-and-effect relations is better for their understanding. (T10)

Mr. Chu, a chemistry teacher at a late–partial EMI school explained:

> I think the motivation or benefit [of using Cantonese] would be [teachers] can have more choices, because you can never force weaker students to adapt to 100% English. (T8)

In sum, using Cantonese is necessary for teachers that have to accommodate students with poor English proficiency, as well as consolidating students' science knowledge and getting them to think deeply in the late–partial EMI schools.

6.5.3.4 Language challenges in teaching science through English

Teachers from the early–full EMI schools stressed that English is the best possible language to teach scientific terms. They reported that English is more convenient for naming the scientific terms, e.g. elements in the periodic table. For instance, Mr Lam, an early–full chemistry teacher, stated:

> If you ask me to tell the Periodic Table in Chinese, I can't… Except Chinese Language and Liberal Studies, all subjects are taught in English, so our ability to express and write in English is not a problem. However, if you ask me to express some concepts in Chinese, that will be hard. T6)

Other teachers said delivering science content in English helps students recall what they learned in other science subjects, which are also conducted in English.

However, when discussing the specific language challenges in different science subjects, teachers from both of the early–full and late–partial EMI schools admitted that their students have a number of challenges. The EMI biology teachers from both groups expressed their concerns about students' analytical, reading and communication skills. They highlighted the following language challenges:

- lack of analytical skills necessary to understand the examination questions, identify the important concepts or interpret abstract questions
- lack of motivation to read extensively about the learned science concepts in textbooks or other sources like the internet

- lack of communication skills in presenting science ideas in a logical, coherent way with adequate use of scientific vocabulary and expressions
- excessive reliance on rote-memorisation
- failure to express science ideas with correct English vocabulary.

Most of the early–full EMI biology teachers said their students did not have good analytical skills. The teachers found their students could not understand the examination questions, identify the important concepts or interpret abstract questions. When reading, students only skimmed through the bullet points and were rarely motivated to read the whole chapter of their science textbooks or to explore the relevant science content in other chapters.

In contrast to the early–full teachers, nearly all the late–partial EMI biology teachers believed their students could not communicate science ideas in English. Teachers said that although students could recall terms in Chinese, they generally did not know English technical terms. Students were reluctant to speak English in the class and found it difficult to raise questions or interact with their peers in English. The teachers also expressed concerns about students not being able to describe and explain their science ideas in simple English. A late–partial EMI biology teacher pointed out that his students could not present any coherent science explanation in English with adequate vocabulary or scientific expressions. He said that students know the science ideas but fail to

organise them in a logical and coherent manner. Students used inappropriate choices of vocabulary, often making their argument incomplete. As Mr. Law, a late–partial biology teacher explained:

> The biggest problem is students are bad at presenting these ideas in exams and tests. This problem is related to their English. They understand the ideas, but since they use inappropriate vocabulary or write incomplete answers, they can't get the marks. Sometimes when it comes to long questions, I can get their points, but their answers are just not coherent. They have so much information, but they don't know how to organise it into a logical argument or explanation. (T11)

Ms. Leung, a late–partial biology teacher similarly noted:

> Students who understand the science concepts often can't express their ideas and logic accurately. I believe this is due to their poor English and lack of adequate vocabulary to describe the abstract science concept. (T12)

Another late–partial EMI biology teacher said that teachers would help students to interpret questions and then help them to memorise the answers and write the answers once by themselves. She added, 'The grammar is not important as long as they apply the right concepts and flow of ideas.'

Ms. Leung, a late–partial EMI Physics teacher, also added that one major concern is that students who attempted to express ideas in their own words often failed to provide the correct explanation. She explained that 'this is due to

students' poor answering skills. I can just ask them to answer in detail.' She approached this problem by encouraging students to highlight key points and cut long sentences into short phrases in order to simplify the abstract and lengthy science content. She said:

> For English students, I will need to take more care of them, since their English ability is relatively low. I have to highlight the key points in the textbook in order to draw their attention to the key words and also to simplify the content needed for memorization … Highlight the conceptual words in questions, hope they can recognise these concepts and be able to understand the questions in the future, in order to have a greater chance to get the marks. (T8)

On rote-memorisation, a late–partial EMI chemistry teacher stressed that weaker students would not spend time unpacking the technical, dense, abstract science expressions. Instead, they would memorise lengthy sentences to describe a science phenomenon in examinations. As Mr. Yu, a late–partial chemistry teacher, explained:

> Students find it difficult to use specific terms to explain a concept. Instead, they just resort to lengthy sentences. Some students don't understand specific concepts and even have wrong concepts, which may be due to their lack of reading textbooks or practising practically. Others simply can't express systematically. (T7).

Similarly, Ms. Leung, a late–partial biology teacher, noted:

> Students directly copy everything from the textbook when answering questions. This is because students get used to the learning style at junior forms … I would remind students and encourage them to critically analyse the science phenomena. (T8)

Overall, the late–partial teachers thought that this attitude towards language use was likely to create significant problems when students attempted to explain science concepts.

A few biology teachers expressed concerns about their students handling the new biology curriculum. For instance, Mr. Wong, an early–full biology teacher said of his students:

> they cannot interpret exam questions accurately; cannot handle important concepts, although these concepts have been questions in public exams for many years; cannot handle abstract questions related to the nature of science. Students' English is not too bad. It's a lack of student motivation to memorise vocabulary and phrases. (T4)

Another late–partial biology teacher, Mr Law, also commented that his students did not read the textbooks enough:

> Textbooks in DSE are being simplified, as content is mainly presented in point form. Therefore, there is not much to read and the books are not as thick and comprehensive as those at A-level. Because of that, I will ask

> them to read extra information, such as the booklets offered by the Department of Health. (T9)

Other biology teachers from the both groups expressed concern about students' communication skills in presenting science ideas in writing and in speaking. Students could not present coherent science explanations in English with adequate vocabulary and expressions. Mr. Ng, a late–partial biology teacher explained:

> I think it is the part they performed the worst. They can't express what they want. Firstly, the technical terms are too difficult, so they don't know how to use them. Secondly, students know the terms in Chinese, but don't know how to present them in English. Thirdly, they don't get used to speaking English. In classroom interaction, students are not so willing to use English to raise questions. I think it is because they don't have many chances and the environment to practise English. (T15)

Another late–partial biology teacher, Mr. Law, said:

> The biggest problem is students are bad at presenting these ideas in exams and tests. This problem is related to their English. They understand the ideas, but since they use inaccurate vocabulary or write incomplete answers, they can't get the marks. Sometimes when it comes to long questions [questions that require comparing and contrasting and systematic explanation], I can get their points, but their answers are just

> not coherent. They have so much information, but they don't know how to organise it into a logical argument or explanation. (T9)

In sum, teachers from both schools highlighted language challenges regarding: students' lack of analytical skills necessary to understand the examination questions, identify the important concepts or interpret abstract questions; students lack of motivation to read extensively about the learned science concepts in textbooks or other sources like the internet; students lack of communication skills in presenting science ideas in a logical, coherent way with adequate use of scientific vocabulary and expressions; students use of rote-memorisation; and students failure to express science ideas with the correct English vocabulary.

6.5.3.3 Coping strategies

Teachers from both groups indicated that they use a range of pre-class activities to accommodate students. Mr Lui (T2), an early–full EMI Physics teacher, said that the use of pre-lab experiment videos could raise students' awareness of the steps necessary when conducting a lab experiment. He would ask his students to comment on what was done in the video and consider what precautions they would need to consider when carrying out the experiment. He found that this motivated students to become more involved, challenged their existing knowledge of science concepts and improved their analytical skills in understanding an unfamiliar situation. Mr Yu, (T9) a late–partial chemistry

teacher, would encourage students to read aloud the questions in class. This strategy helped students explain how to address different questions by identifying the specific question types, such as 'describe' or 'account for.' Mr. Yu (late–partial chemistry) explained:

> When coming across some difficult terms, I will ask them to read them aloud. What's more, they are required to practise past papers and I will teach them how to answer specific question types. (T9)

Late-partial EMI science teachers would encourage students to practise writing explanations for long questions, thereby helping students memorise the adequate scientific expressions. Mr. Law (biology, late–partial) hoped that this strategy would help students develop scientific expression in writing:

> I will provide more training to my students by asking the students to practise how to answer long questions for homework. Students usually perform badly, because the topic is new to them and they have not done any revision yet … I encourage my students to spend time on memorising the adequate scientific expressions; that really helps them to construct an articulated science argument in a logical manner and to connect different technical terms. (T9)

Three early–full teachers (2 physics and 1 chemistry) suggested using various technologies, such as flipped-classroom or text-messenges, to improve the quality of teaching and hence address students' language challenges. For

example, Mr Lui, an early–full Physics teacher, recommended that students learn all the key concepts at home by watching a teacher-prepared video and come back with questions to be discussed in class. He said that this flipped-classroom model can 'create more opportunities for meaningful interaction, and more time for students to ask questions'. As students all watch the same video at home, teachers can ensure that the teaching process is consistent across different classes. This relaxes the teaching process, reducing the time necessary prepare classroom teaching materials. He explains:

> My teaching is more relaxed, as I don't have to shout and students aren't able to disturb my teaching. Also, writing on the blackboard, showing the PowerPoint and waiting for students to copy notes can waste quite a lot of time during lessons. By using this method, if students can't follow, they can just pause the video, and it will waste less time during the lesson. (T2)

Mr. Luk also uses the flipped-classroom model, recognising that it allowed students to:

> do more exercises in class, and generate more discussion around the topic. I see it is an active way of learning, as they could discover what they don't understand or lack. At the same time, they can ask me (teacher) questions and discuss with other classmates immediately to clarify their misconceptions. (T2)

Teachers also reported using other technologies. Mr. Lai, an early–full Physics teacher, found that an e-learning platform similarly increased classroom capabilities by allowing students to learn first at home. He notes:

> An e-learning platform allows students to learn at home and review the teaching materials several times. Students have more questions to ask now. They ask questions almost every day. Students would have more chance to practise their science knowledge via the assignments provided by the e-learning platform. (T3)

He further explained:

> Online teaching video clips are provided and I (teacher) will know whether students have watched or not because there is a record. In addition, if students have asked me questions but the answers have already been mentioned in the video, I will know that s/he hasn't seen the video, but of course, if they still have questions, I will go through the video with them. (T3)

Another late–partial EMI Physics teacher, Mr. Lai, used an e-learning platform during the class to help students to learn physics concepts by interacting with the online learning materials. He said that the e-learning platform could allow students to continue their learning at home and accommodate individual learning differences. The platform allowed him to check students' progress in learning essential science concepts. He also added that students could

overcome their language challenges in English by watching the Chinese video first to understand the main concepts and then watch the English version to master English expressions. He saw this as a means to help students effectively learn both content and the language.

Mr. Lai (early–full, Physics) also provided online material in both Chinese and English versions, recognising that:

> Students can watch the online teaching videos that are presented in Cantonese and in English. Students can choose to watch it in Cantonese, and later in English to ensure they understand science concepts in Cantonese and later the technical terms in English. Students would be reminded to highlight key points in the textbooks and draw simple diagrams to clarify the concepts. I would provide more exercise to help students to practise. (T3)

Several teachers used a mobile text messenger service to facilitate interactive discussions. Mr. Lai said that through this platform:

> students can raise questions any time they like, and they can share YouTube video clips that are related to Physics on WhatsApp group and discuss them together. (T3)

Mr. Yu (late–partial chemistry) uses WhatsApp, but found it only worked for students that were already highly motivated:

> I have set up a WhatsApp group for my students to raise their problems. Students with good results are highly motivated and interactive as they keep asking and answering questions in English but there is no response for students of poor academic results. (T9)

Physics teacher Mr. Lai found that his interaction with students increased significantly after he started to communicate with them using a mobile online text messenger. This tool helped build rapport and relationships with students, allowing students to ask questions at home and share questions and answers with other students. Teachers could also distribute relevant science materials online and create a discussion among students to cultivate their interest in learning extended topics in science.

Specific coping strategies: examples from biology class

A number of biology teachers shared coping strategies used to address students' language issues in studying biology. One biology teacher, Mr Wong, described the nature of study in secondary biology as learning a great deal of vocabulary and their semantic relations in different biological contexts. He explained:

> I think teaching is a way of living. I don't separate different types of vocabulary to teach. Our goal is not making students understand that three kinds of vocabulary. Our goal is teaching students to read and write,

> and then get marks. You will mention technical terms, comparison and keywords naturally while you are teaching a topic. (T4)

A biology teacher from the early–full EMI schools suggested six strategies to promote effective learning. They included:

- Using examples from daily life to demonstrate what students have learnt.
- Asking questions to prompt students' answers, which leads to constructing science explanations together with the students by making summaries.
- Asking more higher-order questions to check students' understanding of the cause-and-effect relationship between different factors and variables of a science phenomenon. This strategy can help students to understand the principle of the experiment.
- Checking students' misconceptions (both in lab and lectures) that are common mistakes in exams (e.g. the difference between sodium hydrogen carbonate and sodium carbonate).
- Connecting students' biological concepts with other science subjects (e.g. reminding students of the properties of water they have learned about in chemistry when teaching the concept of diffusion in biology).

- Drawing simplified diagrams on the blackboard to demonstrate the steps for describing experimental procedures and explaining experiment results. (Through graphic presentations, students can more easily understand the entire process of scientific investigation, and at the end will be able to use words to present the scientific explanation).

One biology teacher from the late–partial EMI schools suggested six coping strategies. The first of these strategies involved dividing students into groups according to their abilities. He explained:

> The groups are divided according to ability, which means smart students lead the weak ones. After the final exam, the group will change again according to the new ranking. It can keep the attraction fresh. At the same time, it reminds strong students that they are the leaders. It is an honour to them, and they will be more active in leading and guiding their groups. If I am working on group exercises, the whole group will get the same score. They need to work on one worksheet. Some students might not be involved, and some might just discuss. It could be bad if only one student works on it. However, I ask all of them to participate, as I will randomly pick one person as the group representative. Therefore, they need to participate in order make sure their scores will not be too bad. (T9)

He also found that he could use the group strategy to help students prepare for exams, where he would have students discuss the questions in a hypothetical exam together.

The second strategy involved using mind-maps to raise initial awareness. He felt that mind-maps were helpful in linking different concepts together and helping students understand how these concepts are developed. This helped students move beyond memorisation.

The third strategy involved writing down important and frequently used expressions on the blackboard, which encouraged students to also write them down and reflect on them at home. The fourth strategy was to highlight the key words in certain questions, such as change and population. He explains:

> I have to do this. The aim is to teach students how to deal with the questions. When we are correcting their exam papers, we are not just looking at whether the expressions are in complete sentences. We are also looking at whether they have presented the key concept. (T9)

He similarly felt that he had to teaching Basic English vocabulary that had special meanings in biology (strategy five):

> You can see I spent some time to teach the meaning of 'lagging behind'. After they understood the meaning, I told them the term lagging behind. Maybe I can try asking if they have learnt it before. If they have learnt it

> before, this would become constructivism, which means building up knowledge from their prior knowledge. (T9)

Strategy six involved forcing students to take notes:

> Actually I am trying to force them to write more and process the idea once more. I hope they are willing write more, then, they will find that it's easier to answer exam questions. I think it is related to a feedback mechanism. Writing is different from speaking and reading. You need to write in order to express your ideas in the exam. Students are just staying at the level that they think they understand. They think they can write it, but they just don't know how to, because they don't practise much. That's why I insist that students jot down notes. Biology requires writing. If you like physics, which mainly focuses on calculation, you don't have to write much. However, if you don't provide a chance or an atmosphere of always listening and writing, they don't have many chances to practise. (T9)

In sum, teachers from the early–full EMI schools suggested a number of strategies they use to help students solve language challenges. They include:

1. highlighting key words and dictations
2. going through past papers (sentence structure in the marking scheme)
3. understanding questioning words

4. going through similar lexical items (e.g. anti-words like antibiotics and anti-body)
5. using multiple-choice questions to consolidate science concepts
6. watching the interactive/lab-experiment videos to arouse students' interest in related science topics
7. reading aloud in class to familiarise the vocabulary and the text
8. practising scientific expressions.

6.5.3.4 When to use L1

Teachers from early–full EMI schools were asked in what situation they would opt for L1. If the school policy allows a mixed-mode instruction, these teachers would likely to use L1 in the classroom and encouraged students to use Chinese when they were finding it difficult to express themselves in English. They found that this strategy often works for students with limited English proficiency. Teachers reported asking their students to translate what the teacher asked into Cantonese and then allowing them to respond in Cantonese. Once students developed confidence in the content, the teacher would then guide them to respond in English through closed questions, thereby reducing the demand on students' output. They would gradually encourage them to produce phrases and short utterances in English with open-ended questions.

These teachers felt that this mixed-mode instruction helped students learn more effectively. Mr. Wong, Mr. Lai, and Mr. Wong respectively reported:

> If they really can't express their ideas in English, I encourage them to use Chinese, because I just want to check whether they understood. Sometimes if they don't understand what I am asking, I will repeat the question in Chinese as well. (T1)

> I use Cantonese when I communicate with students with lower ability individually, rephrasing what the student said and try to correct his wording in English. I provide hints, key words to students, so that they can continue their answer. (T2)

> Students tried to use Cantonese to answer my questions. Firstly, I remind them to try to use English. Secondly, I give them some guiding questions, turning the question from open-ended to close-ended. Thirdly, I give students choices and ask them to pick the right answer. (T5)

Teachers from both early–full and late–partial schools would also consider using L1 in their teaching when explaining abstract ideas and important steps in experiments, as sometimes the experiment could be dangerous. They would also use L1 in giving examples from daily, those terms they understand in Chinese; or when communicating individually with students with lower ability. Ms Chow, an early–full biology teacher, thought that 'an interactive

atmosphere is of vital importance' as it helps to promote the acquisition of scientific knowledge and language. She noted that:

> The learning style of each student varies. Some prefer lecturing and doing exercises while others prefer interaction. What's more, different students have different ways to express their thoughts. Some do better in verbal communication and others in writing. Apart from that, students' attention span is limited, so they will get bored if I keep speaking. (T8)

She suggested a number of ways to create meaningful interactions through questioning and observation: 'Teachers shouldn't say everything, but should leave some space for students to think, although teachers will have to prepare more before class'. She gives an example:

> For instance, when it comes to teaching the topic of plants, I will bring them true fruits to assess the state of the fruit. It is to enhance students' understanding. Students are excited to have such hands-on experience and they are more interested and enthusiastic in biology. (T7)

She also added that she would encourage students to speak in Cantonese first and check their understanding. For those who have problems in articulating their ideas in English, she would encourage them to translate it from Cantonese to English:

> If they have questions for me, I won't reply directly. Instead, I will allow them to generate the answer first. (T7)

In this way, Ms Chow believes that students can build up their confidence and understand clearly the reasoning behind the content, which requires higher-order thinking, which is difficult for students to do in English. Quick mediation through Cantonese can help students to develop long-term memory and reasoning. Other science teachers from the late–partial schools would explain the English expressions and draw attention to students about the different meanings of certain writing styles. For example, one physics teacher paid attention to specific meaning of certain words and explained to students, e.g. that 'what time' in physics is actually asking the duration, and that this meaning is therefore different from everyday English.

The teachers interviewed also suggested a number of way to deal with students who have difficulty in communicating in English. Three science teachers from the early–full EMI schools said they collaborated with English language teachers at their school to improve students' abilities in reading and writing science through English. They communicated with English teachers about their students' language weaknesses (e.g. problems with question words, writing expressions), hoping the English teachers would revisit these language problems in English lessons. Two science teachers from the early–full EMI schools became involved in the Language Across Curriculum class in junior forms to develop students' scientific language competence from junior to senior levels.

6.5.3.5 Questioning technique in EMI classrooms

Science teachers in both early–full and late–partial EMI schools generally used a range of question types such as recalling, higher-order and reasoning questions to promote students' science learning. Mr. Law (late–partial biology) explained:

> asking the right questions is key. I will start to teach the basic concept or content before asking any questions to students. Then, I use a range of questions at different levels, from easy to deep, to help my students to consolidate their science understanding. (T9, late–partial, biology)

Teachers tended to use recalling questions frequently, to remind students of what they had learned previously. Mr. Wong (early–full biology) reported that 'students have no problem in answering recall type questions'.

Teachers only used higher-order questions according to their teaching topics. One biology teacher from early–full EMI school, Mr Wong, said that as students may not be able to express themselves in complete English sentences, teachers have to use higher-order questions skillfully, perhaps through the mediation of the L1. Teachers also used a number of reasoning questions in students' discussion, such as of past papers, to which students could provide their answers in short English phrases. Mr. Chik, a physics teacher from a late–partial EMI school, said he loved using reasoning questions:

> I don't really focus on technical details in class, as I think the most important thing in teaching is reasoning, because all the topics rely on reasoning and critical thinking. (T18, late–partial, physics)

Mr. Wong (early–full biology) suggested the following sequence of questioning techniques. He would start by using factual recall-type questions to remind students of the factual information about science topics, which he felt also involved them in the class. If they could grasp these questions, he would move to higher-order questions which aim to increase student-student interaction on the key concepts. He noted:

> High-order questions are not applicable in every lesson, but are good if I can apply them, because they can raise many interactions and discussions. Students will also be more concentrated, because they need to think. (T4)

Later, he would supplement this with reasoning questions. Students would thus engage with the topic and be stimulated to use cognitive thinking skills on the cause-and-effect of the science concepts.

Ms. Leung, another biology teacher from a late–partial school, added that the higher-order questions play an important role in teaching biology. She said the one major obstacle to using higher-order questions is students' English level. Higher-order questions require students to have high cognitive thinking in order to apply what they have learned to a completely new context. Ms Leung explained:

> This requires a good command of English language in order to produce accurate English. If students want to improve, I guess it depends on whether they come to ask me. (T8).

Mr Wong's and Ms Leung's cases perhaps have illustrated there is a need for high levels of langauge (ie. L1) in order to engage in higher order thinking in learning science.

6.5.3.6 Vocabulary types in EMI science classrooms

Teachers from both early–full and late–partial EMI schools pointed out that there were three typical types of vocabulary that students would encounter in learning science: basic English vocabulary, academic vocabulary and scientific or technical vocabulary. Many science teachers from both types of schools admitted in the interviews that their students had more problems with basic English vocabulary. For example, Mr. Chu, a late–partial chemistry teacher, said:

> My students do not have grammar problems, but they can't understand the words in simple English (e.g. account for). I think by learning chemistry, students cannot deal with their language problem. Students would need to do more exercises. (T17)

This is not only the case in the late–partial EMI schools; early–full teachers reported that their students also often misinterpreted what the teachers said and were confused by the other meanings and usage of certain words or

phrases that were taught in their English lessons. In addition, some students made careless pronunciation or spelling mistakes, for instance they mispronounce the word 'damage' as 'demage'. As Mr. Wong (early–full biology) states:

> I think they have no problem in handling technical terms, as we will teach them anyway. The problem is handling simple English, as students don't usually see them. I don't think I can help much, but maybe they can do more exercises to learn more words. (T1)

Although teachers generally believe students do not have problems with scientific vocabulary, a few biology teachers from both types of EMI schools found that their students did have problems with their scientific vocabulary. This may be in part because students were expected to acquire more scientific vocabulary in biology than in other science subjects. Mr. Wong reflects:

> Students need more practice in order to become familiar with the different types of vocabulary and understand the keywords in the questions as some students don't even understand what 'account for' means. This reflects their poor problem solving skills. (T1)

To help students master scientific vocabulary, four biology teachers from both types of schools suggested that they could help students translate things into simplified English and then encourage them to use new acquired technical

terms. For example, when students refer to metabolic reaction in photosynthesis, students can answer with the term 'anabolism'.

The problem of dealing with scientific vocabulary is not limited to biology. Mr Yuk, a chemistry teacher from the late–partial school, said his students sometimes 'mess up' the different wordings, such as 'strong bonding' and 'giant structure' writing 'strong structure' and 'giant bonding' instead. This reflects on students' unclear understanding of two similar concepts. One strategy to overcome this problem is to provide students with an expression to deal with two similar concepts. A physics teacher, Mr. Chik, from the late–partial school, suggested that he would provide 'a fixed structure (like a template)' for students to deal with different kinds of questions, such as reasoning and description for describing physical properties.

A number of science teachers from the two groups said that students with poor vocabulary struggle with writing, especially when students are asked to write an essay to explain a scientific phenomenon. This situation is more serious in biology. Students with a poor vocabulary produce a science essay which is poorly organised and does not elaborate the cause and effect relationships.

Mr Wong, a biology teacher from an early–full school, suggested a number of ways to help students with poor vocabulary write essays. He would explain the essay problems in class by providing authentic examples for students to follow and might ask his students to draw a concept map before writing an

essay. Another strategy was to ask students to produce short paragraphs and then connect a number of short paragraphs in a structured essay. He would elaborate in detail about what students should write in the introduction, body and conclusion. He added that teachers should ignore whether students' essays are grammatically correct or not until they grasp basic writing skills. Ms. Leung (late–partial biology) suggested her students to use a notebook:

> I want my students to spend more time on technical terms. I encourage my students to have a notebook marking their own vocabulary list for biology. In the pubic exam, spelling of the key technical terms has to be correct. (T8)

A number of science teachers believed that poor vocabulary is a major cause of poor English abilities, thereby affecting their communication skills in science. For example, Mr. Yu, a late–partial chemistry teacher, described his students as:

> not good at calculation, which may be due to language problems. They are also poor in understanding abstract concepts, writing equations and calculations. Thus, they had problems in answering descriptive questions, like, explaining properties. (T7)

A biology teacher, Mr Wong, from an early–full school, said students who do not have adequate vocabulary for learning biology sometimes mix up words with similar meanings, such as 'antibody' and 'antibiotics'. He added that he would do more dictations with students to help them remember the necessary

vocabulary and expression in biology. He believed that students with higher language ability would definitely benefit in biology as they can produce a clear presentation of science explanations that teachers find easy to mark.

Mr. Leung, a late–partial physics teacher, described why he thought teachers would need to improve students' language and vocabulary:

> In exams, if students get concepts wrong, it's fine, because once they read the textbook they would be able to catch up. But what students really need to improve is their language – sentence and word structure. (T8)

This view is not shared by other science teachers. Mr. Ng, a late–partial biology teacher said:

> memorising all the technical terms doesn't mean students can handle all questions because we are talking about an idea. It's not satisfactory even if I use Chinese. Therefore, students might really need some special sentence structure, such as lagging behind and A increases and then B increases, followed by A. (T15)

In other words, what students are struggling with is not only language but also how they communicate their science ideas through language.

6.5.3.7 Other teaching challenges related to the new science curriculum

In the most of the teacher interviews, teachers raised questions about the new science curriculum and the associated teaching. Although this is not the focus of

my research, the issues raised from the new curriculum are worth noting as they came up frequently during the interviews.

Teaching students with diversified science backgrounds

Most of the teacher respondents interviewed found it hard to accommodate students with a diversified science background. While some students study physics, biology and chemistry, the majority of them only study one or two of the science subjects. Teachers felt that although it is good for students to freely choose their electives in arts and science, this may suggest that students do not have a comprehensive understanding of science if they only study one science subject. For example, Mr. Wong (early–full biology) pointed out that 'sometimes we have to cover the knowledge in other science subjects, such as oxidation, reduction and the chemical nature of minerals.' He stressed that he and many of his colleagues need to spend additional time to cover basic science knowledge for those only studying one science subject. Mr. Law (late–partial biology) similar noted: 'In a number of biology topics that require concepts in other science subjects, students might not be able to understand.'

In addition to other science concepts, teachers reported needing to teach basic maths concepts, such as graphs, x-axis and y-axis, as not all students are studying advanced-level mathematics. For instance, a chemistry teacher, Mr Chiu, needed to teach students the concept of an intercept for interpreting

scientific diagrams when teaching students about the 'concentration diagram'. Mr. Lui (early–full physics) reported:

> Since DSE students can choose their science electives freely, they do not have concepts from A-math, physics, chemistry and biology at the same time. In the first 2 years, I (physics teacher) did have to cover content related to other science subjects and repeat maths concepts. (T2)

Mr. Chiu (late–partial physics) recognised that this is a problem of 'the worst students:'

> they can't even handle the 1st year secondary curriculum. The school-based assessment done by the students was terrible; they didn't read or understand the questions and just copied the content in the textbook. They didn't understand the whole experiment and they had problems in maths (e.g. units and ratios). I need to spend a lot of time to go through maths concepts in class, especially mode and ratios. Students are used to calculating things one by one, instead of group by group. They also can't visualise a picture or a process in their mind. (T17)

Mr. Chu (late–partial chemistry) stressed the consequences of missing some basic mathematical concepts in learning science:

> I think due to poor maths concepts, students can't understand the content in chemistry. It's because when it comes to a chapter related to maths,

> students who are bad at maths are not able to handle it. However, they have no problem in understanding bonding. (T17)

When the teachers delivered additional maths or related science concepts to students, they would do it in a special sequence to reinforce students' understanding. For example, they would use a step-by-step approach in teaching maths in chemistry, visualising the non-verbal parts, reading aloud the logical connections, or adopting a problem-based solving approach by simply applying the necessary concepts from other science areas without much explanation of theory. Mr. Lam (early–full chemistry) explains the step-by-step approach:

> We need to spend some time to go through maths concepts. When I introduce a new maths concept, I will first define it, and then give the formula and teach them how to use a calculator to do the calculations. I will also provide them the steps for calculation. These steps can be a template for students to follow. At first, I require students to write all the steps, but later when students master the ideas and concepts, they can simplify these steps as long as they get the right answer. (T5)

Ms Leung, a late–partial biology teacher, explains the technique of visualising the non-verbal parts and reading aloud the inter-connections:

> I will recap knowledge of drawing graphs, tables and scope, which are present in biology. Usually, I will let them draw the graph or table

> without any reminder. I will correct them when it is necessary. It is not a waste of time to recap those science concepts as they are inter-related. (T14)

Mr. Yu (late–partial chemistry) explains the problem-based solving approach

> I have to recap some of the physics/biology/chemistry in class for students with only one science subject. It would be better if students understand what I am teaching but if they don't understand, I have to make more mental effort to solve the problems. They are also poor in mathematics, like the 'Log' topic. (T7)

Overloaded teaching, too many topics

Teachers generally believe there are too many topics for students to learn in the new three-year science curriculum, referred to by teachers as the 'DSE'. The majority of the topics are adapted from the previous Certificate Examination (CE) curriculum and only 20 to 30% of these topics are from the Advanced Level (AL) curriculum. Ms. Leung (late–partial biology) felt that 'We have many more students in the Diploma of Secondary Education (DSE) than AL, which has greatly increased our workload,' a sentiment that was shared by other teachers. Ms. Leung also noted:

> DSE papers only have one level of difficulty. It doesn't design any other level to accommodate weaker students. Before in CE and AL, students had to study a two-year syllabus at once, which is quite hard already. Now in

> DSE, students even have to study a 3 to 4-year syllabus at once, which is even harder. (T8)

She felt that:' there are big differences between students' ability in senior school science, so teachers can only take care of smart and weak students, but not average students.' The overloaded curriculum and more students in each class also provided fewer opportunities for students to have hands-on lab experience. Mr. Wong (early–full biology) reported:

> Due to limited time and instruments in the DSE curriculum, students can't do the experiments themselves. This is not good for science students, as you can see some students have high motivations to learn, but only observing the experiments can't satisfy their needs. (T1)

Ms. Chow (early–full biology) found that the overloaded teaching curriculum in biology challenged students' comprehensive knowledge:

> There are so many things students have to cover so that they can't review all of them in a short time before the examination. Students always think they could copy something from textbooks as the answer but in fact, there is nothing they can copy from books since we are now testing how much students can apply their learnt knowledge instead of rote learning the content. They are not aware of the focus of each question type. (T6)

She also explained:

> Even though students understand the biological concepts, they fail to provide exact wordings in biology and do not follow the required pattern in their answers, which is expected in public examinations. Instead, students just write down a descriptive and general expression without directly answering the question.

Similarly, other teachers found that students failed to provide critical scientific explanations, giving general descriptions instead.

Rearrangement of teaching topics according to students' levels

Teachers reported spending extra time re-organising their teaching units in order to more explicitly link relevant science topics in other chapters of the curriculum textbook. The teachers from both types of EMI schools said they needed to rearrange their teaching sequences in order to accommodate their students' needs and their level of science knowledge. Mr. Wong (early–full biology) reported:

> DSE has covered some of the AL topics, but they grouped all the related topics together, without considering the difficulties. For instance, it arranged cell division and cycle before reproduction in F.4, as it's better for students to learn cell before reproduction. However, it didn't consider DNA in cells would be too difficult for F.4 students. Therefore, teachers in DSE have to arrange the teaching sequences carefully, instead of just following the curriculum. (T1)

Teachers from the early–full EMI schools reported that students had difficulty in making connections between related science topics in biology. Some students used simple English rather than scientific English reflecting that they did not have clear sense of concepts. Mr. Wong noted:

> There is poor correlation between different topics in biology. Topics in biology are interrelated. If students can't master different topics, it's hard for them to handle the essay question. Students who use simple English rather than technical English reflect that they do not have clear concepts in biology. Their answers are usually open to interpretation, and these answers are not accepted by teachers; thus, students get no marks. (T4)

Similarly, Mr. Lam (early–full chemistry) found that:

> Students are weak at interconnection across related topics (e.g. inorganic chemistry). They are also weak at pentagons and hexagons, they don't know how to draw them and divide the structure, e.g. they forget to add 'H'. For normal reactions, students are weak at the condition and reaction parts. (T5)

Teachers suggested that they would highlight the key words that are important to a science concept, conduct a lab demonstration to visualise the science concept, and then make the connection between the observation and the explanation. Some teachers would use a 'mind-map' to systematically record

the science concepts and their interrelationships, which they felt might help students to understand the concept better. Mr. Lam stated:

> My strategy is … when I start a new topic, I will point out which words are important. As mentioned, students are weak at the condition and reaction parts, so I will let them do the experiment once and use a mind-map to facilitate their memorisation of these parts. I will classify the observation and chemical equation of each topic for them. (T)

He explained that mind-maps 'can connect ideas systematically across different topics, as students might have forgotten part of the interrelationship as time passes by. Mind maps are an effective way to enhance better understanding and memorisation of scientific ideas.'

A biology teacher, Mr Law, from the late–partial EMI schools suggested a number of coping strategies to address the problem of having diversified science backgrounds in late–partial EMI schools. These strategies include:

1. Be confident enough to use English in teaching
2. Switch to Cantonese when students do not follow in English and ask questions consistently to check students' comprehension.
3. Use concrete examples to explain abstract ideas;
4. Develop students' in-depth, concrete understanding by listening to my explanations, then teacher's demonstration, and later students' practice.

5. Encourage students to do more practice in tutorial lessons, especially for the weak students to consolidate their learned concepts.

Overloaded curriculum with limited study-time

Teachers suspected that the overloaded curriculum with a wide range of broad topics was too much for students to master all three-year course materials in eight to nine months. Under the previous curriculum students were expected to study for 1.5 years at A-Level or 2.5 years at CE-level. Teachers like Mr. Law (late–partial biology) reported that students with poor time management skills might not be able to memorise all the science content. Some students are not able to handle difficult questions derived from the AL curriculum. Mr. Chu (late–partial chemistry) reports:

> Students generally need help to handle the AL part due to their low ability and low motivation. They generally don't understand and often make careless mistakes, because they have bad language and maths concepts. (T17)

Additionally, students may not find their senior science experience fulfilling. Most students made their choices of senior science electives in grade 9 and usually based this on what they learnt from integrated science in junior forms. However, integrated science does not reflect the exact content or the requirements of the discrete science subjects like biology, so some students might find that they did not enjoy learning their chosen science subjects in

senior forms. Mr. Chik (late–partial physics) shared his views on two difficulties in the new science curriculum. First, students with lower ability cannot handle the content or the relevant questions from the previous curriculum:

> If you don't understand, you will not understand even if I explain it to you once more. So, some students can never understand the AL content in DSE. (T18)

Second, the new curriculum has created a high pressure learning environment for students, and teachers find their students generally have low self-esteem in their abilities to learn science:

> Before, students understood everything in CE, but couldn't get good grades just because the questions were difficult or indirect. Now, students can't understand the AL content. It is too difficult and they don't know what's going on during class. DSE is elitist: students with lower abilities are just accompanying. Although they might get a pass at the end, it's lowering their self-esteem. I don't think DSE is an appropriate exam for students.

Declining status of science subjects in the new curriculum

A number of teacher respondents expressed their concern about the declining status of science subjects in students' minds, as these science subjects receive less emphasis in the calculation of university admissions. Some teachers shared

their observations about the change of students' attitude towards science subjects. Mr. Lui (early–full physics) reported that:

> Smart students drop physics in order to spend more time on the other subjects that they perform better in. Some lower-ability students still stay here as they have no choice because they perform badly in other electives. This causes low motivation. In the past, science electives could determine whether students are admitted to university. Now, core subjects are more important. You can see our role and status have changed and this again causes low motivation. (T2)

Gender difference in selecting the MOI for public exams

Some late–partial EMI schools allow their students to opt for a Chinese or English version of the public examination. Generally, one might expect that students would do better in public exams if the language is L1. However, such claim cannot be verified because there is no available figures on the students' science achievements between Chinese and English version of exams. Teachers reported there was a gender difference regarding their science achievements. Male students would choose Chinese as the language for the examination because they can reduce their language barriers and perform better than female students in science. Mr. Chu (late–partial chemistry) explains:

> There are more girls taking English papers, perhaps because girls' English skills are better. However, they don't understand and read quite slowly.

> More boys choose to take the Chinese paper. They perform better than the girls in terms of science achievement as they do not have any language problems in understanding the content and expressing themselves in written Chinese. (T17)

In sum, these teachers discussed the other teaching challenges related to the new science curriculum covering eight different topics:

1. teaching students with diversified science backgrounds
2. overloaded teaching, with too many topics
3. rearrangement of teaching topics according to students' level
4. overloaded curriculum and limited study-time
5. declining status of science subjects in the new curriculum
6. gender differences in selecting the MOI for public exams.

6.5.4 Summary of the teacher interviews

The above analysis has explored the views of science teachers in early–full and late–partial EMI schools on their teaching experience in EMI science classrooms. In the semi-structured interviews, the participating teachers were asked about their perception of EMI in science classrooms.

Eight recurring themes were identified from the teachers' interview transcripts: 1) teacher views on teaching experience in EMI science classrooms; 2) language challenges in teaching science through English; 3) coping strategies;

4) dealing with students with difficulty in communicating in English; 5) when to use L1; 6) questioning technique in EMI classrooms; 7) vocabulary types in EMI science classrooms; 8) other teaching challenges related to the new science curriculum.

As the discussion indicated, the teachers from both the early–full and late–partial EMI schools shared similar views about numerous aspects of their EMI teaching experiences, which I summarise below.

6.5.4.1 Views shared by teachers from early–full and late–partial schools on English as the MOI

1. Many science teachers reported that they are not good at English themselves (none of the early-full and late-partial teachers who participated in the interviews agreed that they speak good English as indicated in their lower score in their self-reported English speaking in appendix L) and thus use Chinese in addition to English in their classrooms. They generally welcome a mixed-mode instruction with Cantonese as the matrix language embedded with English scientific terms. The use of L1 allows teachers to easily explain logical relationships, provide comprehensive explanations to students with limited English, and consolidate students' knowledge by making connections with daily examples.

2. Students' analytical skills, reading skills and communication skills are the major concerns highlighted by science teachers. Students have problems in presenting science ideas in writing and speaking. Students may not understand examination questions, identify important concepts, or interpret abstract questions. They cannot present coherent science explanations in English with adequate vocabulary and expressions.
3. Teachers suggested that the use of technology, such as a flipped-classroom, e-learning platforms, online materials with Chinese and English versions, and text messengers, improve the quality of teaching and hence address students' language challenges.
4. Biology teachers perhaps pay more attention to students' language problems. Two biology teachers from early–full and late–partial EMI schools shared coping strategies to address language issues and improve their students' English abilities in studying biology.
5. When asked about when teachers should use L1, the majority of late-partial teachers said they use L1 for students with limited English abilities and when referring to everyday examples that might be common in Chinese. Some of these teachers prefer L1 first and then recap in L2, particularly in the following situations: when explaining abstract ideas; when explaining important steps of dangerous

experiments; daily life examples, only known in Chinese; or when communicating with students with lower ability individually.

6. Teachers generally used a range of question types, such as recalling, higher-order and reasoning, to promote students' science learning. Preference for types of question was different between groups. Teachers from early–full EMI schools frequently use recalling questions to remind students what they have learned previously. Teachers from late–partial EMI schools use more reasoning questions to develop students' skills in reasoning and critical thinking. One possible reason for the different preferences is that late–partial EMI teachers mediate through Cantonese, avoiding using English and/or technical terms, and thus focus more on the reasoning behind science concepts. Teachers in both groups used reasoning questions in students' discussions where students could provide their answers in short English phrases.

7. One biology teacher from early–full EMI schools suggested a sequence of questioning: start by using recall questions to remind students of the factual information and involve them in the class interactions. If they grasp the concepts, follow with higher-order questions which aim to increase student-student interaction and discussion on key concepts. Later, supplement with reasoning questions. The teachers felt that through this technique, the students' cognitive thinking is stimulated.

8. There are three types of vocabulary that students encounter in learning science: basic English vocabulary, academic vocabulary and scientific or technical vocabulary. Students had more problems with basic English vocabulary than technical vocabulary because they misinterpreted their meanings in science and confused them with other meanings in English lessons. Students also mixed up the meanings of some technical vocabulary in different science contexts
9. Teachers believe that students' poor vocabulary affected their writing ability, especially when students are asked to write an essay to explain a science phenomenon and particularly in biology. Some teachers suggested techniques such as drawing a concept map and/or producing short paragraphs with logical and coherent ideas and then connecting a number of short paragraphs into a structured essay.
10. Teachers also believe that poor vocabulary affected students' communication skills.
11. When asked about the expectation of students' science achievements in EMI classrooms, the majority of science teachers hoped their students would master the key science concepts, develop strong observational skills, improve their analytical and critical thinking skills, and ultimately show a strong interest in science and its application in our society.

6.5.4.2 Points of difference between early–full and late–partial teachers on English as the MOI

1. Teachers from the late–partial EMI schools strongly believe the medium of instruction is just a tool for transmitting knowledge, rather than a means for preparing students to learn a second language, while teachers from the early–full EMI schools stressed that English is the only preferred language because most of the scientific terms are from English, e.g. teaching the periodic table, labelling organic compounds.

2. Teachers from the early–full EMI schools pointed out that students face a number of language challenges when learning biology through English. They expressed their concerns over their students' analytical skills, reading skills and communication skills. One major concern is that students who attempted to express themselves in their own words often failed to provide a correct explanation.

3. In the late–partial EMI schools, teachers said rote memorisation was problematic for weaker students who did not spend time unpacking the technical, dense, abstract science expressions. These students only memorise lengthy sentences in order to describe a science phenomenon in examinations.

4. Teachers from the early–full EMI schools suggested a number of ways to help students solve their language challenges by making the English more accessible to students with low English ability, for example,

highlighting key words and dictations, understanding questioning words, and going through similar lexical items (e.g. anti-words like antibiotics and anti-body).

5. When dealing with students who have difficulty communicating in English, the two groups had different approaches. A few teachers from early–full EMI schools reported that they collaborated with English language teachers at their school to improve students' abilities in reading and writing. The majority of teachers, particularly in the late–partial EMI schools, use Cantonese in teaching and encourage students to explain in L1.

Teachers from both groups also expressed a number of concerns and teaching challenges related to the new science curriculum. They shared their views on: 1) teaching students with diversified science backgrounds; 2) overload teaching, too many topics; 4) rearrangement of teaching topics according to students' level; 5) overload curriculum and limited study-time; 6) declined status of science subjects in the new curriculum; 8) gender makes a difference in selecting the MOI for public examinations. The teachers from both the early–full and late–partial EMI schools shared both similar and differing views.

6.5.4.3 Views shared by early–full and late–partial teachers on challenges of teaching the new school curriculum

1. Most of the teacher respondents found it hard to accommodate students with diversified science backgrounds. Some students study Physics, biology and chemistry, but a lot of students only study one or two of the science subjects. Teachers need to spend additional time to cover the basic science knowledge for those only studying one science subject. This caused teachers to teach outside their science expertise, such as teaching basic maths concepts or related science content.

2. Teachers generally believe there are too many topics for students to learn in the new 3-year science curriculum. The majority of the topics are adapted from the previous CE curriculum and only 20 to 30% of these topics are from the AL curriculum. The consequence is that these overloaded topics are perhaps less coherent and organised in a manageable manner.

3. Teachers need to spend extra time re-organising their teaching units in order to make the connection between relevant science topics in other chapters more explicit.

4. Teachers reported that the increased teaching loads effected the amount of time they could spend with students; one teacher found she focused on the smart and weak students, while average students were ignored.

The overloaded curriculum also provided fewer opportunities for students to have hands-on lab experience.

5. The overloaded curriculum also created a challenge for students to master all the three3-year course materials in eight to nine months. Teachers reported that their students could not memorise all the science content and very often made careless mistakes. They did not seem prepared for public examinations.

6. Students sometimes did not find their senior science experience fulfilling. Most students made their choices of senior science subjects based on their learning experience in junior integrated science, which does not reflect the exact content or requirements of the specific science subjects.

6.5.4.4 Points of difference between early–full and late–partial teachers on the new curriculum

1. Teachers from the early–full EMI schools reported that students had difficulty in making connections between the related science topics in biology. Some students used simple English rather than scientific English. reflecting that they do not have a clear understanding of concepts in biology.

2. In late–partial EMI schools, students often drop the challenging science subjects in Grades 11 or 12 so that they can spend more time on subjects

which they perform better in to get a higher chance of being admitted into university.

3. Some late–partial EMI schools allow their students to opt for a Chinese or English version of the public examination which teachers thought created a gender difference in science achievements. Male students choose Chinese as the language for examinations because they can reduce their language barriers while female students were often better at language; thus, male students often performed better than female students in science.

6.6 Summary of the chapter

This chapter has reported on the survey data and interview data of teachers' perceptions of their EMI experience in both early–full and late–partial EMI schools. A total of 19 teacher surveys were collected and analysed for eight different aspects of teachers' EMI experience. Correlation analysis shows that a number of teachers' demographic characteristics (e.g. teacher's self-reported English overall scores) correlate with the teachers' perceptions of their EMI experience, suggesting that the teachers with lower self-reported English scores tend to use Cantonese in science teaching activities. The early–full EMI teachers rated the importance of English language skills higher, with a higher self-reported English scores as well as four individual language skills, and more

language awareness of teaching science through English, as opposed to the late–partial EMI teachers.

The descriptive analysis shows a similar results of teachers' perception between early–full and late–partial EMI schools. The late–partial EMI school teachers believe their students use more Cantonese in science teaching activities. They had a lower language awareness in teaching science through English, suggesting that these late–partial teachers might pay less attention to their students' language issues. On one hand, the late–partial teachers feel that English language skills are demanding for their students but they also feel that the same set of English language skills are less important for their students in learning science in the EMI classrooms. They believed that their students encounter a number of language challenges when learning science through English. Thus, these teachers had a poor reflection on their science teaching practices in the EMI context as a result of higher number of language challenges their students encountered in EMI classrooms. This same tendency is observed in the late–partial EMI student group (and will be further discussed in chapter eight). The late–partial EMI teachers also reported they used relatively fewer frequent coping strategies and found these coping strategies less useful.

Third, the qualitative interview analysis suggests the early–full and late–partial teachers shared a similar view about many aspects of their EMI teaching experience. Late-partial school teachers generally welcome a mixed-mode

instruction and should allow optimal use of L1 in the science classrooms for different purposes. For examples, they said L1 can help to explain cause-and-effect relationships, provide comprehensible explanation to students with limited English, and also consolidate students' knowledge by making connections with daily examples. However, both groups of teachers' perception of EMI is different. The late–partial teachers strongly believe that the medium of instruction is just a tool for transmitting knowledge rather than preparing students to learn a second language. The early–full teachers stressed that English is the only preferred language to teach scientific terms.

Students' analytical skills, reading skills and communication skills were the major concerns highlighted by science teachers. Students have problems in understanding examination questions, presenting science ideas in writing and in speaking. They cannot present coherent science explanations in English with adequate vocabulary and expressions. This is more serious in the early–full EMI schools as reported by the interviewed teachers. This is the reasons perhaps why some of the interviewed teachers would use L1. The majority of teachers said they would use L1 for students with limited English abilities. For examples, L1 is used when explaining abstract ideas; daily life examples, or when communicating with students with lower ability individually.

When dealing with students with difficultly in communicating in English, the two groups of teachers had different approaches. Under the Education

Bureau's initiation with more emphasis on language across curriculum (Education Bureau, 2017), a few interviewed early–full EMI teachers reported that they had collaborations with English language teachers at their school to improve students' abilities in reading and writing science through English. The late–partial EMI teachers would use optimal Cantonese in teaching and encourage students to explain in L1. Both groups generally use a range of question types to promote students' science learning but the preference is different between groups. Teachers from early–full EMI schools use more recalling questions frequently to remind students of what they had learned previously, while late–partial teachers prefer using reasoning questions (i.e. mediating through Cantonese) to develop students' skills in reasoning and critical thinking.

In the next chapter, I present the analysis of surveys and interviews with students about their EMI experiences. A total of 545 students from early–full and late–partial EMI schools are compared in terms of their choice of instructional language for science teaching activities, their views on the most demanding and important English language skills, their teaching beliefs about EMI classrooms, their language awareness, and the language challenges and coping strategies. ■

An exploratory study of the teaching and learning of secondary science through English in Hong Kong

CLASSROOM INTERACTIONS AND PERCEPTIONS OF TEACHERS AND STUDENTS

Jack PUN, kwok-hung

St Antony's College

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Chapter 7

Result (III): The science students' perceptions of their EMI experiences in science classrooms

7.1 Introduction

In the previous chapter, I presented an analysis of teachers' perception of their EMI experiences, comparing teachers from early–full EMI schools and late–partial EMI. The two groups of teachers shared similar perceptions of their EMI teaching experiences, differing primarily in their views of which were the most important English language skills for students studying science in English and the extent of the teacher's language awareness in teaching science through English.

This chapter reports on students' perceptions of their EMI experiences. The results presented in this chapter address RQ5: What are the students' perceptions of learning science through EMI? I report on the 545 students' survey results from the early–full and late–partial EMI schools. In addition, I compare grade 10 and 11 students in each school type. The questionnaire was similar to the teachers' one. It asked the students to rate their preferred choice of instructional language in science learning activities and to indicate what they

thought were the most demanding and important English skills, their reflections on EMI in general, their self-concept in science and the language challenges that they encountered and strategies that they used in learning science through English.

7.2 Students' perceptions of their learning experiences in EMI science classrooms (questionnaire data)

This section presents a detailed analysis of data and findings about the students' perceptions of their EMI learning experiences in science classrooms based on their questionnaire responses.

7.2.1 Demographic characteristics of the student respondents

Five hundred and forty-five students from early–full and late–partial EMI schools in grades 10 and 11 returned their questionnaires, with a total response rate of 90%. The questionnaire consisted of six scales which explored the students' responses to their experiences in EMI science classrooms: the students' demographic characteristics; their preference of instructional language in current science classrooms; the most important and demanding English language skills needed to study science in English medium; their reflections on science learning in the EMI context; their self-concept in learning science; the language challenges they encountered; and the usefulness and the frequency of using coping strategies. Table 7.1 shows the demographic characteristics of the participating students for gender, school types, age range,

previous medium of instruction (MOI), science and English language achievements, and self-reported English skills.

Characteristics	**Student returned questionnaires (n=545); response rate= 90%**	
Group, n, (%)	Early-Full EMI schools	Late-Partial EMI
	n=284 (52%)	n=261 (48%)
Grade 10	106	144
Grade 11	178	117
Sex: Male	101 (19%)	136 (25%)
Female	182 (33%)	125 (23%)
Age: 15	0	40 (7%)
16	56 (10%)	102 (19%)
17	150 (28%)	88 (16%)
18	59 (11%)	24 (4%)
19 or above	19 (3%)	7 (1%)
First language		
Cantonese	282 (52%)	258 (47%)
Mandarin	2 (0.4%)	3 (1%)
Place of primary education		
Hong Kong	282 (52%)	258 (47%)
Mainland China	2 (0.4%)	3 (1%)
	Mean (SD)	
Chinese Language achievements from last year's school exam	3.22 (1.06)	3.11(.91)
English Language achievements from last year's school exam: Listening	2.73(1.02)	2.61(.90)
Speaking	2.67 (1.05)	2.75 (.844)
Writing	2.8(.98)	2.77(.87)
Reading	2.75(.98)	2.54(.84)
Science achievement from last year's school exam	2.9 (1.02)	2.49 (.79)

Table 7.1 Characteristics of the student respondents

7.2.2 Checking the internal consistency of survey items in five aspects of students' perceptions

Cronbach's alpha reliability analyses were run in order to check for internal consistency among each of the questionnaire items included in the students' perception questionnaire. The analysis summarises the underlying patterns of inter-correlation among the different variables in the questionnaire by reducing the data into a smaller number of clusters of related items. The Cronbach's alpha coefficients for each scale of the students' questionnaire (i.e. language choice in science activities, demanding English, etc.) were calculated in order to check for the reliability of the underlying questionnaire items. All of Cronbach's alpha coefficients were larger than 0.7 (except students' reflections on their MOI), suggesting that the items had relatively high internal consistency. Students' reflections on the impact of MOI on their science learning (three items) were not included for the analysis of correlation between other variables of the other five scales. The survey data measuring students' perception of their EMI experience and their internal consistency are displayed in table 7.2.

Code	Description	Cronbach's alpha (α)
1. Language choice in science activities	choice of instructional language in different science teaching activities (13 items)	.922
2. English demanding	the most demanding English language skills for students to study science in English medium (17 items)	.928
3. English important	the most important English language skills for students to study science in English medium (17 items)	.955
4. EMI reflect	Student's reflections on the impact of MOI on their science learning (3 items)	*.519^*
5. Self-concept	Student's self-concept in learning science through English (7 items)	.781
6. Belief	Student's beliefs about instructional activities in learning science through English (9 items)	.722
7. Challenges	Students' views towards the language challenges for students when learning science through English (27 items)	.949
8. Frequency strategy	Students' views towards the frequency of the coping strategies. (9 items)	.759
9. Usefulness strategy	Students' views towards the usefulness of coping strategies. (9 items)	.821

Table 7.2. Cronbach's alpha reliability for the five scales of questionnaire variables

Note: ^= Cronbach's alpha coefficient is smaller than 0.7, suggesting that the items have relatively low internal consistency. However, given that the three items related to students' reflections on the impact of MOI on their science learning are central to my research questions, and that students from different MOI schools could have a diversified view on their reflections, I will keep this construct for the rest of analysis.

7.2.3. Descriptive and normality

The means of the responses to the items in the six scales of the students' questionnaire were calculated and all the variables were explored with reference to normality of distribution.

After checking the normality of the data (see appendix B for more discussion), a decision was made to use a parametric test for the means comparison of the independent samples (t-test) for the five variables

(demanding English; EMI reflection; self-concept; belief; challenges), which were found to be normally distributed. The other three variables (language choice in science activities; English importance; frequency strategy, useful strategy) were found to be non-normally distributed using Q-Q plots and Kolmogorov-Smirnov tests for checking normality. A decision was made to use a non-parametric test for the means comparison of the Mann-Whitney test.

Any values of the Kolmogorov-Smirnov (K-S) *Z* more than .05 indicates normality. If the Sig. value is lower than .05 (*), it suggests violation of the assumption of normality. Thus, the final decision was to use the parametric test (independent t-test) for scales 2, 4, 5, and 6, and to use a non-parametric test (Mann-Whitney) for scales 1, 3, 7, 8, and 9. Table 7.3 summarises the the Kolmogorov-Smirnov Z values and the decisions about the chosen statistical tests for the nine scales in the questionnaire.

Scale	Kolmogorov-Smirnov Z (Sig.)	Decision on stat. test
1. Choice of instructional language in different science teaching activities	.000*	Mann-Whitney
2. The most demanding English language skills for students to study science in English medium	.222	Independent t-test
3. The most important English language skills for students to study science in English medium	.000*	Mann-Whitney
4.Student's reflection on EMI	.958	Independent t-test
5.Students' self-concept of science	.683	Independent t-test
6.Students' belief in science classrooms	.429	Independent t-test
7.Students' views on language challenge	.01*	Mann-Whitney
8. Students' views towards the frequency of the coping strategies.	.003*	Mann-Whitney
9. Students' views towards the usefulness of coping strategies.	.000*	Mann-Whitney

Table 7.3. K-S (Z) values of all the scales in the questionnaire and the chosen statistical test

*Note: * the Kolmogorov-Smirnov Z value is lower than .05, suggesting violation of the assumption of normality.*

7.3 Questionnaire results: correlation analyses

The relationship between nine variables of students' responses to their perceptions of EMI experience (as indicated by their average total scores of each survey items on a five-point scale) was investigated using Spearman's rho coefficient. Preliminary analyses were performed to check the assumptions of normality, linearity and homoscedasticity.

7.3.1 Correlations among the students' demographic characteristics

A Spearman's rank-order correlation was run to determine the relationship among between 16 students' demographic characteristics and the 9 variables of

students' responses to their perceptions of EMI experience. The results are summarised in table 7.4

	1	2	3	4	5	6	7	8	9
a. School type	.270***	n.s.	-.093*	n.s.	n.s.	n.s.	.157***	n.s.	-.256**
b. Grade	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-.105*	n.s.	n.s.
c. Sex	-.203***	n.s.	.097*	n.s.	-.136**	n.s.	n.s.	n.s.	n.s.
d. Age	n.s.	n.s.	.090*	n.s.	n.s.	-.109*	-.135**	.120**	.241***
e. 1st language	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
f. Birth place	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
g. Science subject	-.118**	-.091*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-.179***
h. Previous MOI (primary)	.385***	.093*	n.s.	n.s.	n.s.	-.115**	n.s.	.124**	.190***
i. Previous MOI (S1-S3)	.247***	n.s.	n.s.	-.099*	n.s.	-.148**	.146**	n.s.	-.089*
j. English total score	.162***	.249***	-.101*	-.106*	n.s.	-.103*	.209***	n.s.	.124**
k. Speaking	.182***	.192***	n.s.	-.112**	n.s.	n.s.	.178***	n.s.	n.s.
l. Reading	.091*	.21***	n.s.	n.s	-.106*	-.111*	.143**	.105*	.149***
n. Writing	.149***	.206***	-.152***	-.115**	-.089*	-.088*	.162***	n.s.	n.s.
m. Listening	.144**	.240***	-.091**	n.s.	n.s.	-.115**	.225***	.110*	.147**
o. Chinese score	n.s.	n.s.	n.s.	n.s.	n.s.	-.112**	n.s.	n.s.	n.s.
p. Science score	n.s.	n.s.	n.s.	n.s.	-.291***	-.166**	n.s.	n.s.	.138**

Table 7.4. The correlation among students' demographic characteristics (n=545)

*Note: *p<.05; **p<.01; ***p<.001; n.s.=no statistically significance*

The results with statistical significance are as follows:

1. Seven students' demographic characteristics were strongly correlated with the students' choices of instructional language in science teaching activities. The school's current MOI (r=.270, p<.0001), previous MOIs in primary (r=.385, p<.0001) and junior secondary (r=.247, p<.0001), students' English language overall results in their previous school year (r=.162, p<.0001), and English productive skills: speaking (r=.182, p<.0001) and writing (r=.149, p <.0001) were found to have a strong and positive correlation with the students' choices of instructional language in science teaching activities.

   This perhaps suggests that students who tend to use Cantonese in the science learning activities are from late–partial EMI schools, with many years of Cantonese instruction in their primary and junior secondary years, and perhaps relatively higher scores for their English productive skills (speaking and writing). Other variables such as sex and science subjects were negatively correlated with the students' choices of instructional language. Students' receptive English skills (reading and listening) were found to have a low and positive correlation. This may suggest that male students and those who study physics tend to have more Cantonese in their teaching science activities. Students with higher scores for reading and listening tend to use more Cantonese.

2. Five students' demographic characteristics were strongly correlated with the students' views on their most demanding English language skills. Students' self-reported overall English language results in their previous school year (r=.249, p<.0001) and individual English skills—speaking (r=.192, p<.0001), reading (r=.21, p<.0001), writing (r=.206, p<.0001) and listening (r=.240, p<.0001)—were found to have a strong and positive correlation with the students' views on their most demanding English language skills.

    a. This perhaps suggests that students who reported their English language results in previous school years rated the most demanding English language skills higher.

    b. Other variables such as science subject were negatively correlated, and previous MOI in primary levels was positively correlated. This may suggest that students who study physics and use more Cantonese at primary levels rated the demanding English language skills higher.

3. The most important English language skills for students to study science in English medium were found to have a strong and negative correlation with the students' results in writing English (r=-.152, p<.0001). This perhaps suggests that students who reported a low score for writing rated the most important English language skills higher.

   a. Other variables such as current MOI, students' overall English score and listening score in the previous school year were found to have a negative correlation with students' views on the most important English language skills. This suggests that students from early–full EMI schools, and those with higher English scores tended to rate the important English language skills higher.

   b. Other variables such as sex and age were found to have a low and positive correlation. This suggests that female and older students rated the important English language skills higher.

4. Four variables were found to have low and negative correlations with the student's reflection on EMI. They included students' previous MOI at junior level (r=-.099, *p*=.02), overall English scores in the previous school year (r=-.106, *p*=.013), English speaking score (r=-.112, *p*=.009) and writing score (r=-.115, *p*=.007).

   a. This perhaps suggests that students who rated their EMI reflection higher had more English in their previous MOI at junior secondary, but also had lower results in their overall English score, and lower results in speaking and writing.

5. Four variables were found to have a negative correlation with students' self-concept in science. These were students' sex (r=-.136, *p*=.001),

students' science score (r=-.291, p<.0001), students' English reading score (r=-.106, p=.014) and writing score (r=-.089, p=.037).

   a. This perhaps suggests that male students with lower scores for science, as well as English reading and writing, may have a higher self-concept in science.

6. Nine variables were found to have a negative correlation with students' belief in science classrooms. They were students' age (r=-.109, p=.011), previous MOI in primary (r=-.115, p=.007) and in junior secondary (r=-.148, p=.001), overall English score (r=-.103, p=.016), reading (r=-.111, p=.01), writing (r=-.088, p=.04), listening (r=-.115, p=.007), Chinese language (r=-.112, p=.009) and science (r=-.166, p=.001).

   a. This perhaps suggests that older students, with more Cantonese in their primary and junior secondary levels, and higher scores for English, Chinese and science, had low student belief in science classrooms.

7. Nine variables were found to have a correlation with the students' views on language challenges. A positive correlation was found with current MOI (r=.157, p<.0001), previous MOI in primary (r=.146, p=.001) English score (r=.209, p<.0001), speaking (r=.178, p<.0001), writing (r=.162, p<.0001), listening (r=.225, p<.0001). This perhaps suggests that students

from late–partial EMI schools with higher scores for English speaking, writing, and listening rated the language challenges higher.

   a. A weak and negative correlation was found with students' current grade (r=-.105, *p*=.014) and students' age (r=-1.35, *p*=.002). This may suggest that younger students in lower grades (i.e. grade 10) rated the same set of language challenges higher.

8. Four variables were found to have a positive correlation with the students' views on the frequency of using coping strategies. They included students' age (r=.12, *p*=.005), previous MOI in primary (r=.124, *p*=.004), English reading score (r=.105, *p*=.015), and listening score (r=.105, *p*=.015). This perhaps suggests that elder students with more Cantonese as the MOI at primary levels, as well as those with higher scores for reading and listening, rated the frequency of using coping strategies higher.

9. Nine variables were found to have a correlation with the students' views on the usefulness of coping strategies. A strong and positive correlation was found with students' age (r=.241, *p*<.0001), previous MOI at primary levels (r=.190, *p*<.0001), overall English score (r=.124, *p*=.004), reading score (r=.149, *p*<.0001), listening score (r=.147, *p*=.001) and science score (r=.138, *p*=.008). This perhaps suggests that older students with more

Cantonese at the primary level, and with higher scores for English and science, rate the usefulness of coping strategies higher.

10. A negative and strong correlation was found with the current MOI at school (r=-.256, p<.0001) and science subject (r=-.179, p<.0001). This may suggest that students from the early–full EMI schools and those choosing Biology as their science subject rated the usefulness of coping strategies higher.

7.3.2 Correlations among the nine questionnaire scales

A Spearman's rank-order correlation was run to determine the relationship among the nine scales of the questionnaire. The results are summarised in table 7.5.

	1	2	3	4	5	6	7	8	9
1. Language choice in science activities	n.s.								
2. English difficulty	.152***								
3. English important	-.126**	n.s.							
4. EMI reflect	n.s.	n.s.	n.s.						
5. Self-concept	n.s.	-.093*	n.s.	.261***					
6. Belief	-.182***	-.092*	.191***	.161***	.305***				
7. Challenges	.212***	.560***	n.s.	-.138**	-.197***	n.s.			
8. Frequency strategy	n.s.	.116**	n.s.	n.s.	n.s.	n.s.	.110*		
9. Usefulness strategy	-.107**	.129**	.206***	n.s.	n.s.	n.s.	.096*	.601***	n.s.

Table 7.5. Summary of the correlations among the nine questionnaire scales (n=545)

*Note: *p<.05; **p<.01; ***p<.001; n.s.=no statistically significance*

The results with statistical significance are as follows:

1. Choice of instructional language in different science teaching activities

The language choice in science activities category was found to have strong and positive correlations with the demanding English skills in learning science (r=.152, p<.0001), and with the language challenges of learning science in English (r=.212, p<.0001). Similarly, it was found to have a strong and negative correlation with the important English skills in learning science (r=-.126, p=.003);

students' belief in learning science (r=-.182, p<.0001) and the usefulness of the coping strategies used by students (r=-.107, p=.012).

This perhaps suggests that students with more Cantonese or code-switching in the science teaching activities rated their most demanding English skills higher, as well as the language challenges of learning science in English. Students with more English in science teaching activities suggests that they rated the important English skills, belief in learning science and the usefulness of coping strategies higher.

2. The most demanding English language skills for students to study science in English medium

The demanding English skills category was found to have strong and positive correlations with students' views on language challenges (r=.560, p<.0001). There were moderate and positive correlations with the students' views on the frequency of using coping strategies (r=.116, p=.007) and the usefulness of the coping strategies (r=.129, p=.003). Also, there were weak and negative correlations with the students' self-concept in science (r=-.093, p=.031) and with the students' belief in science classrooms (r=-.092, p=.032). This suggests that students who rated their demanding English skills higher, also rated the language challenges and the frequency of using coping strategies higher. Those who rated their demanding English skills lower are also likely to have had a

higher response to their self-concept in science and a stronger belief in science classrooms.

This suggests that students who rated their demanding English skills higher were more likely to rate the language challenges and the frequency of using coping strategies higher. Those who rated their demanding English skills lower are more likely to have had a higher response to their self-concept in science and a stronger belief in science classrooms.

3. The most important English language skills for students to study science in English medium

Important English language skills were found to have a strong and positive correlation with the students' belief in science classrooms ($r=.191$, $p<.0001$), and with the usefulness of the strategies used by students ($r=.206$, $p<.0001$). There was also a strong negative correlation with the language choice in science activities ($r=-.126$, $p=.003$). This perhaps suggests that students who rated their important English skills higher had stronger belief in science classrooms and found the coping strategies more useful. They also tended to have more English in science teaching activities.

4. Students' reflection on EMI

The students' reflection on EMI category was found to have a strong positive correlation with students' self-concept in science ($r=.261$, $p<.0001$) and with students' belief in science classrooms ($r=.161$, $p<.0001$). This category was also

found to have a strong and negative correlation with language challenges of learning science (*r=-.138*, *p=.001*). This perhaps suggests that students who rated their reflection on EMI higher had a better self-concept in science and stronger belief in science classrooms. They also tended to have more English in the science teaching activities.

5. Students' self-concept of science

The students' self-concept of science category was found to have a strong positive correlation with students' belief in science classrooms (r=.305, *p*<.0001) and a strong negative correlation with language challenges of learning science (r=-.197, *p*<.0001). This perhaps suggests that students with stronger self-concept in science had a stronger belief in science classrooms and that they tended to have more English in science teaching activities.

6. Students' views on language challenge

The students' views on language challenges category was found to have a positive correlation with the frequency of using coping strategies (r=.110, *p*=.01) and usefulness of coping strategies (r=.096, *p*=.025). This suggests that students with more language challenges used more coping strategies and found them useful.

7. Usefulness of coping strategies

The students' views on the usefulness of coping strategies was found to have a positive correlation with the language challenges category (r=.601, *p*<.0001).

This suggests that students with more language challenges found coping strategies useful.

7.3.3 Summary of the correlations

The major findings of the correlations among different aspects of the students' perceptions of their EMI experience are as follows:

1. Students who used more Cantonese in the science teaching activities likely struggled more with demanding English skills and language challenges.
2. Students who used more English in the science teaching activities likely saw the importance of English skills, believed in learning science and found coping strategies useful.
3. Students who found English skills more demanding were likely to report more language challenges and a higher frequency of using the coping strategies.
4. Students who found English skills less demanding were more likely to have a higher self-concept in science and a stronger belief in science classrooms.
5. Students who rated the importance of English skills higher were more likely to have a stronger belief in science classrooms and find coping strategies useful. These students tended to use more English in science activities.

6. Students who rated their reflection on EMI higher had a better self-concept in science and stronger belief in science classrooms. These students tended to use more English in science activities.
7. Students with stronger self-concept in science also had a stronger belief in science classrooms and tended to use more English in science activities.
8. Students with more language challenges used more coping strategies and found them useful.
9. Students who used coping strategies more frequently also found them useful.

The results of the correlation analysis suggest that there are three possible cases of students in the both early–full and late–partial EMI schools.

1. Combining the two groups, students who prefer to use more Cantonese in interactions find that English language skills are demanding and that they have more language challenges in science classroom. Thus, these students frequently use coping strategies. These students are possibly poorly performing students in the early–full EMI schools or students in the late–partial EMI schools, but the questionnaire analysis showed that the late–partial students use coping strategies less frequently than the early–full students.

2. Students who believe that English language skills are important also believe they can do science well. These students also tend to prefer to use more English in their interactions and found coping strategies useful. This is possibly the case for well performing students in both early–full and late–partial EMI schools.
3. Students who have more language challenges use coping strategies more frequently and find them useful. This is possibly the case for students who are struggling with English but motivated to overcome their language challenges themselves in both early–full and late–partial EMI schools.

7.4 Questionnaire results: mean-comparison analyses

Question RQ5 asks if there was any difference in students' perceptions of EMI experience in science classrooms between students from early–full EMI schools and others from late–partial EMI schools. To answer this question, I first conducted principal component analysis to reduce the number of survey items from the nine questionnaire scales. I then compared the mean differences of the total students' responses between the early–full EMI and late–partial EMI in each of the questionnaire scales using inferential statistics (independent t-test and Mann-Whitney U test). Section 7.4.1 presents the detailed procedures of data reduction using one of the nine scales. Sections 7.4.2 to 7.4.10 present the brief procedures of data reduction for the remaining eight scales. This includes the reduced survey items in each scale and their underlying factors. In addition,

in each of the reduced variables I also report on the comparison of the two means between the two types of EMI schools in the students' responses. The major results are presented in tables 7.4 to 7.12. These tables contain the means and standard deviations of each of the survey items.

7.4.1.1 Data reduction

Of the nine variables, I present here the 17 language challenges as an example of the steps I performed in the data reduction using factor analysis. In table 7.6, the mean scores of the students' responses to their language challenges have been calculated and ranked to determine the order in which the language challenges were most identified within the 545 student sample. I subsequently use factor analysis to determine whether the students' scores in response to these items would reveal any underlying factors in the data.

Rank	Language challenge	Mean (SD)
1	7. Explaining an abstract science concept in English	3.37 (.97)
2	8. Explaining a difficult science concept in English	3.30 (.99)
3	4. Application of the acquired science knowledge	3.15 (.98)
4	6. Discussions with other classmates about science in English	3.09 (.93)
5	16. Studying to meet teacher expectation in a science topic	3.06 (.87)
6	21. Solving problems in spoken English	3.04 (.93)
7	24. Using the correct English technical terms in my science writing	3.03 (.94)
8	9. Answering a question from my science teacher in English	3.00 (.89)

Rank	Language challenge	Mean (SD)
9	3. Comprehension of the acquired science knowledge	3.00 (.93)
10	13. Explaining a science concept in spoken English after reading the textbook	3.00 (.91)
11	22. Solving problems in written English	2.97 (.90)
12	23. Using the correct English basic vocabulary in my science writing	2.96 (.93)
13	14. Explaining a science concept in written English after reading the textbook	2.95 (.89)
14	1. Understanding the meaning of technical terminology in English	2.94 (.90)
15	19. Expressing the right answers in spoken English	2.93 (.92)
16	20. Expressing the right answers in written English	2.90 (.92)
17	2. Understanding the course contents in English	2.87 (.88)
18	15. Distinguishing the basic English vocabulary and technical terminology	2.86 (.94)
19	18. Understanding exam questions in English	2.85 (.94)
20	17. Reading my English science textbooks	2.84 (1.02)
21	10. Finding the appropriate Chinese glossary for reference	2.82 (.99)
22	5. The teaching methods of an individual teacher	2.75 (.86)
23	11. Understanding my science teacher's spoken English during lesson	2.67 (.93)
24	12. Understanding my science teacher's written English during lesson	2.68 (.89)

Table 7.6. Rank order of the language challenges identified by the students' responses

7.4.1.2 Conducting principal component analysis

To identify the number of underlying factors in students' language challenges, I conducted principal component analysis. The 24 items of the students'

language challenges were subjected to principal component analysis using SPSS. Before performing principal component analysis, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin measure of sampling adequacy (KMO) attained a value of .926, higher than the recommended value of .5 (Kaiser, 1970; 1974). The Bartlett's test of sphericity (Bartlett, 1954) reached a statistical significant difference (p<.0001), supporting the factorability of the correlation matrix (figure 7.1).

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.926
Bartlett's Test of Sphericity	Approx. Chi-Square	9709.127
	df	276
	Sig.	.000

Figure 7.1. KMO and Bartlett's test results

Principal component analysis revealed the presence of five components recorded with eigenvalues greater than 1, explaining 46.31%, 8.74%, 5.95%, 4.78% and 4.4% of the variance respectively. An inspection of the scree plot (figure 7.2) revealed a clear break after the second component. Reference to the component matrix (figure 7.3) revealed that the first two components comprised a majority of items with loadings on them of more than 0.4. The two-component solution explained a total of 55.04% of the variance, with

component 1 contributing 46.31% and component 2 contributing 8.74%. To assist in the interpretation of these two components, oblimin rotation was performed. The rotated solution revealed the presence of a simple structure (Thustone, 1947), with both components showing a number of strong loadings and most variables loading substantially on only one component. There was a positive effect for items loading strongly on component 1 and negative affect items loading strongly on component 2 (figure 7.4). There was a weak negative correlation between the two factors (r=-.634). The result of this analysis supports the use of the positive affect items and the negative affect items as separate scales, as suggested by the scale authors (Watson, Clark & Tellegen, 1988).

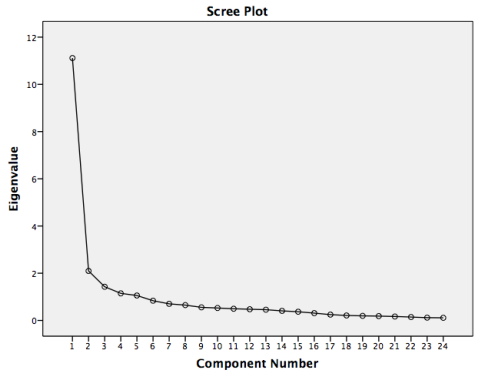


Figure 7.2. Scree plot of principal component analysis factors

Component Matrix[a]

	Component				
	1	2	3	4	5
Understanding the course contents in English	.783	.182		-.245	

Component Matrix[a]

	Component				
	1	2	3	4	5
Expressing the right answers in written English	.749	-.484			
Understanding the meaning of technical terminology in English	.739	.221	.102	-.201	
Solving problems in written English	.729	-.486			
Expressing the right answers in spoken English	.714	-.470			.137
Using the correct English basic vocabulary in my science writing	.713	-.441			
Solving problems in spoken English	.712	-.431			.134
Explaining a science concept in spoken English after reading the textbook	.707	.220		.310	-.347
Using the correct English technical terms in my science writing	.703	-.373	-.105		
Explaining a science concept in written English after reading the textbook	.696	.197		.309	-.408
Comprehension of the acquired science knowledge	.693	.214	-.120	-.512	
Understanding my science teacher's written English during lessons	.689	.202	.518	.101	.198
Understanding exam questions in English	.688	-.414			
Understanding my science teacher's spoken English during lessons	.688	.189	.495		.263
Distinguishing the basic English vocabulary and technical terminology	.671	.103			-.319
Reading my English science textbooks	.668		.101		-.267
Answering a question from my science teacher in English	.664	.208		.283	.222
Application of the acquired science knowledge	.659	.173	-.284	-.508	
Discussions with other classmates about science in English	.641	.246	-.285	.203	.184
Explaining an abstract science concept in English	.638	.238	-.530	.180	.252

Component Matrix[a]

	Component				
	1	2	3	4	5
Explaining a difficult science concept in English	.635	.230	-.481	.204	.267
Studying to meet teachers' expectation in a science topic	.614	.168	-.113		-.406
The teaching methods of an individual teacher	.597	.322	.161	-.297	
Finding the appropriate Chinese glossary for reference	.483	.181	.375		.194

Extraction Method: Principal Component Analysis.

Note: *a. 5 components extracted.*

Figure 7.3. Principal component matrix

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	11.114	46.310	46.310	11.114	46.310	46.310	10.247
2	2.097	8.737	55.047	2.097	8.737	55.047	8.496

Figure 7.4. Principal component analysis oblimin rotation

Notes: a. *Extraction Method: Principal Component Analysis; b. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.*

7.4.1.3 Classification of the reduced data

Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were analysed to determine commonalities and each component was labelled to represent the language

challenges loaded onto it. Table 7.7 shows the two-factor solution of the students' views on their language challenges.

Items	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
The teaching methods of an individual teacher	**.766**	.156	**.667**	-3.30	.460
Understanding the meaning of technical terminology in English	**.756**		**.771**	-.503	.595
Understanding the course contents in English	**.743**		**.801**	-.562	.646
Explaining a science concept in spoken English after reading the textbook	**.732**		**.740**	-.477	.548
Comprehension of the acquired science knowledge	**.716**		**.725**	-.468	.526
Discussions with other classmates about science in English	**.715**		**.686**	-.447	.472
Explaining an abstract science concept in English	**.703**		**.680**	-.409	.463
Understanding my science teacher's written English during lessons	**.700**		**.718**	-.471	.515
Explaining a science concept in written English after reading the textbook	**.699**		**.723**	-.480	.523
Explaining a difficult science concept in English	**.693**		**.675**	-.411	.456
Answering a question from my science teacher in English	**.689**		**.696**	-.447	.484

Understanding my science teacher's spoken English during lessons	**.686**		**.713**	-.477	.509
Application of the acquired science knowledge	**.647**		**.680**	-.462	.464
Studying to meet teachers' expectation in a science topic	**.611**		**.636**	-.427	.405
Distinguishing the basic English vocabulary and technical terminology	**.580**	-.142	**.670**	-.509	.461
Reading my English science textbooks	**.538**	-.186	**.656**	-.527	.451
Finding the appropriate Chinese glossary for reference	**.534**		**.516**	-.310	.266
Expressing the right answers in written English		**-.895**	.561	**-.892**	.795
solving problems in written English		**-.889**	.542	**-.876**	.767
Expressing the right answers in spoken English		**-.864**	.544	**-.832**	.731
Using the correct English basic vocabulary in my science writing		**-.828**	.541	**-.838**	.703
Solving problems in spoken English		**-.815**	.544	**-.832**	.693
Understanding exam questions in English		**-.785**	.525	**-.803**	.645
Using the correct English technical terms in my science writing		**-.740**	.553	**-.793**	.633

Table 7.7. Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' views on their language challenges

Notes: *1. major loadings for each item are bolded; extraction method: principal components analysis;*

2. Each statement was rated by the teachers on a 5-point scale, where 1=least challenging, 5= most challenging;

3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

The first factor comprised the following 17 language challenges, listed in order of heaviest to lightest and worded the same as they appeared in the questionnaire.

Factor 1:

1. The teaching methods of an individual teacher
2. Understanding the meaning of technical terminology in English
3. Understanding the course content in English
4. Explaining a science concept in spoken English after reading the textbook
5. Comprehension of the acquired science knowledge
6. Discussions with other classmates about science in English
7. Explaining an abstract science concept in English
8. Understanding my science teacher's written English during lessons
9. Explaining a science concept in written English after reading the textbook
10. Explaining a difficult science concept in English
11. Answering a question from my science teacher in English
12. Understanding my science teacher's spoken English during lessons
13. Application of the acquired science knowledge

14. Studying to meet teachers' expectation in a science topic

15. Distinguishing the basic English vocabulary and technical terminology

16. Reading my English science textbook.

17. Finding the appropriate Chinese glossary for reference.

All 17 of these language challenges suggest that students in EMI classrooms have experienced difficulties in understanding, comprehending and communicating science content through English. The most heavily weighted challenge is about the teaching methods of an individual teacher; it is less directly about students' own language challenges. The next two most heavily weighted challenges are related to understanding and comprehending scientific terms and content materials in English. All 17 language challenges are closely related to the concept of cognitive academic language proficiency skills (CALP). CALP refers to the language skills that are important for students to succeed in school and these skills are expected to be demonstrated in content subject areas through formal academic learning (Cummins, 2000). As a result, this component was labelled 'challenges (use of basic English), henceforth referred to as 'challenges (use of scientific English)'.

The second factor was made up of seven language challenges:

Factor 2:

1. Expressing the right answers in written English

2. Solving problems in written English
3. Expressing the right answers in spoken English
4. Using the correct basic English vocabulary in my science writing
5. Solving problems in spoken English
6. Understanding exam questions in English
7. Using the correct English technical terms in my science writing

This set of language challenges refers to students' language challenges when reading, presenting and communicating through English without any subject matter. It is similar to the concept of Basic Interpersonal Communication Skills (BICS), i.e. skills that are needed to perform any social interaction in a language or content-subject classroom. This component was labelled 'language challenges (use of basic English)', and is henceforth referred to as 'challenges (use of basic English)'. In summary, principal component analysis found two major components underlying the questionnaire data in students' responses to their language challenges. The two components were labelled and are shown in table 7.8 below, with the most heavily weighted component in the top row of the table.

Components	Descriptions	
challenge (use of scientific English)	*Language challenges related to comprehension, communicating in science content*	Non-parametric
challenge (use of basic English)	*Language challenges related to the use of basic English*	Non-parametric

Table 7.8 Most heavily weighted factors for language challenges when learning science through English

7.4.1.4 Mean comparison (item by item)

A Mann-Whitney test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in regard to students' language challenges. In the 24 items listed below in table 7.9, there was a significant difference in students' responses in the overall scores (p<.0001***): 16 out of the 24 items were found to have a statistically significant difference. These items can be grouped into 3 categories. 1) comprehension (items 1, 2, 3, 11, 12, 18); 2) explaining science (items 7, 8, 13, 14); 3) communicating in English (items 6, 9, 15, 20, 21, 22). As indicated by the five-point scale (1=strongly disagree, 5=strongly agree), the mean scores of students' responses from the late–partial EMI schools in all the items had a slightly larger value than those in early–full EMI schools. This reflects the finding that students in the late–partial EMI schools rated higher the same set of language challenges for learning science in English.

Table 7.9 The students' responses between early-full and late-partial schools to the language challenges for learning science in English

Scale 7: Language Challenge	*Mann-Whitney p-value*	Mean (SD)		
		Early-full	Late-partial	Both group
Factor 1: challenge (use of scientific English)				
5. The teaching methods of an individual teacher	.050	2.67 (.79)	2.84 (.94)	2.75 (.86)
1. Understanding the meaning of technical terminology in English	***p*<.0001***	2.77 (.82)	3.12 (.95)	2.94 (.90)
2. Understanding the course contents in English	***p*<.0001***	2.72 (.81)	3.04 (.91)	2.87 (.88)
13. Explaining a science concept in spoken English after reading the textbook	**.024***	2.91 (.92)	3.10 (.90)	3.00 (.91)
3. Comprehension of the acquired science knowledge	**.019****	2.90 (.90)	3.10 (.96)	3.00 (.93)
6. Discussions with other classmates about science in English	**.006****	2.98 (.88)	3.21 (.97)	3.09 (.93)
7. Explaining an abstract science concept in English	**.023***	3.28 (.91)	3.48 (1.02)	3.37 (.97)
12. Understanding my science teacher's written English during lessons	***p*<.0001***	2.54 (.85)	2.84 (.91)	2.68 (.89)
14. Explaining a science concept in written English after reading the textbook	**.034***	2.86 (.87)	3.05 (.90)	2.95 (.89)
8. Explaining a difficult science concept in English	**.006****	3.19 (.92)	3.42 (1.06)	3.3 (.99)
9. Answering a question from my science teacher in English	**.002****	2.89 (.83)	3.13 (.93)	3.00 (.89)
11. Understanding my science teacher's spoken English during lessons	**.001****	2.54 (.89)	2.82 (.95)	2.67 (.93)
4. Application of the acquired science knowledge	.054	3.07 (.96)	3.24 (.99)	3.15 (.98)
8. Explaining a difficult science concept in English	**.006****	3.19 (.92)	3.42 (1.06)	3.3 (.99)

Scale 7: Language Challenge	*Mann-Whitney p-value*	Mean (SD)		
		Early-full	Late-partial	Both group
16. Studying to meet teacher expectation in a science topic	.184	3.00 (.83)	3.12 (.92)	3.06 (.87)
15. Distinguishing the basic English vocabulary and technical terminology	***p*<.0001***	2.71 (.88)	3.01 (.98)	2.86 (.94)
17. Reading my English science textbooks	.114	2.76 (.99)	2.92 (1.05)	2.84 (1.02)
10. Finding the appropriate Chinese glossary for reference	.237	2.76 (.96)	2.87 (1.02)	2.82 (.99)
Factor 2: challenge (use of basic English)				
20. Expressing the right answers in written English	**.018***	2.81 (.88)	3.00 (.96)	2.9 (.92)
22. Solving problems in written English	**.039***	2.88 (.86)	3.05 (.94)	2.97 (.90)
19. Expressing the right answers in spoken English	.109	2.87 (.90)	3.00 (.93)	2.93 (.92)
23. Using the correct English basic vocabulary in my science writing	.066	2.88 (.92)	3.04 (.93)	2.96 (.93)
21. Solving problems in spoken English	**.002****	2.92 (.90)	3.16 (.94)	3.04 (.93)
18. Understanding exam questions in English	**.008****	2.75 (.92)	2.97 (.96)	2.85 (.94)
24. Using the correct English technical terms in my science writing	.050	2.95 (.94)	3.11 (.95)	3.03 (.94)
overall score of the language challenges for learning science in English	***p*<.0001***	2.86 (.63)	3.07 (.61)	2.96 (.63)

Notes: *1. The language challenges for learning science in English was rated on a 5-point scale, where 1=least challenging), 5=most challenging);*

*2. *p<.05; **p<.01; ***p<.001.*

7.4.2. Data reduction for the other eight scales in the questionnaire

Using the factor analysis described in sections 7.4.1.1 to 7.4.1.4, the results of the eight scales after principal component analysis are shown below.

7.4.3. The choice of instructional language in different science teaching activities

a) Data reduction

The 13 items of the students' language challenges were subjected to principal component analysis using SPSS. Before performing principal component analysis, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin Measure of Sampling Adequacy (KMO) attained a value of 0.901, higher than the recommended value of .6 (Kaiser, 1970; 1974) and Bartlett's test of sphericity (Barlett, 1954) reached a statistically significant difference (p<.0001), supporting the factorability of the correlation matrix. Principal component analysis revealed the presence of three components recorded with eigenvalues greater than 1, explaining 54.02%, 13.77%, and 8.44% of the variance respectively. An inspection of the scree plot (figure 7.5) revealed a clear break after the second component. Reference to the component matrix revealed that only the first two components comprised a majority of items with loadings onto them of more than 0.4. The two-component solution explained a total of 67.78% of the variance, with component 1 contributing 54.02% and component 2 contributing 13.77%. To assist the interpretation of these two components, oblimin rotation was

performed. There was a weak positive correlation between the two factors (r=.358). Table 7.10 shows the two-factor solution of the students' choice of instructional language in different science teaching activities. Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were analysed to determine commonalities and each component was labelled to represent the choice of instructional language that loaded onto it. Major loadings for each item are in bold font. The first component is related to the language choices for interactions and henceforth referred to as 'language choice-interaction'. The second component is related to the language choices for explaining science and henceforth referred as 'language choice for explaining science'.

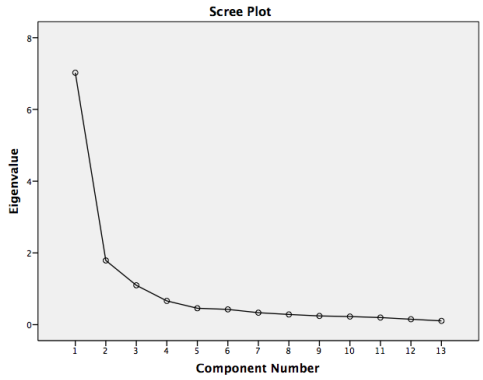


Figure 7.5 Scree plot of principal component analysis factors

Items	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
Factor 1: Language choice for interactions					
Language choice when taking part in student-student interactions	**.893**		**.883**	.294	.780
Language choice when taking part in whole-class discussions	**.882**		**.861**	.257	.744
Language choice when taking part in pair-work activities	**.880**		**.894**	.356	.801
Language choice when taking part in teacher-student interactions	**.875**	-.125	**.830**	.189	.703
Language choice when taking part in group-work activities	**.870**		**.894**	.294	.803
Language choice when asking the teacher questions	**.747**		**.727**	.210	.531
Language choice when answering the teacher's questions	**.745**		**.714**	.182	.516
Language choice when discussing classwork with classmates	**.645**	.214	**.721**	.445	.560
Language choice when responding to your teammates about a lab experiment	**.545**	.415	**.693**	.610	.631
Language choice when giving instructions to your teammates for a lab experiment	**.544**	.424	**.696**	.619	.640
Factor 2: Language choice for explaining science					
Language choice when explaining a science phenomenon		**.866**	.269	**.868**	**.756**
Language choice when explaining the definition of scientific vocabulary	-.125	**.872**	.187	**.828**	**.699**
Language choice when explaining a science phenomenon using everyday experience	.302	**.644**	.533	**.753**	**.646**

Table 7.10 Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' choice of instructional language in different science teaching activities

Notes: *1. major loadings for each item are bolded; extraction method: Principal components analysis.;*

2. Each statement was rated by the teachers on a 5-point scale, where 1=always English), 2=usually English), 3=code-switching between English and Cantonese), 4=usually Cantonese), 5=always Cantonese);

3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

b) Mean comparison (item by item)

A Mann-Whitney test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' choice of instructional language in different science teaching activities. All the 13 items below in table 7.11 were found to have a statistically significant difference between the early–full and late–partial EMI schools. A number of items were found to be highly statistically significantly (items 1–7, 11–12), indicating that there was a group difference in the choice of instructional language in a wide range of science teaching activities involving their science teachers. Three items were found to be relatively less significantly different, indicating both early–full and late–partial EMI schools had less difference in the choice of instructional language for: (8) discussing classwork with classmates; (9) explaining the definition of scientific vocabulary; and (10) explaining a science phenomenon. In addition, the mean score of students' responses from the late–partial EMI schools were higher than those in the early–full EMI schools. This suggests that students in the late–partial EMI schools chose to have more code-switching between English and Cantonese, and more Cantonese for the mentioned science teaching activities.

Scale 1: MOI science activities	*Mann-Whitney (p-value)*	Mean (SD)		
		Early-full	Late-partial	Both group
Factor 1: Language choice for interactions				
5. Language choice when taking part in student-student interactions	***p*<.0001***	3.38 (.88)	3.76 (.83)	3.56 (.88)
3. Language choice when taking part in whole-class discussions	***p*<.0001***	3.30 (.85)	3.72 (.80)	3.5 (.85)
6. Language choice when taking part in pair-work activities	***p*<.0001***	3.40 (.88)	3.74 (.82)	3.57 (.87)
4. Language choice when taking part in teacher-student interactions	***p*<.0001***	2.94 (.87)	3.42 (.80)	3.17 (.87)
7. Language choice when taking part in group-work activities	***p*<.0001***	3.26 (.85)	3.66 (.84)	3.45 (.87)
2. Language choice when asking the teacher questions	***p*<.0001***	2.97 (.92)	3.44 (.91)	3.2 (.94)
1. Language choice when answering the teacher's questions	***p*<.0001***	2.58 (.96)	3.11 (.91)	2.84 (.97)
8. Language choice when discussing classwork with classmates	**.004****	3.52 (.91)	3.75 (.87)	3.63 (.89)
13. Language choice when responding to your teammates about a lab experiment	***p*<.0001***	3.45 (.88)	3.76 (.79)	3.6 (.85)
12. Language choice when giving instructions to your teammates for a lab experiment	***p*<.0001***	3.44 (.85)	3.79 (.75)	3.61 (.82)
Factor 2: Language choice for explaining science				
10. Language choice when explaining a science phenomenon	**.024***	2.89 (.87)	3.05 (.84)	2.79 (.86)
9. Language choice when explaining the definition of scientific vocabulary	**.011***	2.69 (.95)	2.89 (.99)	2.79 (.98)

Scale 1: MOI science activities	*Mann-Whitney (p-value)*	Mean (SD)		
		Early-full	Late-partial	Both group
11. Language choice when explaining a science phenomenon using everyday experience	***p*<.0001***	3.25 (.84)	3.55 (.74)	3.39 (.81)
Overall score of the language choices in different classroom activities	***p*<.0001***	3.16 (.63)	3.51 (.58)	3.33 (.64)

Table 7.11. The students' responses to the choice of instructional language in different science teaching activities

Notes: *1. The choice of instructional language was rated on a 5-point scale, where 1=always English), 2=usually English), 3=code-switching between English and Cantonese), 4=usually Cantonese), 5=always Cantonese);*

*2. *p<.05; **p<.01; ***p<.001.*

7.4.4 The most demanding English language skills for students to study science in English medium

a) Data reduction

The 17 items of the students' views on the most demanding English language skills were subjected to principal component analysis using SPSS. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin Measure of Sampling Adequacy (KMO) attained a value of .893, lower than the recommended value of .5 (Kaiser, 1970; 1974). Bartlett's test of sphericity (Barlett, 1954) reached a statistically significant difference (p<.0001), supporting the factorability of the correlation matrix. Principal component analysis revealed the presence of five components recorded with eigenvalues greater than 1, explaining 46.86%, 10.02%, 9.04%,

and 6.17% of the variance respectively. An inspection of the scree plot (figure 7.6) revealed a clear break after the second and third components. Reference to the component matrix revealed that the first three components comprised a majority of items with loadings onto them of more than 0.4. The three-component solution explained a total of 65.93% of the variance, with component 1 contributing 46.86%, component 2 contributing 10.02% and component 3 contributing 9.04%. To assist the interpretation of these three components, oblimin rotation was performed. There was a low positive correlation between factors 1 and 2 (r=.437); factors 2 and 3 (r=.320) and factors 1 and 3 (r=.325). Table 7.12 shows the two-factor solution of the students' views on the most demanding English language skills. Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were analysed to determine commonalities and each component was labelled to represent the most demanding English language skills that loaded onto it. Major loadings for each item are in bold font. The first component is related to difficult English skills in daily use. The second component is related to difficult English skills in scientific writing. The third component is related to difficult English skills in vocabulary.

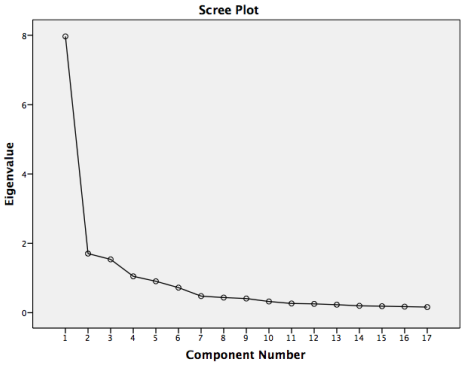


Figure 7.6. Scree plot of principal component analysis factors

Item	Pattern coefficients			Structure coefficients			Communalities
	Component			Component			
	1	2	3	1	2	3	
Factor 1: Demanding English skills related to daily uses							
Reading (science textbooks)	**.838**	-.174	.177	**.820**	.249	.394	.713
Writing (daily assignments)	**.834**			**.850**	.367	.343	.728
Listening	**.790**		.115	**.819**	.364	.366	.683
Distinguishing between English Vocabulary for explanation and technical terminology	**.671**			**.718**	.394	.269	.524
Expressing the right answers in simple English	**.662**	.145		**.742**	.451	.315	.574
Speaking (dialogue, eg. whole class interaction between teacher and classmates)	**.562**	.370	-.158	**.672**	.565	.143	.564
Writing (scientific reports, with specific purpose, structures, language style)	**.519**	.387		**.695**	.620	.314	.608
Factor 2: Demanding English skills related to scientific writing							
Writing scientific texts with appropriate English vocabulary		**.866**		.387	**.873**	.299	.763
Writing scientific texts with accurate English grammar		**.818**		.445	**.850**	.261	.730

Choosing the correct technical terms in expressing a science concept		**.689**	.210	.424	**.780**	.449	.655
Recognising the organisation of a science text	-.148	**.642**	.446	.277	**.720**	.604	.691
Speaking (monologue, e.g. presentation)	.293	**.553**	-.205	.468	**.615**		.464
Balancing the density between content and clarity	.265	**.514**	.267	.576	**.715**	.518	.658
Factor 3: Demanding English skills related to vocabulary							
Understanding the meaning of abstract vocabulary	.200		**.803**	.453	.326	**.862**	**.777**
Understanding the meaning of academic English vocabulary	.179		**.738**	.440	.362	**.811**	**.694**
Understanding the meaning of technical vocabulary	.314		**.732**	.528	.318	**.816**	**.746**
Understanding the style of science writing	-.157	.438	**.609**	.232	.565	**.699**	**.636**

Table 7.12. Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' most demanding English language skills

Notes: *1. major loadings for each item are bolded; Extraction method: Principal components analysis;*

2. Each statement was rated by the teachers on a 5-point scale, where 1=least demanding), 5=most demanding);

3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

b) Mean comparison (Item by item)

An independent sample t-test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' responses to the most demanding English language skills. In the 17 items below in table 7.13, there was a significant difference in the following five related English language skills: (1) 'dialogue speaking skills' (p=.032*); (2) 'writing daily assignments' (p=.017*); 5) 'reading science textbooks' (p<.0001***);

(6) 'listening to science teachers' oral explanations in English' (p<.0001***); and (16) 'distinguishing between English vocabulary for explanation and technical terminology' (p<.0001***). As indicated by the five-point scale, 1=least demanding), 5=most demanding), the mean scores of students' responses from the late–partial EMI schools in all the 17 items had a slightly larger value than those in early–full EMI schools. This reflects that students in the late–partial EMI schools rated higher the level of demanding English for the same set of language skills.

Table 7.13 The students' responses to the most demanding English language skills for students to study science in English medium

Scale 2: Demanding English Skills	*t-test p-value*	Mean (S.D.)		
		Early-full	Late-partial	Both groups
Factor 1: Demanding English skills related to daily uses				
5. Reading (e.g. science textbooks)	***p*<.0001*** **	2.46 (.89)	2.77 (1.10)	2.61 (1.01)
4.Writing (e.g. daily assignments)	**.017***	2.54 (.90)	2.75 (1.07)	2.64 (.99)
6. Listening (e.g. science teacher's oral explanations in English)	***p*<.0001*** **	2.51 (.93)	2.83 (1.08)	2.66 (1.02)
16. Distinguishing between English vocabulary for explanation and technical terminology	**.032***	2.64 (.95)	2.82 (1.02)	2.73 (.99)
17. Expressing the right answers in simple English	.107	2.56 (.93)	2.69 (.96)	2.62 (.96)
1. Speaking (dialogue, e.g. whole class interaction between teacher and classmates)	**.032***	2.74 (.92)	2.91 (.96)	2.82 (.94)

Scale 2: Demanding English Skills	*t-test* *p-value*	Mean (S.D.)		
		Early-full	Late-partial	Both groups
3. Writing (scientific reports, with specific purpose, structures, language style)	.088	2.88 (1.01)	3.03 (1.04)	2.96 (1.03)
Factor 2: Demanding English skills related to scientific writing				
13. Writing scientific texts with appropriate English vocabulary	.303	3.18 (.99)	3.09 (1.07)	3.14 (1.03)
12. Writing scientific texts with accurate English grammar	.858	3.17 (1.03)	3.15 (1.03)	3.16 (1.03)
14. Choosing the correct technical terms in expressing a science concept	.839	3.10 (.98)	3.08 (1.07)	3.09 (1.02)
11. Recognizing the organization of a science text (e.g. the format of a lab report, its components, sub-sections)	.852	3.05 (.90)	3.07 (1.06)	3.08 (.96)
2. Speaking (monologue, e.g. presentation)	.926	3.18 (1.06)	3.19 (1.08)	3.19 (1.07)
15. Balancing the density between content and clarity	.388	2.96 (.97)	3.04 (1.02)	3.00 (.99)
Factor 3: Demanding English skills related to vocabulary				
8. Understanding the meaning of abstract vocabulary (e.g. inert, displacement, reduction, oxidizing)	.282	2.95 (.99)	3.05 (1.07)	3.00 (1.03)
9. Understanding the meaning of academic English vocabulary (e.g. examine, account for, describe, explain)	.168	2.55 (.97)	2.67 (1.08)	2.61 (1.02)
7. Understanding the meaning of technical vocabulary (e.g. oxidation, electrolysis, ionic bond, electrochemical series)	.132	2.8 (.97)	2.93 (1.12)	2.86 (1.04)
10. Understanding the style of science writing (e.g. the language style, language choice in a lab report)	.795	3.07 (.89)	3.09 (1.03)	3.08 (.96)

Scale 2: Demanding English Skills	*t-test p-value*	Mean (S.D.)		
		Early-full	Late-partial	Both groups
Overall score of most demanding English language skills	.071	2.84 (.66)	2.95 (.71)	2.90 (.69)

Notes: *1. The most demanding English skills was rated on a 5-point scale, where 1=least demanding), 5=most demanding); 2.*p<.05; **p<.01; ***p<.001.*

7.4.5 The most important English language skills

a) Data reduction

The 17 items of the students' views on the most important English language skills were subjected to principal component analysis using SPSS. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin Measure of Sampling Adequacy (KMO) attained a value of .920, higher than the recommended value of .5 (Kaiser, 1970; 1974). Bartlett's test of sphericity (Barlett, 1954) reached a statistically significant difference (p<.0001), supporting the factorability of correlation matrix. Principal component analysis revealed the presence of three components recorded with eigenvalues greater than 1, explaining 58.18%, 7.14% and 6.04% of the variance respectively. An inspection of the scree plot (Figure 7.7) revealed a clear break after the second components. Reference to the component matrix revealed that the first two components comprised the majority of items with loadings onto them of more than 0.4. The two-component solution explained a total of 65.33% of the variance, with component 1 contributing 58.18% and component 2

contributing 7.14%. To assist the interpretation of these two components, oblimin rotation was performed. There was a positive correlation between the two factors (r=.638).

Table 7.14 shows the two-factor solution of the students' views on the most important English language skills. Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were analysed to determine commonalities and each component was labelled to represent the most important English language skills that loaded onto it. Major loadings for each item are bolded. The first component is related to academic English, and is henceforth referred to as 'important academic English skills'. The second component is related to the four basic English skills (listening, speaking, reading, and writing) and is henceforth referred to as 'important basic English skills'.

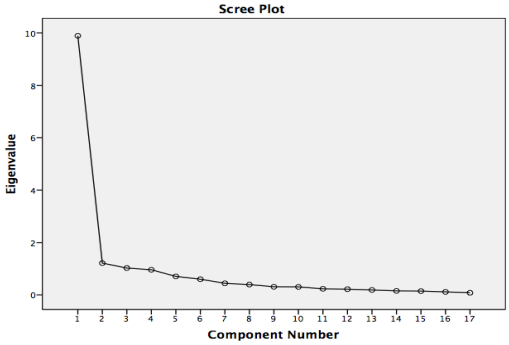


Figure 7.7 Scree plot of principal component analysis factors

Scale 2: important English language skills	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
Factor 1: Important academic English skills					
Writing scientific texts with appropriate English vocabulary	**.878**		.850	.515	.724
Distinguishing between English vocabulary for explanation and technical terminology	**.878**	-.126	.797	.434	.645
Expressing the right answers in simple English	**.858**	-.116	.784	.432	.623
Balancing the density between content and clarity	**.850**		.836	.520	.699
Choosing the correct technical terms in expressing a science concept	**.824**		.835	.543	.698
Writing scientific texts with accurate English grammar	**.811**		.812	.518	.659
Understanding the meaning of academic English vocabulary	**.737**	.139	.825	.609	.692
Understanding the meaning of abstract vocabulary	**.668**	.205	.799	.631	.663
Recognising the organisation of a science text	**.662**	.175	.774	.597	.617
Understanding the style of science writing	**.655**	.153	.752	.570	.579
Understanding the meaning of technical vocabulary	**.582**	.284	.762	.655	.629
Factor 2: Important basic English skills					

Scale 2: important English language skills	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
Speaking (dialogue, e.g. whole class interaction between teacher and classmates)	-.108	**.884**	.455	.815	.671
Speaking (monologue, e.g. presentation)		**.864**	.500	.832	.694
Reading (science textbooks)	.217	**.598**	.598	.736	.570
Writing (scientific reports, with specific purpose, structures, language style)	.310	**.593**	.688	.791	.682
Listening	.283	**.579**	.652	.760	.625
Writing (daily assignments)	.391	**.489**	.703	.738	.635

Table 7.14 Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' most important English language skills

Notes: *1. major loadings for each item are bolded; Extraction method: Principal components analysis;*

2. Each statement was rated by the teachers on a 5-point scale, where 1=least important), 5=most important);

3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

b) Mean comparison (Item by item)

A Mann-Whitney test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' responses to the most important English language skills. In the 17 items below, there was a significant difference in students' responses in the overall scores

(*p*=.030*). In the 17 items below in table 7.15, there was a significant difference in the following three related English language skills: (1) 'Writing (e.g. daily assignments)' (*p*=.001**); (2) 'Listening (e.g. science teachers' oral explanations in English)''(*p*=.048*); (3) 'Expressing the right answers in simple English' (*p*=.040*). As indicated by the five-point scale (1=least important), 5=most important), the mean scores of students' responses from the late–partial EMI schools in all the 17 items were slightly less than those in early–full EMI schools. This indicates that students in the late–partial EMI schools rated the level of importance lower than early–full students for the same set of English language skills.

Scale 3: Important English Skills	*Mann-Whitney (p-value)*	Mean (SD)		
		Early-full	Late-partial	Both
Factor 1: Important academic English skills				
13. Writing scientific texts with appropriate English vocabulary	.571	3.82 (.87)	3.76 (1.01)	3.79 (.94)
16. Distinguishing between English vocabulary for explanation and technical terminology	.143	3.78 (.90)	3.67 (.99)	3.73 (.94)
17. Expressing the right answers in simple English	**.040***	3.82 (.91)	3.66 (.99)	3.75 (.95)
15. Balancing the density between content and clarity	.079	3.83 (.82)	3.71 (.97)	3.77 (.89)
14. Choosing the correct technical terms in expressing a science concept	.807	3.89 (.81)	3.87 (.91)	3.88 (.86)
12. Writing scientific texts with accurate English grammar	.406	3.71 (.92)	3.66 (1.02)	3.69 (.97)
9. Understanding the meaning of academic English Vocabulary (e.g. examine, account for, describe, explain)	.068	3.88 (.84)	3.70 (1.05)	3.80 (.95)
8. Understanding the meaning of abstract vocabulary (e.g. inert, displacement, reduction, oxidizing)	.186	3.97 (.85)	3.82 (1.05)	3.90 (.95)
11. Recognizing the organization of a science text (e.g. the format of a lab report, its components, sub-sections)	.606	3.68 (.89)	3.63 (1.001)	3.66 (.94)
10. Understanding the style of science writing (e.g. the language style, language choice in a lab report)	.152	3.69 (.89)	3.55 (1.08)	3.62 (.99)
7. Understanding the meaning of technical vocabulary (e.g. oxidation, electrolysis, ionic bond, electrochemical series)	.147	4.00 (.89)	3.83 (1.09)	3.92 (.99)

Scale 3: Important English Skills	*Mann-Whitney (p-value)*	Mean (SD)		
		Early-full	Late-partial	Both
Factor 2: Important basic English skills				
1. Speaking (dialogue, e.g. whole class interaction between teacher and classmates)	.292	3.70 (.85)	3.65 (.91)	3.68 (.88)
2. Speaking (monologue, e.g. presentation)	.652	3.76 (.92)	3.75 (.92)	3.75 (.92)
5. Reading (e.g. science textbooks)	.824	3.81 (.89)	3.76 (1.05)	3.79 (.97)
3. Writing (scientific reports, with specific purpose, structures, language style)	.106	3.80 (.85)	3.66 (.99)	3.73 (.92)
6. Listening (e.g. science teacher's oral explanations in English)	**.048***	3.96 (.83)	3.79 (1.00)	3.88 (.92)
4. Writing (e.g. daily assignments)	**.001****	3.79 (.81)	3.51 (1.09)	3.65 (.96)
Overall score of the most important English skills	**.030***	3.82 (.61)	3.70 (.81)	3.76 (.71)

Table 7.15 The students' responses to the most important English language skills

*Notes: 1. The most important English skills for learning science through English was rated on a 5-point scale, where 1=least demanding), 5=most demanding). 2.*p<.05; **p<.01; ***p<.001.*

7.4.6 Students' self-concept of their science learning

a) Data reduction

No data reduction was performed due to the small number of survey items in this scale.

b) Mean comparison (item by item)

An independent sample t-test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' learning experiences in EMI classrooms. In the three items in table 7.16 below, there was no statistically significant difference in students' responses in the overall scores. However, in the three items in table 7.17 below, there was a significant difference in three out of four aspects of reflection. Three differences emerge from the five-point scale (1=untrue of me, 5=very true of me). First, the mean scores of students' responses from the early–full EMI schools had a slightly larger value for statement 1. Statement 1 likely reflected more students from the early–full EMI schools, suggesting that these students were confident that their level of English would meet the demands of using EMI to study science subjects before studying at secondary school. Second, the mean score of the students from late–partial EMI schools had a slightly larger value for statement 2. Statement 2 likely reflected more students from late–partial EMI schools, suggesting that they felt that they were at a disadvantage to study science in EMI during their junior levels. Third, there was a statistically significant difference between the two school groups. The mean score of

students from the early–full EMI schools was slightly larger. Statement 3 likely reflected more the students from the early–full EMI schools, suggesting that they felt confident that their level of English meets the demands of EMI.

Scale 4: Reflection. MOI	*t-test* *p-value*	Mean (S.D.)		
		Early-full	Late-partial	Both group
1. Before studying at my secondary school, I felt confident that my level of English would meet the demand of using EMI to study science subjects.	**.078***	3.32 (.92)	3.18 (.94)	3.25 (.93)
2. I felt I was at disadvantage to study science in EMI during junior levels.	**.014***	2.76 (1.07)	2.98 (1.09)	2.87 (1.08)
3. I now feel confident my level of English meets the demands of using EMI to study science.	**.006***	3.51 (.83)	3.30 (.96)	3.41 (.90)
Overall score of students' reflection on their learning experience in EMI classrooms	.320	3.20 (.48)	3.15 (.49)	3.18 (.49)

Table 7.16 The students' responses to their learning experience in EMI classrooms

*Notes: 1. The students' reflection on their learning experience in EMI classrooms was rated on a 5-point scale, where 1= (untrue of me), 2=somewhat untrue of me), 3=neutral), 4=somewhat true of me), 5=very true of me). 2.*p<.05; **p<.01; ***p<.001.*

7.4.7 Students' belief in science classrooms

a) Data reduction:

The nine items of the students' views on their beliefs in science classrooms were subjected to component analysis using SPSS. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin measure of sampling adequacy attained a value of .759, higher than the recommended value of .5 (Kaiser, 1970; 1974). Bartlett's test of sphericity (Barlett, 1954) reached a statistically significant difference ($p<.0001$), supporting the factorability of the correlation matrix. Principal component analysis revealed the presence of three components recorded with eigenvalues greater than 1, explaining 34.13%, 14.72% and 12.64% of the variance respectively. An inspection of the scree plot (figure 7.8) revealed a clear break after the second components. Reference to the component matrix revealed that only the first two components comprised a majority of items with loadings onto them of more than 0.4. The two-component solution explained a total of 48.85% of the variance, with component 1 contributing 34.13% and component 2 contributing 48.85%. To assist the interpretation of these two components, oblimin rotation was performed. There was a positive correlation between the two factors ($r=.229$). Table 7.17 shows the two-factor solution of the students' beliefs in science classrooms. Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were

analysed to determine commonalities and each component was labelled to represent the most important English language skills that loaded onto it. Major loadings for each item are bolded. The first component is related to common classroom activities such as following instructions, watching teachers' demonstration, and is henceforth referred to as 'students' belief related to classroom activities'. The second component is related to their participation in science learning activities such as designing lab experiments, and is henceforth referred to as 'students' belief related to their participation in science learning activities'.

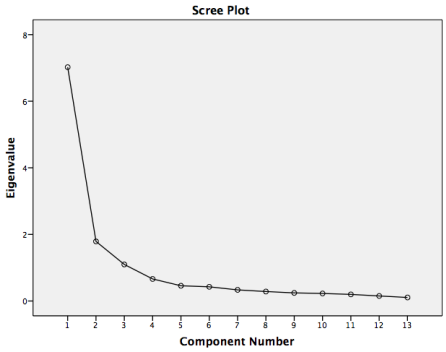


Figure 7.8 Scree plot of principal component analysis factors

Item	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
Factor 1: Students' belief related to classroom activities					
Students following instruction of manual to conduct experiments	**.821**		**.802**	.102	.650
Students watching teachers' demonstration in the laboratory	**.818**		**.807**	.138	.654

Item	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
Teachers checking the answers on the work sheets with us	**.644**		**.633**	.101	.403
Teachers managing classroom order	**.624**		**.630**	.168	.398
Students listening to teachers' explanation of subject content	**.560**	.188	**.603**	.316	.397
Factor 2: Students' belief related to their participations in science learning activities					
Students conducting group discussions		**.678**	.117	**.669**	.449
Students asking teachers questions related to the subject	.241	**.672**	.394	**.727**	.583
Students designing the procedures of experiment themselves	-.165	**.594**		**.556**	.335
Teachers asking students questions related to the subject	.355	**.558**	.482	**.639**	.528

Table 7.17 Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' beliefs in science classrooms

Notes: *1. major loadings for each item are bolded; Extraction method: Principal components analysis;*

2. Each statement was rated by the teachers on a 5-point scale, where 1= (untrue of me), 2=somewhat untrue of me), 3=neutral), 4=somewhat true of me), 5=very true of me);

3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

b) Mean comparison (item by item)

An independent sample t-test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' responses to the students' belief in science classrooms. In the nine items below in table 7.18, there was no statistically significant difference in

students' responses in the overall scores. However, there was only one significant difference in students' belief when asking teachers questions related to the subject. As indicated by the five -point scale (1=untrue of me), 5=very true of me), the mean scores of students' responses from the early–full EMI schools in most of the survey items (including students' belief when asking teachers questions related to the subject) had a slightly larger value than those in late–partial EMI schools. This suggests that most of the statements related more to students from the early–full EMI schools. Students from late–partial EMI schools rated the statements lower that related to lab experiments (5, 6, 7 and 8), suggesting that they may have more reflections on lab experiments.

Scale 6: Student's belief	*t-test* *p-value*	Mean (S.D.)		
		Early-full	Late-partial	Both groups
Factor 1: Students' belief related to classroom activities				
7. Students following instruction of manual to conduct experiments	.438	3.99 (.72)	*4.03 (.74)*	4.01 (.73)
6. Students watching teachers' demonstration in the laboratory	.158	3.96 (.74)	*4.05 (.72)*	4.00 (.73)
9. Teachers checking the answers on the work sheets with us	.287	3.88 (.79)	3.81 (.77)	3.85 (.78)
5. Teachers managing classroom order	.707	3.68 (.76)	*3.71 (.83)*	3.70 (.79)
1. Students listening to teachers' explanation of subject content	.480	3.75 (.62)	3.71 (.72)	3.73 (.67)

Factor 2: Students' belief related to their participations in science learning activities				
4. Students conducting group discussions	.675	3.14 (.75)	3.11 (.91)	3.12 (.83)
3. Students asking teachers questions related to the subject	**.001****	3.67 (.84)	3.44 (.86)	3.56 (.86)
8. Students designing the procedures of experiment themselves	.163	2.58 (.93)	*2.70 (1.07)*	2.64 (1.00)
2. Teachers asking students questions related to the subject	.126	3.78 (.79)	3.68 (.79)	3.73 (.79)
Overall score on students' belief in science classrooms	.567	3.60 (.44)	3.58 (.45)	3.59 (.45)

Table 7.18 The students' responses to their beliefs in learning science
*Notes: 1. The students' belief in science classrooms was rated on a 5-point scale, where 1= (untrue of me), 2=somewhat untrue of me), 3=neutral), 4=somewhat true of me), 5=very true of me). 2.*p<.05; **p<.01; ***p<.001.*

7.4.8 Students' self-concept in science learning

a) Data reduction

The seven items of the students' views on the self-concept in science learning were subjected to principal component analysis using SPSS. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin measure of sampling adequacy attained a value of .772, higher than the recommended value of .5 (Kaiser, 1970; 1974). Bartlett's test of sphericity (Barlett, 1954) reached a statistically significant difference (p<.0001), supporting the factorability of the correlation matrix. Principal component analysis revealed the presence of two components recorded with eigenvalues greater than 1, explaining 47.87%, and 16.36% of the variance

respectively. An inspection of the scree plot (figure 7.9) revealed a clear break after the second components. Reference to the component matrix revealed that only the first two components comprised a majority of items with loadings onto them of more than 0.4. The two-component solution explained a total of 64.22% of the variance, with component 1 contributing 47.87% and component 2 contributing 16.36%. To assist the interpretation of these two components, oblimin rotation was performed. There was a positive correlation between the two factors (*r=.07*). Table 7.19 shows the two-factor solution of the students' beliefs in science classrooms. Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were analysed to determine commonalities and each component was labelled to represent the most important English language skills that loaded onto it. Major loadings for each item are bolded. The first component is related self-concept in learning science, and is henceforth referred to as 'students' self-concept in learning science'. The second component is related to their cognitive demand in learning science and is henceforth referred to as 'students' self-concept in relation to their cognitive demand'.

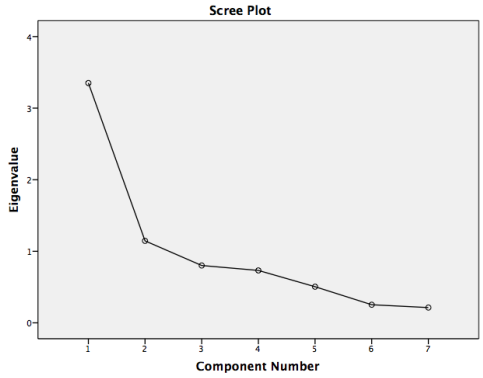


Figure 7.9 Scree plot of principal component analysis factors

Items	Pattern Matrix		Structure Matrix		Communalities
	Component		Component		
	1	2	1	2	
Factor 1: Self-concept in science learning					
My performance in science subjects is always good.	**.835**	-.166	**.824**	-.107	.721
My achievement in science is better than in other subjects.	**.834**	-.230	**.818**	-.171	.706
I like attending science lessons.	**.761**	.346	**.785**	.400	.736
I think science subjects are easy.	**.730**	-.214	**.715**	-.163	.709
I think science subjects are interesting and challenging.	**.668**	.467	**.701**	.514	.680
I understand the explanations given by my science teacher(s).	**.598**	.138	**.607**	.180	.556
Factor 2: Self-concept in relation to cognitive demand					
I think science subjects demand a lot of memory work.		**.826**		**.819**	.388

Table 7.19 Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' self-concept in learning science

Notes: *1. major loadings for each item are bolded; Extraction method: principal components analysis;*

2. Each statement was rated by the teachers on a 5-point scale, where 1=untrue of me, 2=somewhat untrue of me, 3=neutral, 4=somewhat true of me, 5=very true of me.; 3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

b) Mean comparison (item by item)

An independent sample t-test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' responses to their self-concept in science learning. In the 17 items below in table 7.20, there was no statistically significant difference in students' responses in their self-concept in science learning.

Scale 5: Student's self-concept	*t-test* *p-value*	Mean (S.D.)		
		Early-full	Late-partial	Both group
Factor 1: Self-concept in science learning				
2. My performance in the science subject is always good.	.247	3.07 (1.01)	3.16 (.96)	3.11 (.99)
1. My achievement in science is better than in other subjects.	.090	3.13 (1.09)	3.28 (1.02)	3.20 (1.06)
3. I like attending science lessons.	.061	3.83 (.86)	3.97 (.82)	3.90 (.84)
6. I think science subjects are easy.	.116	2.96 (.93)	3.10 (1.01)	3.03 (.97)
4. I think science subjects are interesting and challenging.	.150	3.95 (.75)	4.04 (.78)	3.99 (.77)
7. I understand the explanations given by my science teacher(s).	.110	3.65 (.73)	3.54 (.87)	3.60 (.80)
Factor 2: Self-concept in relation to cognitive demand				
5. I think science subjects demand a lot of memory work.	.306	3.67 (.85)	3.74 (.92)	3.70 (.88)
Overall score on students' self-concept of science	.111	3.47 (.60)	3.55 (.59)	3.51 (.59)

Table 7.20 The students' responses to their self-concept in learning science

*Notes: 1. The students' self-concept on their science learning was rated on a 5-point scale, where 1= (untrue of me, 2=somewhat untrue of me, 3=neutral, 4=somewhat true of me, 5=very true of me; 2.*p<.05; **p<.01; ***p<.001.*

7.4.9 Students' views on the frequency of using coping strategies

a) Data reduction

The nine items of the students' views on their frequency of using coping strategies were subjected to principal component analysis using SPSS. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin measure of sampling adequacy attained a value of .791, higher than the recommended value of .5 (Kaiser, 1970; 1974). Bartlett's test of sphericity (Barlett, 1954) reached a statistically significant difference (p<.0001), supporting the factorability of the correlation matrix. Principal component analysis revealed the presence of three components recorded with eigenvalues greater than 1, explaining 35.96%, 13.51% and 12.25% of the variance respectively. An inspection of the scree plot (figure 7.10) revealed a clear break after the second component. Reference to the component matrix revealed that the first two components comprised a majority of items with loadings onto them of more than 0.4. The two-component solution explained a total of 49.47% of the variance, with component 1 contributing to 35.96% and component 2 contributing 13.51%. To assist the interpretation of these two components, oblimin rotation was performed. There was a positive correlation between the two factors (r=.306). Table 7.21 shows the two-factor solution of the students' beliefs in science classrooms. Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were analysed to determine commonalities and each

component was labelled to represent the students' responses on their frequency of using coping strategies that loaded onto it. Major loadings for each item are bolded. The first component is related to coping strategies involving external help from teachers and is henceforth referred to as 'frequency of using coping strategies related to external help'. The second component is related to coping strategies from students' own initiatives and is henceforth referred to as 'frequency of using coping strategies related to self-initiatives'.

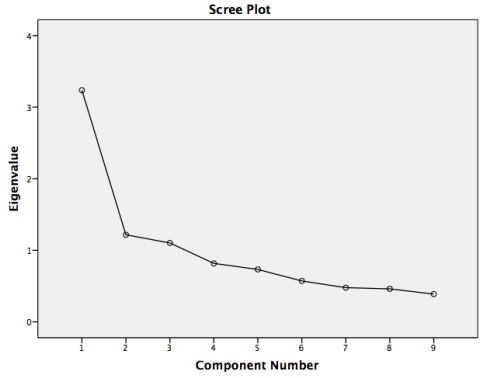


Figure 7.10 Scree plot of principal component analysis factors

Items	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
Factor 1: Frequency of coping strategies related to external help					
Requesting lesson materials printed in bilingual languages (Chinese and English)	**.805**		**.792**	.202	.629
Seeking support from English language teachers on learning science through English	**.777**		**.772**	.221	.596
Requesting additional English explanations from my science teacher	**.719**	.159	**.768**	.379	.613
Attending tutorials and seeking study assistants outside school	**.697**	-.114	**.662**		.450
Requesting additional Chinese explanations from my science teacher	**.618**		**.612**	.167	.375
Asking my science teachers for feedback on and corrections of my science writing in English	**.456**	.232	**.527**	.371	.327
Factor 2: Frequency of coping strategies related to self-initiatives					
Checking the Chinese translation of scientific vocabulary		**.804**	.350	**.821**	.620
Checking the meanings of the English vocabulary (non-scientific)	.109	**.788**	.186	**.785**	.685
Understanding the science concept from more examples and rephrasing but do not need to translate them into Chinese		**.401**	.111	**.398**	.158

Table 7.21 Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' views on the frequency of using coping strategies

Notes: *1. major loadings for each item are bolded; Extraction method: Principal components analysis.*

2. Each statement was rated by the teachers on a 5-point scale, where 1=untrue of me, 2=somewhat untrue of me, 3=neutral, 4=somewhat true of me, 5=very true of me.

3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

b) Mean comparison (item by item)

A Mann-Whitney test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' responses to the frequency of using coping strategies. In the nine items below in table 7.22, there was no statistically significant difference in students' responses in the overall scores. Three out of the nine items were found to have a statistically significant difference. These items are: (1) checking Chinese translation of technical words (p=.006**); (2) understanding from examples (p=.003**); and (5) requesting more explanations from teachers in English (p=.011*). As indicated by the five-point scale (1=untrue of me, 5=very true of me), the mean scores of students' responses from the late–partial EMI schools in item 1 had a slightly larger value, suggesting that students in the late–partial EMI schools used more Chinese translations of technical vocabulary (p=.006**). For item 2, the mean score of early-partial EMI schools was higher, indicating that these students tended to understand the science concepts from more examples and/or rephrasing but that they did not need to translate into Chinese. For item 5, the mean score of early-partial EMI schools was higher, suggesting that students might request additional English explanations from their science teacher.

	Mann-Whitney p-value	Mean (SD)		
		Early-full	Late-partial	Both group
Factor 1: Frequency of coping strategies related to external help				
8. Requesting lesson materials printed in bilingual languages (Chinese and English)	.107	2.16 (1.12)	2.00 (1.55)	2.08 (1.34)
4. Seeking support from English language teachers on learning science through English	.060	2.16 (.98)	1.92 (1.40)	2.04 (1.21)
5. Requesting additional English explanations from my science teacher	**.011***	2.50 (.84)	2.11 (1.41)	2.32 (1.17)
7. Attending tutorials and seeking study assistants outside school	.106	2.38 (1.18)	2.16 (1.49)	2.28 (1.34)
6. Requesting additional Chinese explanations from my science teacher	.680	2.72 (.94)	2.65 (1.36)	2.69 (1.16)
9. Asking my science teachers for feedbacks on and corrections of my science writing in English	.103	2.82 (.95)	2.80 (1.33)	2.81 (1.15)
Factor 2: Frequency of coping strategies related to self-initiatives				
1. Checking the Chinese translation of scientific vocabulary	**.006****	2.78 (.89)	2.98 (1.14)	2.88 (1.02)
2. Checking the Chinese translation of abstract English vocabulary (non-scientific)	.650	2.92 (.84)	2.85 (1.17)	2.88 (1.01)
3. Understanding the science concept from more examples and rephrasing but do not need to translate them into Chinese	**.003****	3.29 (.82)	2.84 (1.40)	3.07 (1.15)
Overall score of frequency of coping strategies rated by students	.091	2.64 (.56)	2.48 (.79)	2.56 (.69)

Table 7.22 The students' responses to views on the frequency of using coping strategies

Notes: *1. The frequency of coping strategies was rated on a 5-point scale, where 1=never, 2=rarely, 3=sometimes, 4=often, 5=always. 2.*p<.05; **p<.01; ***p<.001.*

7.4.10 Students' views on the usefulness of their coping strategies

a) Data reduction:

The nine items about the students' views on the usefulness of their coping strategies were subjected to principal component analysis using SPSS. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin measure of sampling adequacy attained a value of .858, higher than the recommended value of .5 (Kaiser, 1970; 1974). Bartlett's test of sphericity (Barlett, 1954) reached a statistically significant difference (p<.0001), supporting the factorability of the correlation matrix. Principal component analysis revealed the presence of two components with eigenvalues greater than 1, explaining 41.63% and 12.03% of the variance respectively. An inspection of the scree plot (figure 7.11) revealed a clear break after the second components. Reference to the component matrix revealed that the two components comprised a majority of items with loadings onto them of more than 0.4. The two-component solution explained a total of 53.66% of the variance, with component 1 contributing 41.63% and component 2 contributing 12.03%. To assist the interpretation of these two components, oblimin rotation was performed. There was a positive correlation between the two factors (r=.482). Table 7.23 shows the two-factor solution of the students' views on the usefulness of the coping strategies. Items that loaded onto a component at more than .4 in the pattern and structure matrix for principal component analysis were analysed to determine commonalities and each component was labelled to

represent the students' responses on their frequency of using coping strategies that loaded onto it. Major loadings for each item are bolded.

The first component is related to coping strategies related to understanding science concepts and meaning of scientific words and ishenceforth referred to as 'usefulness of coping strategies related to comprehension of science concepts'. The second component is related to coping strategies related to learning difficulties in science classrooms and is henceforth referred to as 'usefulness of coping strategies related to learning in science classrooms'.

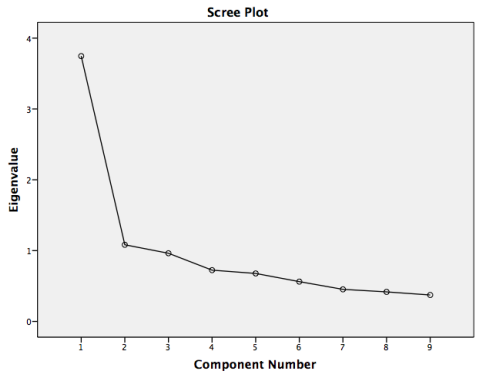


Figure 7.11 Scree plot of principal component analysis factors

Items	Pattern coefficients		Structure coefficients		Communalities
	Component		Component		
	1	2	1	2	
Factor 1: Usefulness of coping strategies related to comprehension of science concepts					
Understanding the science concept from more examples and rephrasing but do not need to translate them into Chinese	**.888**	-.136	**.822**	.292	.690
Checking the meanings of the English vocabulary (non-scientific)	**.853**		**.838**	.380	.702
Requesting additional English explanations from my science teacher	**.749**		**.769**	.402	.593
Requesting additional Chinese explanations from my science teacher	**.649**	.211	**.751**	.524	.598
Checking the Chinese translation of scientific vocabulary	**.514**		**.553**	.328	.310
Factor 2: usefulness of coping strategies related to learning in science classrooms					
Asking my science teachers for feedbacks on and corrections of my science writing in English	-.140	**.835**	.263	**.768**	.605
Requesting lessons materials printed in bilingual languages (Chinese and English)		**.805**	.396	**.808**	.654
Seeking support from English language teachers on learning science through English	.219	**.469**	.445	**.575**	.367
Attending tutorials and seek for study assistants outside school	.150	**.469**	.376	**.541**	.310

Table 7.23 Pattern and structure matrix for principal component analysis with oblimin rotation of the two-factor solution of the students' views on the usefulness of the coping strategies

Notes: *1. major loadings for each item are bolded; Extraction method: Principal components analysis.*

2. Each statement was rated by the teachers on a 5-point scale, where 1= (untrue of me, 2=somewhat untrue of me, 3=neutral, 4=somewhat true of me, 5=very true of me.

3. Only statements with factor loadings that have an absolute value greater than 0.3 are shown in the table. The statements are ordered within each factor according to the magnitude of their loadings.

b) Mean comparison (item by item)

A Mann-Whitney test was conducted to determine whether there was a group difference between the early–full and late–partial EMI schools in students' responses to the usefulness of their coping strategies. In the nine items below in table 7.24, there was a statistically significant difference in students' responses in the overall scores (p<.0001***). Six out of the nine items were found to have a statistically significant difference. These items are item (2) 'checking Chinese translation of abstract English words' (p<.0001***); item (3) 'understanding from examples' (p<.0001***); items (5) and (6) 'requesting teacher's explanations in English' (p=.001**) and 'in Chinese' (p<.0001***); item (7) 'attending tutorials' (p=.008**); and item (8) 'requesting bilingual materials' (p=.001**).

As indicated by the five-point scale (1=untrue of me, 5=very true of me), the mean scores of students' responses from the early–full EMI schools in all the mentioned items 2, 3, 5, 6, and 7, had a slightly larger value, suggesting that students in the early–full EMI schools used the following coping strategies useful: the Chinese translation of technical vocabulary; having examples in Chinese; requesting additional teacher explanations in both English and Chinese; attending tutorials; and requesting bilingual materials.

	Mann-Whitney p-value	Mean (SD)		
		Early-full	Late-partial	Both group
Factor 1: Usefulness of coping strategies related to comprehension of science concepts				
3. Understanding the science concept from more examples and rephrasing but do not need to translate them into Chinese	***p*<.0001*** **	3.51 (.90)	2.59 (1.63)	3.07 (1.38)
2. Checking Chinese translation of abstract English vocabulary (non scientific)	***p*<.0001*** **	3.32 (.97)	2.49 (1.62)	2.92 (1.39)
5. Requesting additional English explanations from my science teacher	**.001****	3.13 (.99)	2.61 (1.52)	2.88 (1.30)
6. Requesting additional Chinese explanations from my science teacher	***p*<.0001*** **	3.31 (1.04)	2.48 (1.67)	2.91 (1.44)
1. Checking Chinese translation of technical vocabulary	.070	3.13 (1.08)	2.82 (1.44)	2.98 (1.28)
Factor 2: Usefulness of coping strategies related to learning in science classrooms				
9. Asking my science teachers for feedbacks on and corrections of my science writing in English	.688	3.20 (1.00)	2.99 (1.43)	3.10 (1.23)
8. Requesting lessons materials printed in bilingual languages (Chinese and English)	**.001****	2.96 (1.12)	2.43 (1.63)	2.71 (1.41)
4. Seeking support from English language teachers on learning science through English	.096	2.70 (1.10)	2.76 (1.39)	2.73 (1.25)
7. Attending tutorials and seek for study assistants outside school	**.008****	3.02 (1.06)	2.66 (1.38)	2.85 (1.24)
Overall score of frequency of coping strategies rated by students	***p*<.0001*** **	3.14 (.66)	2.65 (.95)	2.91 (.85)

Table 7.24. The students' responses to views on the usefulness of their coping strategies

Notes: *1. The usefulness of coping strategies was rated on a 5-point scale, where 1=least useful, 5=most useful; 2.*p<.05; **p<.01; ***p<.001.*

7.5 Exploitation of the reduced data

The new components of each of the questionnaire scales were added to the dataset as new variables. The two variables represented the differential loadings of the students' responses to each of the questionnaire scales onto each component respectively. These factored variables were computed in order to determine whether there was a group difference between the early–full and late–partial EMI schools, and a possible relationship between them and among other 'factored' variables (e.g. students' reflections on EMI, etc.) in the questionnaires. The 'factored' variables were checked individually for normality of distribution. These variables were normally distributed and as such were deemed suitable for using parametric tests. Table 7.25 summarizes the 'factored' variables of each questionnaire scales and the decision of chosen statistical tests.

Scale		**Major factors**	**Descriptions**	**Kolmogorov-Smirnov Z (sig)**	**Normality**
1. Choice of instructional language in different science teaching activities	**1a**	**Lang. choice for interactions**	Language choice for interaction	***p*<.0001*** **	Non-parametric
	1b	Lang. choice for explaining science	Language choice for explaining science	.011*	Non-parametric
2. The most demanding English language skills for students to study science in English medium	**2a**	**Demanding Eng. (daily uses)**	Demanding English skills related to daily uses	***p*<.0001*** **	Non-parametric
	2b	**Demanding Eng. (scientific writing)**	Demanding English skills related to scientific writing	***p*<.0001*** **	Non-parametric
	2c	**Demanding Eng. (vocabulary)**	Demanding English skills related to vocabulary	***p*<.0001*** **	Non-parametric
3. The most important English language skills for students to study science in English medium	**3a**	**Important Eng. (academic)**	Important English skills related to academic language	**.006****	Non-parametric
	3b	**Important Eng. (basic)**	Important English skills related to basic language	**.007****	Non-parametric
4. Student's reflection on EMI	4	Students' reflection	Overall score of students' reflection on their learning experience in EMI classrooms	.320	*parametric*
5. Students' self-concept of science	5a	Self-concept (science)	Self-concept in science learning	.357	*parametric*
	5b	Self-concept (cognitive. demand)	Self-concept in relation to cognitive demand	.361	*parametric*
6. Students' belief in science classrooms	**6a**	**Students' belief (classroom activities)**	Students' belief related to classroom	***p*<.0001*** **	Non-parametric

Scale		Major factors	Descriptions	Kolmogorov-Smirnov Z (sig)	Normality
			activities		
	6b	**Students' belief (science learning activities)**	Students' belief related to their participations in science learning activities	***p*<.0001***	Non-parametric
7. Students' views on language challenge	**7a**	**challenge (use of scientific English)**	*Language challenges related to comprehension, communicating in science content*	***p*<.0001***	Non-parametric
	7b	**challenge (use of basic English)**	*Language challenges related to basic English skills*	***p*<.0001***	Non-parametric
8. Students' views towards the frequency of the coping strategies.	**8a**	**Freq. strategies (external help)**	Frequency of coping strategies related to external help	***p*<.0001***	Non-parametric
	8b	**Freq. strategies (self-initiatives)**	Frequency of coping strategies related to self-initiatives	***p*<.0001***	Non-parametric
9. Students' views towards the usefulness of coping strategies.	**9a**	**Useful. Strategies (comprehension. Science concept)**	Usefulness of coping strategies related to comprehension of science concepts	***p*<.0001***	Non-parametric
	9b	**Useful. Strategies (learning in science)**	Usefulness of coping Strategies related to learning in science classrooms	***p*<.0001***	Non-parametric

Table 7.25 The 'factored' variables of each questionnaire scale and their normality

Note: *1.*p<.05; **p<.01; ***p<.001.*

7.6 Comparison of means (reduced factors)

The major results are presented in tables 7.26 and 7.27. Table 7.26 summarises the overall results on the nine reduced' variables of the students' perceptions between early–full and late–partial EMI schools. Table 7.27 summarises the overall results between grades 10 and 11 in each school group. For all the comparisons, each table contains the means and standard deviations of the questionnaire items rated by the two groups of students from the early–full and late–partial EMI schools.

	p-value	Mean (SD)			Effect Size* (Cohen's *d)*
		Early-full (n=284)	Late-partial (n=261)	Both group (n=545)	
1a Lang. choice for interactions	M, ***p*<.0001*** **	3.23 (.70)	3.62 (.65)	3.41 (.70)	**0.58** (moderate)
1b Lang. choice for explaining science	M, ***p*=.001****	2.94 (.77)	3.16 (.71)	3.05 (.75)	**0.30** (small)
2a Demanding Eng. (daily uses)	M, ***p*=.006****	2.62 (.71)	2.83 (.81)	2.72 (.77)	**0.28** (small)
2b Demanding Eng. (scientific writing)	.705 (n.s.)	3.11 (.76)	3.10 (.84)	3.11 (.80)	0.012
2c Demanding Eng. (vocabulary)	.147 (n.s.)	2.84 (.79)	2.94 (.90)	2.88 (.84)	0.12
3a Important Eng. (academic)	.066 (n.s.)	3.82 (.67)	3.71 (.85)	3.77 (.76)	0.14
3b Important Eng. (basic)	M, ***p*=.021***	3.80 (.66)	3.68 (.82)	3.75 (.74)	0.16

4 Student's self-concept in learning science through English (same as section 7.5)	.320 (n.s.)	3.20 (.48)	3.15 (.49)	3.18 (.49)	0.10
5a Self-concept (science)	T, ***p*=.031***	3.43 (.63)	3.55 (.61)	3.49 (.62)	0.19
5b Self-concept (cognitive. demand)	.110 (n.s.)	3.65 (.73)	3.54 (.87)	3.60 (.80)	0.14
6a Belief (classroom activities)	.915 (n.s.)	3.85 (.53)	3.86 (.51)	3.86 (.52)	0.02
6b Belief (science activities)	.150 (n.s.)	3.29 (.55)	3.23 (.59)	3.26 (.57)	0.11
7a challenge (use of scientific English)	M, ***p*<.0001*****	2.86 (.62)	3.08 (.65)	2.96 (.64)	**0.35** (small)
7b challenge (use of basic English)	M, ***p*=.009****	2.87 (.76)	3.05 (.79)	2.95 (.78)	**0.23** (small)
8a Freq. strategies (external help)	.113 (n.s.)	2.45 (.70)	2.27 (.98)	2.37 (.85)	0.21 (small)
8b Freq. strategies (self-initiatives)	.287 (n.s.)	2.99 (.58)	2.89 (.86)	2.95 (.73)	0.14
9a Useful. Strategies (comprehension. Science concept)	M, ***p*<.0001*****	3.28 (.69)	2.60 (1.20)	2.95 (1.02)	**0.69** (moderate)
9b Useful. Strategies (learning in science)	M, ***p*=.003****	2.97 (.79)	2.71 (.96)	2.84 (.89)	**0.30** (small)

Table 7.26 Overall results of the mean-comparison of the nine 'factored' variables of students' perception of their EMI experience

Notes: *1.*d=0.2 (small effect), d= 0.5 (moderate effect), d=0.8 (large effect); 2. M: Mann-Whitney; T: independent sample t-test; 3. *p<.05; **p<.01; ***p<.001.*

Between grades	Early-full				Late-partial			
	Mean (SD)		*p-value*	Effect Size* (Cohen's *d)*	Mean (SD)		*p-value*	Effect Size* (Cohen's *d)*
	Grade 10	Grade 11			Grade 10	Grade 11		
1a Lang. choice for interactions	3.00 (.59)	3.35 (.73)	***p*<.0001***	0.53 (moderate)	3.57 (.63)	3.66 (.66)	.208	0.14
1b Lang. choice for explaining science	2.96 (.81)	2.96 (.76)	.685	0	3.19 (.74)	3.13 (.66)	.439	0.09
2a Demanding Eng. (daily uses)	2.54 (.62)	2.64 (.75)	.175	0.15	2.96 (.81)	2.67 (.77)	**.006****	**0.37** (small)
2b Demanding Eng. (scientific writing)	3.04 (.65)	3.10 (.81)	.357	0.08	3.04 (.84)	3.18 (.85)	.175	0.17
2c Demanding Eng. (vocabulary)	2.91 (.74)	2.82 (.82)	.523	0.12	3.05 (.85)	2.78 (.94)	**.019***	**0.30** (small)
3a Important Eng. (academic)	3.83 (.61)	3.83 (.69)	.720	0	3.67 (.85)	3.79 (.83)	.259	0.14
3b Important Eng. (basic)	3.81 (.59)	3.81 (.71)	.796	0	3.64 (.79)	3.75 (.84)	.306	0.13
4 Student's self-concept in learning science through English (same as section 7.5)	*3.54 (.57)*	*3.42 (.61)*	*.126*	0.20 (small)	*3.50 (.57)*	*3.59 (.60)*	*.210*	0.15
5a Self-concept (science)	3.47 (.59)	3.39 (.64)	.295	0.13	3.55 (.60)	3.57 (.57)	.883	0.03
5b Self-concept (cognitive. demand)	3.68 (.71)	3.63 (.76)	.560	0.07	3.52 (.88)	3.60 (.83)	.458	0.09

6a Belief (classroom activities)	3.94 (.54)	3.83 (.53)	.050	0.21 (small)	3.91 (.48)	3.82 (.54)	.098	0.18
6b Belief (science activities)	3.37 (.56)	3.25 (.53)	.208	0.22 (small)	3.28 (.56)	3.18 (.62)	.212	0.17
7a challenge (use of scientific English)	2.95 (.55)	2.81 (.66)	.224	0.23 (small)	3.09 (.68)	3.05 (.61)	.363	0.06
7b challenge (use of basic English)	2.92 (.66)	2.81 (.80)	.260	0.15	3.09 (.82)	2.99 (.77)	.292	0.13
8a Freq. strategies (external help)	2.46 (.73)	2.47 (.70)	.935	0.01	2.26 (.99)	2.26 (.99)	.973	0
8b Freq. strategies (self-initiatives)	3.09 (.53)	2.95 (.60)	**.027***	**0.25** (small)	2.81 (.91)	2.99 (.78)	.124	0.21 (small)
9a Useful strategies (comprehension, science concepts)	3.42 (.67)	3.19 (.70)	**.020***	0.34 (small)	2.57 (1.23)	2.62 (1.16)	.713	0.04
9b Usefulstrategies (learning in science)	3.03 (.83)	2.93 (.79)	.267	0.12	2.75 (.99)	2.66 (.93)	.552	0.09

Table 7.27 Overall results of the mean-comparison on the nine 'factored' variables of students' perception of their EMI experience between grades in each school group

Notes: *1.*d=0.2 (small effect), d= 0.5 (moderate effect), d=0.8 (large effect); 2. M: Mann-Whiteny; T: independent sample t-test; 3.*p<.05; **p<.01; ***p<.001.*

For means-comparison of the 17 reduced factors, there was a statistically significant difference in students' responses between early–full and late–partial EMI schools in the following nine factored variables:

1a) Language choice for interactions (moderate effect size)

1b) Language choice for explaining science (small effect size)

2a) Demanding English (daily uses) (small effect size)

3b) Important English (basic) (relatively small effect size);

5a) Self-concept (science) (relatively small effect size)

7a) challenges (use of scientific English) (small effect size)

7b) challenges (use of basic English) (small effect size)

9a) Useful strategies (comprehension and science concepts) (moderate effect size)

9b) Useful strategies (learning in science) (small effect size).

For grade comparisons, there was a statistical difference only between grades 10 and 11 in the early–full EMI schools for:

1a) Language choice for interactions (relatively small effect size)

8b) Frequency of using strategies (self-initiatives) (small effect size)

9a) Useful strategies (comprehension and science concepts) (small effect size).

There was also a statistical difference between grades 10 and 11 in the late–partial EMI schools for:

2a) Demanding English (daily use) (small effect size)

2c) Demanding English (vocabulary) (small effect size).

1a Language choice for interactions

The Mann-Whitney U Test revealed a statistically significant difference in the two factors under the choice of instructional language in different science teaching activities. For the language choices related to interaction (1a), there was a group difference between early–full (Md=3.1, n=284) and late–partial EMI schools (Md=3.6, n=261), U=25502, z=-6.531, p<.0001, r=0.27. The average mean score in the late–partial EMI schools was higher, suggesting that these students more often chose Cantonese as their language for interactions. From the grades comparison, there was a statistically significant difference only in the early–full EMI schools between grades 10 (Md=3.0, n=106) and 11 (Md=3.25, n=178), U=5166.5, z=-4.056, *p*<.0001, r=-.24. There was no significant difference between grades 10 and 11 in the late–partial EMI school group.

1b Language choice for explaining science

For the language choices related to explaining science (1b), the Mann-Whitney U Test revealed there was a group difference between early–full (Md=3.0, n=284) and late–partial EMI schools (Md=3.0, n=261), U=30802, z=-3.464, *p*=.001, r=-.15. The average mean score in the late–partial EMI schools was higher, suggesting that students chose to use more Cantonese when explaining science. There was no significant difference between grades 10 and 11 in both types of EMI schools.

2a Demanding English (daily use)

The Mann-Whitney U Test revealed a statistically significant difference in only one of the factors under the most demanding English language skills. There was a group difference for students' responses to the most demanding English skills for daily use between early–full (Md=2.64, n=284) and late–partial EMI schools (Md=2.86, n=261), U=32046.5, z=-2.737, *p*=.006, r=-.12. The average mean score was higher, suggesting that students in the late–partial EMI schools found daily-use English skills more demanding than their counterparts in the early–full EMI schools. From the grades comparison, there was no significant difference between grades 10 and 11 in the early–full EMI schools. The only statistically significant difference was found in the late–partial EMI schools between Grades 10 (Md=2.57, n=144) and 11 (Md=2.71, n=117), U=6646, z=-2.733, *p*=.006, r=-.17.

2c Demanding English (vocabulary)

The Mann-Whitney U Test revealed that while there was no statistically significant difference between early–full and late–partial EMI schools, there was a significant difference in the late–partial EMI schools between grade 10 (Md=3.00, n=144) and grade 11 (Md=3.00, n=117), U=6877, z=-2.352, r=-.15. The average mean score was higher, suggesting that students in the early–full EMI schools found English skills related to vocabulary more demanding than their counterparts in the early–full EMI schools.

3b Important English (basic)

The Mann-Whitney U Test revealed a statistically significant difference in only one of the factors under the most important English language skills. There was a group difference for students' responses to the most important English skills (Basic) between early–full (Md=4.00, n=284) and late–partial EMI schools (Md=4.00, n=261), U=32864, z=-2.302, *p*=.021, r=-.10. The average mean score was lower, suggesting that students in the late–partial EMI schools found basic English skills more difficult than their counterparts in the early–full EMI schools. There was no significant difference between grades 10 and 11 in both types of schools.

5a Self-concept (science)

An independent t-test revealed a statistically significant difference in the students' response to one of the factors under the students' self-concept of science. There was a group difference for students' responses to their self-concept in science between early–full (M=3.43, SD=.63) and late–partial EMI schools (M=3.55, SD=.61), t=545)=-2.167, *p*=.031. The average mean score was higher, suggesting that students in the late–partial EMI schools were more confident of their science abilities than their counterparts in the early–full EMI schools. There was no significant difference between Grades 10 and 11 in both types of schools.

7a Language challenges (use of scientific English)

The Mann-Whitney U Test revealed a statistically significant difference in the two factors under students' views on language challenges. There was a group difference for students' responses to the language challenges that related to comprehension and communication in science content between early–full (Md=3.0, n=284) and late–partial EMI schools (Md=3.12, n=261), U=29978, *z*=-3.86, *p*<.0001, r=-.17. The average mean score was higher, suggesting that students in the late–partial EMI schools found the same set of language challenges more difficult than their counterparts in the early–full EMI schools. There was no significant difference between grades 10 and 11 in both types of schools.

7b Language challenges (use of basic English)

Secondly, the Mann-Whitney U Test revealed there was a group difference for students' responses to language challenges related to basic English skills between early–full (Md=3.0, n=284) and late–partial EMI schools (Md=3.00, n=261), U=32310, *z*=-2.596, *p*=.009, r=-.11. The average mean score was higher, suggesting that students in the late–partial EMI schools found the same set of language challenges more difficult than their counterparts in the early–full EMI schools. There was no significant difference between grades 10 and 11 in both types of schools.

8b Frequent strategies (self-initiatives)

The Mann-Whitney U Test revealed that there was no statistically significant difference between early–full and late–partial EMI schools on the frequency of using coping strategies related to self-initiatives. However, there was a significant difference in the early–full EMI schools between grade 10 (Md=3.00, n=106) and grade 11 (Md=3.00, n=178), U=6243.5, z=-2.21, r=-.13. The average mean score was higher, suggesting that students in the early–full EMI schools used self-initiated coping strategies more frequently than their counterparts in the early–full EMI schools.

9a Useful strategies (comprehension and science concepts)

The Mann-Whitney U Test revealed a statistically significant difference in the two factors under students' views on the usefulness of coping strategies. First, there was a group difference for students' responses to the usefulness of coping strategies related to comprehension of science concepts between early–full (Md=3.2, n=284) and late–partial EMI schools (Md=3.0, n=261), U=25455.5, z=-6.357, p<.0001, r=-.27. The average mean score was higher, suggesting that students in the early–full EMI schools found the same set of coping strategies (comprehension in science concepts) more useful than their counterparts in the late–partial EMI schools. There was a significant difference only between grades 10 (Md=3.2, n=106) and 11 (Md=3.2, n=178) in the early–full EMI schools, U=6161, z=-2.326, p=.02, r=-.14.

9b Useful strategies (learning in science)

The second factor revealed by the Mann-Whitney U Test is a group difference for students' responses to the usefulness of coping strategies related to learning in science classrooms between early–full (Md=3.0, n=284) and late–partial EMI schools (Md=3.0, n=261), U=31681, z=-2.953, *p*=.003, r=-. The average mean score was higher, suggesting that students in the early–full EMI schools found the same set of coping strategies more useful than their counterparts in the late–partial EMI schools. There was only a significant difference between grades 10 (Md=3.00, n=106) and 11 (Md=3.00, n=178) in the early–full EMI schools, U=6161, z=-2.326, *p*=.02, r=-.13. The average mean score was higher suggesting that students in the early–full EMI schools found the same set of coping strategies (learning in science) more useful than their counterparts in the late–partial EMI schools. There was no significant difference between grades 10 and 11 in both types of schools.

7.7 Summary of students' perception of their EMI experience (the 17 factored variables)

The major findings of the students' perception of their EMI experience are as follows:

1. Science students from early–full and late–partial EMI schools had different perceptions on the following: the preferred language choice for interaction and explaining science; which English skills are most

demanding; which English (basic) skills are most important; language challenges; and the usefulness of coping strategies.

2. Students from the late–partial EMI schools preferred more Cantonese for interactions and for explaining science.
3. Students from the late–partial EMI schools believed that English language skills for daily use were more demanding.
4. Grade 11 students believed that English skills related to daily use vocabulary were more demanding did than students in grade 10.
5. Students from the late–partial EMI schools thought basic English language skills for daily use were less important than did students from the early–full schools.
6. More students from the late–partial EMI schools believed they could do well in science than those in the early-full EMI schools.
7. Students from the late–partial EMI schools reported that they had more language challenges in the areas of comprehension and communicating science content, as well as in basic English language skills, than did students in the early–full schools.
8. Students from the late–partial EMI schools reported that they use the self-initiated coping strategies less frequently than do the students in the early–full EMI schools.

9. Students from the late–partial EMI schools reported that they found the coping strategies to improve their comprehension of science concepts less useful than did the students in the early–full EMI schools.
10. Students from the late–partial EMI schools reported that they found the coping strategies to enhance their learning in science less useful than did the students in the early–full EMI schools.

To conclude, the questionnaire results show that students from the late–partial EMI schools preferred more Cantonese for interactions and explaining science. Although these students believed that daily English language skills and basic vocabulary are more demanding, they found these skills less important than their peers in the early–full EMI schools. This was also observed among the late–partial EMI teachers (in chapter 6). In addition, students in the late–partial schools believed that they have the ability to do well in science, but they encountered more language challenges related to comprehension and communicating in science content, as well as in basic English skills. In terms of coping strategies, late–partial students used self-initiated coping strategies less frequently than do students in the early–full schools. Late-partial students also found strategies that enhance their comprehension of science concepts and learning of science to be less useful than students in the early–full EMI schools.

7.8 Focus group interview with students

This interview analysis draws from the semi-structured interviews with students from the observed science lessons. The students were first asked about their overall impression of the observed lessons, providing important data about their perceptions of science learning in EMI classrooms. Students were also asked to share their perceptions of using English to learn senior secondary science, specific language challenges in specific science subjects (physics, biology, chemistry), language challenges in interactions with teachers and their coping strategies.

7.11.1 The background of the student focus group interviews

Fifty-two science students from 33 lessons were recruited to participate in focus group interviews. I invited five to eight randomly selected students from each lesson to attend the interviews after the observations. Teachers were not asked to nominate students. If students could not attend the interviews, I arranged another interview on the same day of the observation. Students who participated in the interviews were invited to discuss the topic freely but I guided discussion following the interview protocol (discussed in chapter 3). Students shared their opinions about the use of Cantonese in the EMI experience, possible language challenges when studying science through English, and their coping strategies. The interviews lasted for 20 to 40 minutes and each of the students had at least two to three minutes to speak during the

discussion. All students identified Cantonese as their first language. Each of the participating students was given a pseudonym and a code (S1 to SX) to be referred to in the analysis. In addition, students were invited to share their experiences of responding to teachers' questions or discussing something with classmates in English, helpful question types for understanding science, the kind of vocabulary that is important for learning science and their expectations of their English proficiency in learning science.

7.11.3 Results of the students' interviews

The interviews were analysed for seven different areas related to students' perceptions of their EMI learning experience:

1. language choice for interactions, and the challenges
2. vocabulary in science subjects
3. the coping strategies related to vocabulary
4. language challenges related to writing and reading in science
5. coping strategies for writing and reading in science
6. strategies related to external help
7. positive and negative attitudes towards EMI.

a) Language choice for interactions and the challenges

The majority of the students from the early–full and late–partial EMI schools highly valued the role of L1 in learning science through English, particularly

when interacting with their science teachers or working with their peers during a lab experiment. Students from the late–partial EMI schools strongly believed that their L1 is an easy and efficient means for communicating science in lab operations, as the following two examples show:

> 'It is because mother tongue is the most convenient language to express the message I want to say. If we use English, we would waste a lot of time to communicate and ignore the importance of the experiment.' (Student 1, late–partial EMI)

> 'I will respond in mostly Cantonese, when I don't understand what the teacher said in English.' (Student 3, late–partial EMI)

Students also reported that more Cantonese was spoken in biology and chemistry than in physics. For instance, student 2 said:

> 'I use Chinese more in biology class as well as chemistry class. But I would use English if the situation is okay. And if it doesn't work, I would mix Chinese with English'. (Student 2, early–full EMI)

Despite the usefulness of Cantonese, the students highlighted a few possible consequences of using L1:

> 'When answering questions, I know the Chinese but forgot their English words. Like before … that's because he uses Chinese to memorise.' (Student 3, late–partial EMI)

> 'An example is about a test before. Did you remember something like, foetus, like the peeling off of the placenta would lead to miscarriage … But I couldn't write the word 'miscarriage' in English. I could only write down something about babies ... But I couldn't write that noun and that I didn't know the word.' (Student 3)

Coping strategies for overcoming the challenges of communicating in English:

Some students with less competence in English try to organise their thoughts in their mother-tongue (Cantonese) first and then translate them into English. Students called this way of translating ideas from Cantonese to English 'Chinglish'. The students felt that this is an efficient way for those with limited English skills to express science ideas. As student 3 said:

> 'For me, I would use English to express myself if I can. If I can't, I would use Chinglish.' (late–partial, Student 3)

Others with poor English skills reported that they relied on their body language in order to communicate with their teachers in English. For instance, student 2 explained:

> 'When the teacher asks you a question, but I can't express it in English, I would try my best to use body language to help my teacher to understand me when I cannot express myself'. (Student 2)

In addition, when students are struggling with abstract science explanations from their teachers, many of them would wait for their teacher to 'recap' the key concepts in L1 and then in English. Students would only use the 'simplest and condensed' L2 expressions. Here are two examples:

> 'In most situations, I would use Chinese to tell my teacher and wait for the English explanation of the teacher.' (Student 2, late–partial EMI)

> 'Researcher: [What would you do] if you were asked to write the observable result from today's experiment?
>
> Student: I would use the simplest expression 'This is zinc' rather than 'in this experiment, zinc was generated and we observed a metal layer was formed and that was zinc metal'. (Student 4, late–partial EMI)

b) Vocabulary in science subjects and coping strategies

Vocabulary in science subjects

Students from both early–full and late–partial EMI schools in the focus group interviews expressed the challenges of learning English vocabulary in science subjects. They found that there are too many specific science terms. For instance, in biology, particular vocabulary regularly appears in a number of related science topics. Students claimed that they had more problems remembering all the vocabulary, particularly the descriptive vocabulary:

'I think … this … bio … there is too much vocabulary.' (Student 1, late–partial EMI)

'So, it is very hard to memorise them all … Those kind of vocabulary that describe bones and brain etc. Don't quite remember. I forgot them right after the exam.' (Student 3, late–partial EMI)

bii. Words with multiple meanings and the process of nominalisation

Another challenge is scientific terms with multiple meanings in different science subjects. Students from the early–full EMI schools with good proficiency in English still found it puzzling that the same words have multiple meanings in science. For example, 'normal' in physics means an object such as a line or vector that is perpendicular to a given object, but in other science subjects like chemistry or biology, it suggests the meaning 'ordinary'.

Students from both early–full and late–partial EMI schools said that sometimes it is very difficult to use scientific words to convey simple meanings because students are not familiar with the different grammatical or semantic categories of words such as synonyms, derivations and verbs. One student said that using action verbs to describe scientific processes is challenging. He found it very difficult to rephrase them into everyday language, and change the grammatical configuration of these words (e.g. neutralise → neutralisation) or what linguists call the process of 'nominalisation' (Halliday & Martin, 1993).

The student said he needed to memorise the same words with different grammatical forms for different semantic contexts:

> 'Verbs to describe the process are more difficult. The solutions are … to read more and do more references. […] (Student 2 late–partial EMI)
>
> I can memorise those terms if I really study hard, but it's hard to change the form of a word and to come up with the verb.' (Student 2, late–partial EMI)

c) Coping strategies related to vocabulary

Students from both early–full and late–partial EMI schools suggested that there are a number of coping strategies to overcome the challenges of the vocabulary in science. The first is rote memorisation. Students from early–full EMI schools work hard at spelling, understanding the meaning in the context, and word association. They make notes with a list of examples in complete sentences. This helps them develop their vocabulary by connecting their pronunciation and word meanings:

> 'I guess the most difficult part is those new terms when using English to learn. For example, in physics, chemistry and biology, there are some words that have a different meaning from the meaning we usually perceive. So, I think the solution is to spell more and do more exercises.' (Student 2, late–partial EMI)

> 'Sometimes we need to use a more complicated word to express a simple meaning. And my solution is jotting down those words if the teacher has said them. Or when I go home, I may go to check the meaning of the sentences if they are really difficult.' (Student 3, late–partial EMI)

> 'And for me, there are so many technical terms in Biology like those words in the human body and that structure stuff, etc. But my English is not too bad so I can spell them when I pronounce them.' (Student 4, late–partial EMI)

> 'In my opinion, both Chinese and English are OK. I mean, using English in teaching is OK. However, I need some time to memorise.' (Student 3, late–partial EMI)

The students in both types of EMI schools stressed that memorising vocabulary means that they have to truly understand both the English and Chinese meanings. For students with poor English, knowing the Chinese meaning helps them in memorisation. But some students believe that memorising does not help them truly understand word meanings. Instead, they argue that one should understand how to use the word according to its context and make a connection to its scientific meanings.

Students also said a second strategy is to try to express the same meanings by using synonyms (e.g. affect, influence) in order to increase their vocabulary in science:

> 'As for writing the observation, Mr. Kwok (teacher) reminded us that we should not use the word 'affect' if we are trying to convey the meaning 'influence' in experiments. We need to use another word to substitute it. Also, using complete sentences to write is difficult as well. These are the difficulties I think. And the solution is the same, to revise the content in the textbook and write according to the structure Mr. Kwok taught us before.' (Student 4, late–partial EMI)

> 'It is not easy to memorise some technical terms. Also normally you recite the English and then need to know the Chinese meaning so you can memorise it, truly in your mind. Because you only memorise English, you do not know its meaning.' (Student 4, late–partial EMI)

A third strategy mentioned by the students is to try to understand the word-associated meanings in similar contexts. For example, the word 'dissolve' in chemistry can have different meanings according to the context. When it refers to a substitution reaction, it is related to the process of dissociation, meaning a substance is dissolving into a solution. When it refers to an electrochemical cell, it is related to the process of ionisation, meaning the ions are dissolving into an electrode.

> 'For example, you don't know the Chinese meaning of the terms 'dissolve'. I memorise the English term … for example … I memorise 'dissolve', I know it is about dissociation, when it is related with

substation reaction, but when it is related to electrochemical cell, it is about ionisation … The most important part is to describe the word-associated meaning.' (Student 5, early–full EMI)'

d) Language challenges related to writing and reading in science

When dealing with the demand of writing and reading in science, students from the late–partial EMI schools in particular found it hard to write a good explanation with the correct choice of key scientific terms. Students complained that they could not locate the key concepts in writing science explanations in a test. Some students relied on their thinking to convey a complete explanation but found it did not match with what they expressed in English. Obviously, there is a discrepancy between what students understand in Cantonese and what they produce in English. Students complained that they did not know the 'accurate terms' to use to write a science explanation. This situation is particularly serious in the late–partial EMI schools where students produce their explanations by rote memorisation. Students also seem to have difficulty picking up relevant key scientific words to remember if these scientific words are not highlighted by their teachers or textbooks. They write down every single English sentence from their science textbooks in order to attempt all related exam questions without truly understanding them. For example, an early–full student described about his challenges in reading and writing science:

> 'I always cannot write the key points. That is not getting the main points … I don't know why I couldn't get the mark … I missed some details, and maybe then I couldn't get the marks.' (Student 2, early–full).

Another student from an early–full school described her problem with accurate terms. She said:

> 'Incomplete meaning? It was indeed quite complete. Like, it was following my way of thinking. Like I had this thought, but maybe I didn't use the accurate terms … Maybe I saw it in the book, and my teacher didn't really talk about the terms. And then we answered at last.'(Student 2, early–full)

Students also reported other challenges related to reading and writing in science. First, students struggle with question words, or not knowing the nature of questions. For example, with question words like 'account, analyse, exemplify', some students misinterpret these words as asking them to show the calculation rather than to produce a narrative to describe and explain their reasoning:

> 'Sometimes when you look at the questions, there are some words you don't know … e.g. solving the question.' (Student 1)

Second, students struggle with unfamiliar terms in a topic they are studying, for example, the name of a disease, bacteria or a chemical compound. Students may learn the word 'acetylsalicylic acid' from their textbooks but do not know it is called 'aspirin' in daily life as they have only heard the Chinese name from

TV (阿士匹靈, direct translation from English 'a+s+pr+in'). As one student explained:

> 'They are technical terms. Like some diseases. Like the one ... Glucose is OK. But hypoglycaemia, this term is included in the textbook. Since we have learnt it before and we know what it means, we can guess the question. But sometimes, there are questions about some symptoms that we don't know. But you are required to write down the functions of the diseases, or their harm, or how the diseases are formed. '(Student 2, late–partial)

Third, some students are not familiar with essay topics that cover more than a few science topics or are not explained in detail in their textbooks. These essay topics rely on students' analytical skills to generate arguments from what they have learned in different topics. For example, when students learn about reproduction in biology, they are asked to discuss the ethical concerns of having a test-tube baby. Students found it very difficult to formulate their arguments due to their limited English. Student 1 reports:

> 'The difficulties of writing essays are that, sometimes it is more extra-curricular oriented. Like one essay before was about 'test tube babies, but there was not much information about it in our textbook. We need more extra information to write the essay … What is a test tube baby? And then religion, or some effects on other aspects. About the effect, we will make a

comparison. But there is not much information in the textbook, nor will it contain knowledge related to effects. So you will need your own knowledge and also use English to write the ideas. Then there are some terms, grammar and other aspects in English that I am not good enough to write.' (Student 2, late–partial)

d) Coping strategies for writing and reading in science

When students discussed the coping strategies for writing and reading in science, the majority from both schools stressed the need for explicit teaching about the structure and the kind of sentence patterns expected in their science writing. One student from the early–full EMI school with good English proficiency still stressed that she needed to read reference books on the subject and do more practical exercises in order to better understand the structure and key points to succeed at writing about science. She suggested that science teachers should focus on key concepts rather than spend lots of time on elaborations or explaining daily examples:

'Although writing complete sentences and paragraphs might be more difficult for me, teachers sometimes teach us how to write to build a better structure and to get the points. As for my solution, I would read more reference books on the subject and do some practice exercises before exams and during practice. […] You (the teacher) can keep repeating the points but not say lots of other things and leave the main point to the very

> end and point out the main point directly and give some examples as we won't understand the main point if there are just a few examples.'
> (Student 4, late–partial)

The majority of other strategies relied on external help from tutorial centres. Students valued the role of tutorial centres where they can reinforce their understanding and highlight the key concepts through dedicated L1 instruction. For instance, student 2 reported:

> 'I go to chemistry tutorial classes. I think the tutorial class teaches too fast. I am in form 4 now but it already taught the curriculum after form 5 so I quit it. But what the class teaches is rather common. It will teach the content in the textbook more deeply and help you understand more. Also, it uses Chinese in teaching which makes it easier to understand.' (Student 3, late–partial EMI)

In the centres, students receive more guided support while working on exercises based on past public examination papers. Some students with limited English proficiency found this process very helpful because they were taught explicitly how to write equations and essays, and they were also given techniques to get higher marks in exams. One student explained:

> 'For Biology, they will give us many past exam papers and exercises to us. For Chemistry, they will create some exercises themselves. For example,

> when they teach writing equations, they will teach you some methods.' (Student 2, late–partial EMI)

Students also pointed out the drawbacks of attending tutorial classes. Most of the tutorial classes are very exam-oriented, focusing on examination skills rather than on the science content. The time frame of the teaching sequence in different science topics at the same grade sometimes is not the same for all secondary schools. Students reported being bored the second time they had to learn the same content. Student 1 mentioned this issue of tutorials being exam-oriented, even though she still found it helpful:

> 'I think the tutorial classes outside are very exam-oriented. They focus on the exam skills. And they are really different from school. The difference is that you won't get interested after school has taught you but I don't know why when you join tutorial classes outside, the content will be more profound and you will learn some tricks, so …' (Student 2, late–partial EMI)

g) Positive and negative attitudes towards EMI

Students in both early–full and late–partial EMI schools have mixed feelings towards their EMI experience. While more students in the late–partial EMI schools see EMI as an opportunity to improve their English, their counterparts in the early–full EMI schools believe that learning science through English has

perhaps caused them to be less motivated to learn both science and English. One student from a late–partial school explained:

> 'And I think using English to teach science subjects is quite good because my English is not bad, so spelling is not a problem for me.' (Student 4, late–partial EMI).

On the other hand, one early–full student said:

> 'I think I am less interested to learn science in English compared with learning science in Chinese. The difficulties are the words are difficult to understand and to use such as some technical verbs.' (Student 2, early–full EMI)

A few students from the early–full EMI schools welcomed more L1 in their EMI science classrooms to help them understand abstract concepts and communicate more effectively with teachers and their peers. They think that L1 is better than L2 in learning science.

7.12 Summary of the interviews: students' perception of EMI learning in science classrooms

The above analysis explored early–full and late–partial students' views on their science learning in EMI classrooms. The students from both schools shared similar views in many aspects. First, one important findings is that both early-full and late-partial EMI students valued highly the role of L1 in learning science through English, particularly when interacting with their science

teachers or working with their peers during a lab experiment. Students with limited English in both EMI groups would use body language or 'Chinglish' to help them communicate effectively. Some of these students would rely on their science teacher to 'recap' the key concepts in L1 and then in English.

Both early–full and late–partial EMI students commented on the challenges of learning vocabulary in science subjects. They struggled with the number of specific science terms, words with multiple meanings, connotations, and word-associated meanings. Some students find it difficult to use scientific words to convey simple meanings because they do not know how to manipulate the different grammatical forms and semantic categories. Students in both groups suggested a number of ways to overcome these challenges, including rote memorisation, using synonyms, understanding the word-associated meanings in science contexts and making connections with a word's function in science and in daily life.

Students in both groups pointed out a number of language challenges related to writing and reading in science, but there were greater challenges for the students in the late–partial EMI schools with limited English abilities and experience. Students found it very difficult to convey a complete meaning in their science explanations, and sometimes found that what they wrote in their examinations did not match what they could express in spoken Cantonese. Students complained that they did not know the 'accurate terms' to use when

writing a science explanation. In addition, students reported that they struggle to identify relevant key scientific ideas, guess the meaning of an unfamiliar word in a topic (e.g. a disease's name), and fail to understand the nature of examination question words.

Students from both groups suggested a number of strategies. They stressed the need for explicit teaching about the structure and kind of sentence patterns expected in their science writing. They also sought help from tutorial centres where they receive more guided support while working on exercises based on past public examination papers on a range of science topics. The tutorial centres also provide support in writing essays in a well-organised manner. The only drawback, according to some students, is that these tutorial centres are exam-oriented.

7.9 Summary of the chapter

This chapter has reported on the interview and questionnaire data of students' perceptions of their EMI experiences in both early–full and late–partial EMI schools. Analysis of the questionnaires identified 6 correlations:

1. The language choice in science activities items was positively correlated with the demanding English skills and with the language challenges, but negatively correlated with the important English skills, students' belief and the usefulness of coping strategies.

2. The demanding English skills factor was positively correlated with students' views on language challenges and their frequency of using and usefulness of the coping strategies, but negatively correlated with the self-concept in science and with the students' belief in science classrooms.
3. The important English language skills factor was positively correlated with the students' belief in science classrooms and with the usefulness of the strategies used by students.
4. The students' reflection factor was positively correlated with students' self-concept in science and with students' belief in science classrooms and negatively correlated with language challenges.
5. The students' self-concept of science factor was positively correlated with students' belief in science classrooms and negatively correlated with language challenges.
6. The students' views on language challenges factor was positively correlated with the frequency of using coping strategies and the usefulness of coping strategies.

The result of correlation analysis suggests that there are three possible groups of students in the early–full and late–partial EMI schools. The first group are students who prefer more Cantonese for interaction, find English language

skills demanding and face more language challenges in science classroom. These students frequently use coping strategies. While this case might reflect the poorly performing students in either school, the questionnaire analysis showed the late–partial EMI students used coping strategies less frequently.

The second group includes students who believe that English language skills are important in EMI science classroom and who also are confident in their science abilities. These students also tend to prefer more English in classroom interactions and find coping strategies useful. This group is likely to contain well performing students in both schools.

The third group includes students who face many language challenges in the science classroom, use coping strategies frequently, and find these strategies useful. This group is likely to include students who are struggling with English but are motivated to overcome their language challenges themselves.

Data reduction of the nine scales of the questionnaires generated 17 factored variables, summarised in Table 7.26. For means-comparison (reduced factors), there was a statistically significant difference in students' responses between early–full and late–partial EMI schools in the following nine factored variables: (1a) language choice for interactions; (1b) language choice for explaining science; (2a) demanding English (daily use); (3b) important English (basic); (5a) self-concept (science); (7a) language challenges (use of scientific English); (7b)

language challenges (use of basic English); (9a) useful strategies (comprehension and science concepts); and (9b) useful strategies (learning in science).

The only statistically significant differences between grades 10 and 11 were in the early–full EMI schools for (1a) the language choice for interactions, (8b) frequent strategies (self-initiatives), and (9a) useful strategies (comprehension and science concepts). There were statistically significant differences between grades 10 and 11 in the late–partial EMI schools for (2a) demanding English (daily use) and (2c) demanding English (vocabulary).

The questionnaire results showed that students from the late–partial EMI schools preferred more Cantonese for interactions and explaining science. Although these students believed that daily English language skills and basic vocabulary are more demanding in science classrooms, they found them important. In addition, students believed that they have the ability to do well in science but they found that there are more language challenges related to comprehension and communication of science content, as well as basic English skills. In terms of coping strategies, these students used self-initiated coping strategies less frequently and found the strategies that enhance their comprehension of science concepts and learning of science less useful as opposed to those students in the early–full EMI schools.

Seven recurring themes were identified from the focus group students' interview transcripts. These themes, discussed above, are (a) language choice for

interactions, and the challenges; (b) vocabulary in science subjects; (c) the coping strategies related to vocabulary; (d) language challenges related to writing and reading in science; (e) coping strategies for writing and reading in science; (f) strategies related to external help; (g) positive and negative attitudes towards EMI.

In the next chapter, I summarise all the major findings and triangulate data from multiple sources, classroom observation, survey and interview data, in order to answer each of the research questions. ■

Chapter 8

Discussion: recognising the differences between early–full and late–partial EMI classrooms

8.1 Introduction

The previous four chapters have presented the findings from the qualitative and quantitative investigations into the study's research questions. In this chapter, I summarise the major findings from the previous chapters and compare them to any previous relevant literature in order to provide an overall picture of the nature of classroom interaction in different EMI secondary senior science classrooms, including teachers' and students' attitudes towards their EMI experience.

8.2 Summary of overall findings

This study explored classroom interactions in different EMI classrooms and the science teachers' and students' attitudes towards their EMI experience. It did not seek to evaluate the schools, teachers or students, and the findings are by no means an indicator of the quality or effectiveness of the different types of EMI schools.

8.2.1 What did this study do?

This study adopted a research design from Lo and Macaro, (2012) to extend the scope of investigation on classroom interaction to the previously unexamined context of senior secondary science classrooms in the Hong Kong context. Nineteen teachers and 545 students from grades 10 and 11 EMI science classrooms were recruited eight schools: four 'early–full EMI' (full English medium of instruction from grades 7 to 12) and four 'late–partial EMI' (Chinese medium from grade 7s to 9, switching to partial EMI instruction for grades 10 to 12). It used multiple sources of data collected from video-recorded classroom observations, questionnaires and interviews with teachers and students. All data were analysed quantitatively and qualitatively, considering choices of instructional language for teaching science, teachers' beliefs about EMI, students' self-concepts in science, language challenges encountered and coping strategies used in learning science through English. In the following sections I summarise the key findings and describe how they answer my four research questions.

8.2.2 Research Question 1

RQ1: What is the nature of classroom interaction in EMI science classrooms?

Despite the schools 'claiming' they are EMI schools, there was diversity in the actual amount of English used between the early–full and late–partial EMI

schools. It is quite evident that the four early–full EMI schools used English mostly as the medium of instruction, while two of the four late–partial EMI schools used more Cantonese for instruction language together with English despite their stated policy as EMI schools.

However, regardless of the MOI, the nature of interaction patterns in both early–full EMI and late–partial EMI (or MOI-switching) schools were similar in this study. I cannot find any examples of negotiation of meaning or L2 learning, particularly of students making clarification requests. The nature of interaction was much shorter, usually the simple IRF sequences, tending to limit opportunities for teacher student negotiation of meaning and understanding.

This is echoed in a number of studies that have compared the interaction between full EMI and partial EMI (or MOI-switching schools) in Hong Kong. Lo and Macaro (2012) observed when the MOI was changed from Cantonese to English, the teacher–student interaction became very minimal and took the form of short interactive sequences. Yip et al (2007) also found the quality of instructional activities in these EMI science classrooms became very limited, with little interaction between teacher and students and use of a high number of recall-type questions. Lin (2006) observed the interactive teaching practices in some of the mixed-mode science classrooms in which teachers delivered the

content in L1 and recapped it in L2. Whereas these previous studies suggest that late–partial EMI (or MOI-switching) are more interactive, and therefore different from the early EMI schools, the current study reveals that lessons from both types of EMI contexts tend to be authoritative and less interactive.

The instructional approach of classroom interactions in the lessons observed was authoritative, very often with teachers controlling interactions in an effort to relay their specific viewpoint on a science topic. This is evident in the qualitative analysis of transcripts from the four sampled biology EMI science classrooms. Interactions between teachers and students were limited, with very few extended Initiation–Response–Feedback (IRF) patterns. The nature of teacher student interaction changed, with fewer cycles of prolonged I-R-F-R-F sequences.

This is what I saw in the classes as most late–partial EMI schools did not have any opportunities for teachers could negotiate the meaning of words with students or provide 'scaffolding' for concepts and processes in the academic curriculum. This echoes Lo and Macaro's (2012) observation of the MoI-switching schools which tended to become more teacher-centred with students' participation being inhibited. The interaction pattern in both types of EMI schools were reduced from grade 10 to 11 and the extended IRFRF sequences rarely found in grade 11.

In my study, students seldom initiated interactions and were mainly invited by teachers to give a response to show their understanding of the science topic. Teachers tended to select which students' responses they wanted to respond to, follow up or ignore. The teachers mainly checked students' understanding, shared their own ideas, and highlighted key ideas that matched their planned science views. This is again consistent with Lo and Macaro's observation of the MOI-switching teachers who appeared less skilful in helping students answer cognitively demanding questions.

The authoritative nature of teaching suggests that the teachers perhaps lacked instructional strategies for interacting with students in L2. This reflects the findings of previous studies which revealed very few instances of negotiation of meaning at the lexical level among content–subject teachers in EMI classrooms as indicated by Lo and Macaro (2012). The teachers could have encouraged students to arrive at conceptual understandings themselves through higher-order pedagogical skills (clarification requests, confirmation checks and signals, comprehension checks) and match their existing knowledge in L1, thereby promoting their students' deeper understanding of the science concepts and process. Instead, the EMI teachers in this study tended to adopt lower-order pedagogical scaffolding, only 'informing' their students of the facts. This strategy subsequently encouraged students' rote-memorisation of the

factual information, a similar finding to Yip et al (2007), who found that many EMI science classrooms promoted rote-memorisation of facts.

This study found that language use, in terms of developing students' understanding of science knowledge, is similar between the early–full and late–partial EMI schools. This study found that the science language used by teachers in classroom interaction was high in the use of: (1) subject–specific vocabulary; (2) nominalisations and grammatical metaphors; (3) complex noun phrases; (4) language of knowledge relationships; and (5) lexical density. These observations are similar to Kong and Hoare's (2012) findings that teachers in junior secondary science classrooms in Hong Kong used complex academic language (i.e. a high proportion of subject–specific vocabulary and nominalisation, complex noun phrase and high lexical density in teacher's spoken language use: (3.08-4.85, as compared with science writing: 5-6, Christie & Derewianka, 2008).

In term of students' language production, in the early–full EMI schools, students did not appear to be able to interact with teachers as freely and fluently as their counterparts in the late–partial EMI Schools. Students in the early–full EMI schools had experienced EMI for more than three years and may have become accustomed to EMI teaching. This finding contradicts previous studies such as Marsh et al.'s (2000) six-year longitudinal study, which showed that early–full EMI students would 'catch-up' in their English in senior forms, and that thus the disadvantages of using EMI would have been offset at later stage

of secondary education. This finding is also counter to Cummins' proposal (1979) that it may take three to five years for students to reach the threshold level required to benefit from immersion programmes. The disadvantage of using EMI is not simply a time issue but the necessity of providing conditions such as more teacher input modification in L2, the teacher's allocation time for whole class interaction, and the availability of bridging courses for improving students' English proficiency (Lo & Macaro, 2012) that could enhance the learning outcomes of all students, especially for those with lower language proficiency (Chan, 2014).

The qualitative analysis of lesson transcripts in chapter five revealed that students from both early–full EMI and late–partial EMI schools predominately produced a number of incomplete sentences consisting of short, technical nouns or noun phrases referring to scientific items. Science teachers rarely made any attempts to correct their students' language mistakes or encourage students to produce a complete sentence. This lack of teacher feedback on students' L2 language production reflects the fact that EMI science teachers rarely provide any input to facilitate students' L2 language learning.

As a result of their language shortfalls, the students' L2 remains under-developed despite English instruction. This reality of lack of language support perhaps reflects a gap between the aim of the fine-tuning EMI policy and its actual implementation. The original aim of the fine-tuning policy was to create

an additional English environment to increase students' exposure to English in order to improve their English proficiency (Poon, 2013). The lack of students' language outputs in Hong Kong EMI classrooms appears similar to that of Canadian immersion programmes which found that students could not produce advanced level language skills, especially orally. Swain (1995) pointed out the important role of 'pushed output' in achieving effective immersion programme.

In the four biology EMI classrooms from both the early–full and late–partial EMI schools, the adoption of EMI instruction perhaps only led to the development of students' comprehension of content knowledge, rather than the development of the proficiency in language production, although of course I did not set out to deliberately test their comprehension. The absence of teacher support and pushed output on students' language production from their teachers perhaps is the major challenge in achieving the goal of improving EMI students' English skills, both receptive and productive.

The lack of language learning and teacher support in EMI science classrooms in this study can perhaps explain why Hong Kong senior secondary students experience tremendous language challenges during their first-year at university. As pointed out by Lin and Morrison (2010), the adoption of CMI teaching had a significant negative effect on the size of the academic vocabulary of Hong Kong tertiary students. Thus, students from CMI were disadvantaged during their first year of university study. Given the results of the present study,

we can predict similar results from students in the late–partial EMI schools. This again contradicts research by Marsh and his colleagues (2000), a six-year longitudinal study of the MOI impact on secondary school students' English and other content-subject achievements, which found that early–full EMI students would 'catch-up' in their English in senior forms and thus the disadvantages of using EMI would have been offset at later stage of secondary education.

As seen in the lesson transcript, classes only developed students' receptive language skills (reading and listening), but not their productive language skills (writing and speaking) in their content subject. These students perhaps have not acquired the cognitive academic language proficiency skills in L2 needed for them to study effectively in their subject at university. This is especially true for the students from the late–partial EMI schools as they have acquired lesser amounts of disciplinary vocabulary than their counterparts from the early–full EMI schools. The underdeveloped disciplinary language in L2 creates numerous language challenges for these students in coping with the demands at university. The analysis of classroom interaction shows that students at grades 10 and 11 from the early–full EMI schools could only produce incomplete English sentences in responding to their science teachers.

The analysis of the four biology lessons echoed Lin and Wu's (2016) argument on the role of teacher-modified input in creating space for

'translanguaging'. They reported on a junior biology secondary science teacher in Hong Kong skilfully allowing a low-proficiency student to contribute her class discussion input in L1 and guiding the whole class to discover the equivalent meaning in L2. In my analysis, although the two EMI teachers spoke mostly in English, they skilfully intervened with their students' responses at the feedback stage by either expanding, acknowledging, or ignoring students' ideas in developing students' understanding of the scientific story. Teachers' modified input through extended IRF exchanges, either in L2-only or translanguaging between L1 and L2, serves as an important way of providing comprehensive feedback to students in developing their scientific knowledge. The lesson examples in chapter 5 from early–full and late–partial EMI biology classrooms have reference value for other EMI teachers who are routinely faced with the similar challenge of teaching both content knowledge and language through L2.

8.2.3 Research Question 2

> RQ2: What are the differences and similarities in classroom interaction between early–full and late–partial EMI schools?

In chapter four, I showed that the interaction time and distribution of teacher and student talk are similar in early–full and late–partial EMI schools. The percentages of interaction time between the early–full EMI schools (69%) and the late–partial EMI (73%) were similar. In both school types, 62 to 68% of the

interactions is teacher talk, with very little student talk (5-8%), and the average length of a teacher turn is longer than that of a student turn, suggesting that these EMI lessons were teacher-centred, authoritative, very often with teachers controlling interactions in an effort to relay their specific viewpoint on a science topic. This is different from Lo & Macaro's where they found the mean length of teacher and student turns increased significantly from grade 9 to 10 in the MOI-switching schools.

In addition, a high percentage of L2 (93.5% vs L1: 6.5%) use was observed in the early–full EMI schools, and a high percentage of L1 (53% vs L2: 44%) was observed in the late–partial EMI schools. This is similar to Lo & Macaro's study (2012) where they found their early–full EMI school with over 96.8% of L2 use and but the L1 use in their three MOI-switching schools is higher with over 97.6%.

The descriptive statistics show that teachers and students in early–full EMI schools tended to have more inter-sentential code switching (in between sentences). Those in late–partial EMI schools tended to have more intra-sentential code switching (within a sentence) although the difference here is not large when compared with the early–full EMI schools. This perhaps suggests that teachers and students in early–full schools were experienced in EMI and thus they could produce more completed utterances in English and inter-sentential code switching. Those in the late–partial EMI schools were at the

early transition of MOI changed, thus students would only produce phrasal utterance in English and intra-sentential code switching with Cantonese as the matrix language.

Although the observed late–partial EMI schools appeared to be slightly more teacher-centred, with teacher contributed over 68% of the interaction time and student contributed less than 5% of the interaction time, the late–partial schools seemed to be more interactive, given that teachers and students took more turns. This finding is similar to previous research which found that MOI-switching schools (equivalent to late–partial EMI schools) are more interactive when the MOI changed from English to Cantonese (Lo and Macaro, 2012).

Given that the nature of science teaching is often monologic and that most science classrooms are teacher-centred in Hong Kong (Yip 2003; Lin 2006), it is unsurprising that in both types of schools nearly 70% of all interactions is teacher talk, with only a small percentage of student talk. However, there is more student talk in the early–full EMI schools than in the late–partial EMI schools. This is perhaps because students have more experience in EMI instruction and better English proficiency, which allows them to be more confident in responding to teacher questions.

Although the late–partial schools seemed to be more interactive, the average length of teacher turns (42.03 s <49.29 s) and student turns (3.16 s<8.48 s) were slightly shorter. The maximum length of student turns in the late–partial EMI

schools was four times shorter (302.6 s<1,192.1 s) than teacher turns. This could be explained by the fact that students encountered difficulties in expressing themselves using the L2 (e.g. they only used English for scientific terms), leading to shorter answers and also shorter turns when the MoI changes to L2, as Lo & Macaro indicated that there was a significant negative relationship between L2 use and student talk. They found in their MOI-switching schools where students had shorter turns even they had been studying at EMI for a few years.

In addition, my study's findings revealed that teachers in both types of schools used a similar set of pedagogical functions during interaction (e.g. teacher informs, teacher self-utterances, teacher directs, and teacher replies) and offered similar types of feedbacks. In other words, the typical sequence was: 'affirmation-direct instruction' > 'extension by responsive questioning: focusing and zooming' > 'explicit correction-direct instruction' > 'constructive challenge'.

The results for pedagogical functions during interaction are similar to Lo and Macaro's (2012) findings, where 'inform' and 'direct' were the predominate teacher acts in most content subject classrooms in Hong Kong. In the three observed MOI-switching schools, they found that the mostf frequent act was 'inform' (46.8% to 50.6%), and the second most frequent was 'direct'. This echoes Lo and Macaro's observations of teachers' pedagogical skills where they found teachers rarely adopted the kind of pedagogical scaffolding that would

enable students to arrive at a deeper understanding of the concepts and processes in academic subjects. Instead, the teachers were generally 'informing' students of the facts, as seen in the cases in early–full and late–partial EMI schools.

Previous studies have pointed out that science classrooms in Hong Kong are teacher-centred and that the role of the teacher seems to be to transmit knowledge to students (Lin, 2006; Lo and Macaro, 2012; Yip et al., 2007; Yip, 2003). To transmit knowledge, these teachers use monologic-style teaching techniques such as informing, self-utterance and directing. For instance, teachers inform students about a science phenomenon, provide definitions and explanations in a number of self-utterances (i.e. extended teacher informs) and direct students to their intended view of the science phenomenon. Teachers only reply to students who share the teacher's interpretation of the science phenomenon or whose responses fit the teacher's goals for the lesson. These features of transmitting teacher's own view of the scientific story to students may reflect that the nature of science teaching in Hong Kong at senior secondary levels is teacher-centred, monologic, authoritative and non-interactive. The authoritative, teacher-centred interaction patterns revealed in the data perhaps explain why the teaching styles of the EMI science teachers in the early–full and late–partial EMI schools did not vary dramatically. Thus,

differences in this kind of 'teacher-centred, transmitting' teaching styles cannot solely explain the observed differences between schools.

The findings of this study are therefore different from those of the previous studies by Lo and Macaro (2012; 2015). Those studies claimed that the overall interaction patterns of schools with an earlier start and those schools with a later start of EMI were different in terms of their nature of classroom interaction. For example, Lo and Macaro found more and longer interactive sequences in classes where the MOI was changed from English to Cantonese. However, their findings were based on the situation before the launch of the fine-tuning language policy in 2010, at a time where there was a clear division between CMI and EMI schools. After the implementation of the fine-tuning policy under which all schools became EMI, differing only in whether they began using EMI earlier or later, this study found that the degree of similarity in the interactions between early–full and late–partial EMI schools is limited to the macro level. There were substantial differences at the micro-level.

At the macro level, in both types of EMI schools 62 to 68% of the interactions were teacher talk, with very little student talk (5 to 8%). Teachers' turns were on average longer than students' turns. Teachers from both types of schools used a similar set of pedagogical functions during interaction and offered similar types of feedback.

When the classroom interactions were examined at the micro level in terms of the average length of teacher and student talk, the ratio between L1 and L2 use and the patterns of code switching (inter- and intra-sentential) suggest a number of subtle differences between early and late EMI schools.

In the early–full EMI schools, the average turn length of teacher talk and student talk is longer than in the late–partial schools. Teachers and students use relatively more L2 than L1 in interactions, with the majority of interactions spoken in English. Teachers and students tend to code switch between English and Cantonese at sentence level (inter-sentential). In other words, in the early–full schools, teachers use English as the matrix language and embed within it Chinese phrases or words for direct translation. Teachers used more lower-order questions, as compared with those in late–partial schools, to recall students' previous learned science concepts. This is reflected in a shorter wait time between teachers' initiations and students' responses. This echoes Lo and Macaro's study, in which they found that the most frequent question was factual questions in their schools, and the more L2 used, the more teachers talked in lessons, spoke longer in each turn, gave longer wait time for students to formulate answers to questions, asked fewer questions and asked questions less frequently.

Unlike Lo and Macaro's observation in the MOI-switching schools, overall in the late–partial EMI schools, there are more (but shorter) student initiations

and responses, higher-order questions from the teachers, to encourage students' cognitive thinking about science concepts. These questions are challenging enough to encourage students to resolve inconsistent views on science topics and develop scientific concepts themselves. Teachers provide less direct feedback to students than those in the early–full EMI schools. Teachers and students use relatively more L1 than L2 in the interactions, with the majority of interactions spoken in Cantonese. This result echoes Lo's (2015) finding that content–subject teachers in Hong Kong use more L1 but in a skilful way.

One question that then arises is this: Why did the early–full teachers use more lower-order questions? It could be that the students' English proficiency is limited, such that they cannot respond to higher-order questions. Teachers in the early–full EMI schools thus have to use lower-order questions to ensure that their students with poor English ability still can interact in an English environment. This raise the question about to what extent EMI is effective in content teaching in the late-partial immersion context. Another possible reason could be that teachers believe that by using more lower-order questions they are more likely to ensure that students master the teachers' authoritative scientific view. As was explained in chapter four, the early–full EMI classrooms are slightly more teacher-centred, authoritative and non-interactive than the late–partial EMI classrooms.

A further possible explanation is that teachers in early–full EMI schools use lower-order questions because they expect students to answer in English. They may believe that lower-order questions are more appropriate in a context where all interactions have to be conducted in English but the students' English proficiency is limited. On the other hand, the late–partial EMI teachers use more higher-order questions possibly because they allow their students to reply in Cantonese. Although the students' English is limited, teachers and students can interact through Cantonese, and thus teachers perhaps feel it is possible to use more higher-order questions.

The late–partial EMI teachers and their students tend to code switch between English and Cantonese at the intra-sentential level, suggesting that teachers and students tend to insert English technical terms into Cantonese grammar and discourse. However, in both early–full EMI and late–partial EMI schools, code-switching between sentences is more frequent in grade 11, suggesting that the extra year of EMI may help students to move from inserting single English noun phrases into their Cantonese to using more complete English sentences in interacting.

When the pedagogical functions of both teachers' and students' interactions were examined, it was surprising to find that the functions of interactive moves, and the choices of teachers' questions were perhaps the two key indicators marking the differences between early–full and late–partial EMI schools.

The four most frequent pedagogical functions in the interaction sequences were inform, self-utterance (or extended teacher informs), direct and reply. This suggest that science teaching in Hong Kong is teacher-centred and authoritative, with very few opportunities for students to negotiate meaning at the lexical level and the conceptual level. Teachers in both early–full and late–partial EMI schools tend to direct students to their own pre-planned scientific view and guide them with explicit instruction to understand scientific phenomena. This may be the reason why, as mentioned earlier, in the early–full EMI schools, teachers seem to help students less to develop higher-order thinking. Lo and Macaro (2012) found that teachers in both early and late EMI (or MOI-switching schools) rarely adopted the pedagogical scaffolding that enables students to achieve a deep understanding of content concepts. This was the case in my study, where both early–full and late–partial EMI teachers rarely interact with students skilfully in developing their understanding in science and language. The teachers in my study generally inform their students of factual information and tend to ask lower-order questions, namely recalling questions, to help students to achieve basic understanding of concepts.

However, in my study, the late–partial EMI teachers seem to ask more cognitively challenging questions to stimulate students' higher-order thinking. Perhaps this is because the late–partial EMI schools are in a transitional phase of adopting EMI instruction. These teachers can use pure Cantonese as the

medium of instruction or English technical terms inserted into Cantonese as the matrix language. In this way, teachers and students can work on cognitively challenging questions in Cantonese, using their rich semantic resources in their mother tongue to help promote higher-order thinking. This echoes Lo & Macaro (2012) 's observation of the teachers' questioning technique in the MOI-switching schools. They found that teachers and students freely switched back to Chinese when students had difficulties in answering questions.

These teachers are demonstrating the kind of bilingual pedagogical scaffolding that enables students to arrive at a deep understanding of science concepts (Lin, 2006). The use of Cantonese is likely to greatly reduce students' anxiety and lower the language barrier. Interactions in late–partial EMI schools are thus not surprisingly more interactive than those in early–full EMI schools. This echoes with the findings from previous studies which showed that MOI-switching schools are interactive and that the L1 can serve as a rich semantic resource to promote higher-order thinking (Lin, 2006; Lo and Macaro, 2012; Yip et al., 2007).

The subtle differences reviewed above reflect the fact that the interactions in early–full and late–partial EMI schools are different on a micro level. Perhaps this relates to the choice and extent of L1 use in the classroom, reflecting the fact that late–partial EMI science teachers in Hong Kong make judicious use of Cantonese to facilitate their students' learning, taking into account their English

abilities (Lo 2015, Lin 2006). This echoes Lo & Macaro's study (2012), which found that lessons with more Chinese as the MOI tended to be more interactive than those with more English.

8.2.4 Research Question 3

RQ3: What are the differences and similarities in classroom interaction between grades 10 and 11 in each group?

During the first year of the senior secondary science classroom (year 11), the students in my study had switched from Cantonese to English medium, and from studying one integrated science subject into different science subjects (physics, chemistry, biology). Comparing interaction in grades 10 and 11, regardless of school type, showed that both types of schools share a number of similarities in terms of interaction time, length of student turns and ratio between L1 and L2 use.

In both types of schools, there was a small decrease in the percentage of interaction time, a decrease in the maximum length of student turns and a small increase of L1 use from grade 10 to grade 11. Similar patterns were observed in L1 and L2 use. Teachers and students use relatively less L2 in interactions, with a similar ratio between L1 and L2 use in both teacher and student talk. In the late–partial schools, teachers and students contributed 44% L2 and 56% L1 at Grade 11 and at Grade 10 with 47.5% L2 and 52.5% L1. Unlike Lo & Macaro's study (2012), which they found their MOI-switching schools had a dramatic

increase (20% to 70%) of L2 use a year later after the MOI change. I did not observe any such obvious change in the MOI from L1 to L2 in my two types of EMI schools.

Teachers and students tend to insert English technical terms into Cantonese interactions. There is more L1 use (46%-->54%) at grade 10 than grade 11 in late–partial EMI schools, which suggests that students and teachers in grade 11 still use an extensive amount of L1 in their teaching and learning after the first year of EMI experience. More code switching between sentences (inter-sentential) was observed in grade 11 in both types of schools. This is perhaps because students and teachers with more experience in EMI instruction have increased in confidence in producing English utterances.

Lo and Macaro (2012) showed that there were noticeable changes in teacher student interaction patterns when the MoI changed substantially from the students' L1 in Grade 9 to L2 in Grade 10. But in my data I did not see such changes in the four late–partial EMI schools from grade 10 to 11. The teacher–student interaction pattern in both early–full EMI and late–partial EMI (or MOI-switching) schools were similar in this study. One possible reason is that two of the four late–partial EMI schools used more Cantonese as their instructional language together with English despite their stated policy as EMI schools.

Although the language policy and the school website indicated that English is the official instructional language in the class, teachers and students in both

the early–full and late–partial EMI schools used English and Cantonese. As regards the language of the written materials, I observed that the textbooks and notes used in the four early–full and four late–partial EMI schools were in English, but two of the late–partial schools provided written materials, including Chinese glosses of difficult vocabulary items.

From the post-observation interviews with the teachers, I established that the amount of Cantonese use in the classrooms largely depended on their students' English proficiency. Different schools might change the proportionality of their medium of instruction (i.e. using a different amount of L1 in the classroom). In early–full EMI schools, a number of lessons were observed in which the majority of the teachers and students interacted in English with some degree of Cantonese.

In late–partial EMI schools, the majority of the teachers and students interacted mostly in Cantonese with English technical terms being used. In school G, I observed a class in which students assigned to either L1 or L2 instruction were studying in the same class due to a shortage of manpower. There were not enough teachers to offer separate English-medium and Chinese-medium classes for each science subject.

The reasons for an increase in L1 use from grades 10 to 11 may be to do with examinations. In the post-observation interviews, teachers explained that students in grade 11 were planning to switch back to the L1 medium for their

public examination in grade 12. Thus, the teachers used more L1 in the class to accommodate these students' needs. This result echoes Lin's (2006) and Lo's (2015) findings that teachers adopted bilingual pedagogical strategies and used L1 to make science content more accessible to students with poor English abilities. Other research has disclosed the gap between policy and implementation through actual practice in the recent fine-tuning of the Hong Kong language policy (Chan, 2014; Evans, 2009; Poon, 2013). In other words, it seems that there was definitely a subtle change in the MOI in oral and written materials in the late–partial EMI schools. However, this change in the MOI from English-only to mixed-mode instruction did not, in turn, result in the different classroom interaction patterns illustrated above.

My data also revealed subtle differences between the two types of schools between grades 10 and 11. In the early–full EMI schools, the difference in the mean length of teacher turn is statistically significant. There is more teacher talk but less student talk in grade 11 than in grade 10. In the late–partial schools, however, teacher and student talk are shorter in grade 11 than in Grade 10. The average length of teacher turns in the early–full EMI schools is much shorter than the late–partial schools.

Comparing grades 10 and 11, the average length of teacher turns were longer in grade 11 (38.67 s →47.24 s) but the student turns were shorter (3.31 s→ 3.00 s) in the late–partial EMI schools. In addition, the maximum length of

student turns in grade 11 was shorter in both types of schools. The late–partial schools in this study contradict Lo and Macaro's (2012) observation in MOI-switching schools, where they found the student turns were longer in terms of time taken to utter their thoughts.

Given that the science curriculum is more difficult in grade 11 than in grade 10, and that students have become used to EMI teaching, teachers in early–full EMI schools might use much shorter turns to elicit science explanations. I had expected to find that students in early–full EMI schools would interact more in grade 11 but the data show that student talk in grade 11 is much less than in grade 10 (17% → 4%). However, there is no major change in the late–partial EMI schools. In my study, teachers and students interacted mainly in Cantonese. This result is different from that of Lo and Macaro's study (2012), in which they concluded that the change of MOI to more English could cause lessons to become more teacher-centred, with fewer opportunities for negotiating meaning and scaffolding. In this study, even though late–partial EMI students in grade 11 are changing their MOI to English, they are able to interact freely in their comfortable language environment when learning more abstract and difficult science topics.

In addition, with pedagogical moves, there are more 'checks'[1] than 'self-utterances'[2] in grade 11 in the late–partial EMI schools but this pattern is reversed in grade 10 in the early–full EMI schools. Perhaps the teachers in grade 11 in the early–full EMI schools make more effort to make sure that students share the same understanding of the science topic. In the late–partial EMI schools, in gade 11, there is more 'self-utterance' than 'direct'[3] but this pattern is reversed in the early–full EMI schools. Perhaps the early–full EMI teachers make more effort to provide explanations to the students when the topic is abstract and difficult.

8.2.5 Research Question 4

RQ4: What are teachers' perceptions of teaching science through EMI?

From the interviews with the early–full and late–partial EMI school teachers, eleven re-occurring issues were identified: (1) overall views on teaching experience in EMI science classrooms; (2) language challenges in teaching science through English; (3) specific language challenges in Biology/Chemistry/Physics; (4) coping strategies; (5) dealing with students with

[1] 'Check' is realised by a closed class of questions such as 'O.K.?', 'Finished?' 'Ready?' It helps the teacher to know the progress of the lesson and usually occurs when the teacher wants to move from one task or topic to another.

[2] 'Self-utterance' is realised by statements or rhetoric questions. It refers to those utterances that the teacher speaks to himself/herself. It is an extended teachers' informs. It does not aim at eliciting students' responses.

[3] 'Direct' elicits non-verbal responses. It can be realized by questions or imperatives. For example 'Sit down' or 'Turn to page xx'.

difficulty in communicating in English; (6) when to use L1; (7) questioning techniques in EMI classrooms; (8) vocabulary types in EMI science classrooms; (9) teacher's expectations of students' English level; (10) teacher's expectations on students' science learning; (11) other teaching challenges related to the new science curriculum.

The teachers from both the early–full and late–partial EMI schools shared many similar views about EMI teaching, such as their preferred instructional language and identifying the most important and demanding English language skills for learning science. This finding of common attitudes was unexpected. Teachers generally welcomed a mixed-mode instruction to allow for the optimal use of L1 in explaining cause-and-effect relationships, giving manageable explanations to students with limited English, and also consolidating students' knowledge by making connections with everyday examples. However, the teachers' views about the reason for adopting EMI differed. Teachers from the late–partial EMI schools strongly believe the MOI is just a tool for transmitting knowledge rather than a way of preparing students to learn a second language, whereas at least some few biology teachers from early–full EMI schools believe that they need to help students with their English in science. When asked when teachers should use L1, the majority of teachers said that they would use L1 for students with limited English abilities. This echoes findings of previous studies (Lo & Macaro, 2012; 2015; Lo 2015, Lin 2006; Tavare, 2015) in Hong Kong and in

South Africa (Probyn 2006, 2009), where content–subject teachers in L2 classrooms judiciously use L1 to facilitate their students' learning, taking into account their English language ability.

Teachers in late–partial EMI schools generally used a range of question types, such as recalling, higher-order and reasoning questions, to promote student's science learning but overall teachers tended to use more low-order questions. Yip (2003) also found that junior science teachers in Hong Kong were generally skilful in questioning, but focused on questions with a lower cognitive demand. This was due to the time constraints on teaching, the pressure to cover the examination syllabus within a tight schedule (Yip, 1999), the low English proficiency of students and the poor communication skills of some EMI science teachers (Yip and Tsang, 2006). However, in my study, I found that biology teachers paid more attention to students' language problems. Biology teachers from early–full and late–partial EMI schools shared a number of coping strategies to address their language issues and improve their students' English abilities. Although these biology teachers felt they should help with students' English, none of them (from the interviews) said they had the opportunity and responsibility.

Both early–full and late–partial EMI teachers said that the major challenges of teaching science through EMI were students' analytical, reading and communication skills. They recognised that students have problems

understanding examination questions and presenting science ideas in writing or speaking. They cannot present coherent science explanations in English using adequate vocabulary and expressions. When learning science, students encountered three types of vocabulary: basic English vocabulary, academic vocabulary and scientific or technical vocabulary. In the teacher interviews, teachers said students had more problems with basic English vocabulary because they misinterpreted its meanings in science and confused word meaning with other meanings they had learned in English lessons. Students also mixed up technical vocabulary that had different meanings in different scientific contexts. Teachers believed poor vocabulary skills affected students' writing ability and communication skills, especially when students were asked to write an essay explaining a scientific phenomenon.

When asked about their expectations of students' English levels, the majority of science teachers said they did not have any expectations. These science teachers believed that language is just a tool to facilitate learning. Perhaps there is a gap here in science teachers' perceptions about EMI and their actual responsibilities in teaching (Probyn 2006, Yip, 2003). In addition, research in teacher education programmes has shown that teacher training does not prepare science teachers to develop the necessary pedagogical skills for integrating both content and language (Othman and Saat, 2009), nor does the training help them develop their identity as a teacher of both academic content

and academic language (Coyle et al, 2010). Wannagat (2007) compared the classroom interactions of history lessons between EMI and CLIL (Content Language Integrated Learning) settings and from his observations that the role of language in learning goals is not clearly explicated in EMI, and that the language issue is largely ignored in curriculum development and teacher training. Thus, he believed EMI is less successful than CLIL because there is no language focus in the EMI curriculum, although there is more English exposure for students in EMI.

When asked about their expectations of students' science achievements in EMI classrooms, the majority of science teachers said they hoped that their students would master key scientific concepts, develop strong observational skills, improve their analytical and critical thinking skills, and ultimately show a strong interest in science and its applications in our society.

On two points there were two statistically significant differences in the questionnaire responses from teachers in the early–full and late–partial EMI schools: (3) the most important English language skills for students to study science in English medium; and (4) teachers' language awareness in teaching science through English. The late–partial EMI teachers used more Cantonese in science teaching activities. They believe that the English language skills students need to learn science are more demanding, but that these language skills are less important. The early–full EMI teachers think the reverse. In addition, the late–

partial EMI teachers had a lower language awareness than those in early–full EMI schools, suggesting that they pay less attention to the students' language issues. However, the late–partial EMI teachers reported that they had more language challenges, suggesting that they believed their students encountered a number of language challenges. However, the late–partial EMI teachers reported they used coping strategies less frequently and found these strategies less useful than teachers in the early–full EMI schools. The late–partial teachers also had a higher positive reflection towards their teaching practices in the EMI context, suggesting that EMI has impacted on their teaching.

A number of teacher demographic characteristics are correlated (e.g. the school's current MOI, teachers' self-reported English overall scores, scores in listening, reading, writing and speaking, EMI training). Teachers with lower self-reported English scores, particularly those with poor speaking skills, tended to use Cantonese in science teaching activities. The late–partial EMI teachers believe that the English language skills are more important than the early–full teachers. The early–full EMI teachers with higher self-reported English scores had a higher language awareness than the late–partial EMI teachers. Teachers with self-reported EMI training, fewer teaching experiences at senior levels, or those who believe English language skills are important, had a positive teaching belief towards EMI. Those teachers who reported that they used the coping strategies frequently also found these strategies more useful.

8.2.6 Research Question 5

RQ5: What are students' perceptions of learning science through EMI?

The interview analysis identified seven recurrent themes from the focus group student interviews: (a) language choice for interactions, and the language challenges; (b) vocabulary in science subjects; (c) coping strategies related to vocabulary; (d) language challenges related to writing and reading in science; (e) coping strategies for writing and reading in science; (f) strategies related to external help; (g) positive and negative attitudes towards EMI.

Students from both the early–full and late–partial schools shared many similar views about their EMI experiences. Students in both groups welcomed EMI instruction. However, while students in the late–partial schools saw EMI as an opportunity to improve their English, those in the early–full schools believed that EMI demotivated their learning of science. In the interviews, both groups of students valued highly the role of L1 in learning science through English. They identified the challenges of learning vocabulary in science subjects, noting that there are too many specific science terms to remember, words with multiple meanings, connotations, and associated meanings. Some students found it difficult to use scientific words to convey simple meanings due to problems conjugating parts of speech or forming different words forms. Students used a number of coping strategies: rote memorisation, using synonyms, understanding associated meanings in similar science contexts.

Students in both groups also pointed out a number of language challenges related to writing and reading in science. Students found it very difficult to communicate and explain their scientific ideas in a complete sentence. In my study, there was clear evidence of a discrepancy between what students understood in Cantonese and what students produced in English. Students also reported that they struggled to identify the relevant key scientific ideas, guess the meaning of an unfamiliar word (e.g. a disease name), and understand the nature of examination question words. They stressed the need for explicit teaching about the kind of sentence patterns and structures expected in their science writing. The students interviewed said perhaps it was the responsibility of their science teacher to focus on key concepts rather than to spend lots of time on elaborations or explaining everyday examples. Students also seek help from tutorial centres.

There is a statistically significant difference in students' survey responses in early–full and late–partial schools for the following four aspects: (1) their language choices in science teaching activities; (2) the most important English skills; (3) their language challenges; and (4) the frequency of coping strategies. Between grade 10 and grade 11, there is a significant difference in the early–full school group in two aspects: students prefer more English as the language choices in science teaching activities and they found coping strategies useful in adopting to the EMI language challenges.

Students from the late–partial schools had a higher mean score in the four aspects mentioned above, suggesting that the late–partial EMI students use more Cantonese. On average, students in the late–partial schools were more concerned with the most demanding English skills than with the most important English skills than were their peers in the early–full EMI schools. This was also observed for their teachers (see chapter seven). Students in the late–partial schools also reported lower self-concepts in science, suggesting that fewer of the students in the late–partial schools were confident in their ability to do well in science. The late–partial students also rated the same set of language challenges higher than the early–full students, yet used coping strategies less frequently and found them less useful than students in the early–full schools. The late–partial students found demanding English skills in everyday use and related to vocabulary to be of higher difficulty than the same set of basic English skills for daily use, while the early–full students were the opposite.

Students with more Cantonese in science teaching activities believe the English language skills for learning science are demanding. They reported they faced more language challenges learning science in English. Those who rated their demanding English skills higher also reported more language challenges and the frequent use of coping strategies.

These results could explain the findings of Yip et al (2007), in which 6000 EMI junior secondary science students reported a lower self-concept in science

(students' view of their ability to do well in science, Wilkins, 2004) than those taught in CMI. Although EMI students had a lower self-concept and self-competence in science, they performed better in science achievement tests than many of the CMI students. Students who think the English skills for learning science are important had a stronger positive belief in EMI. These students also found coping strategies more useful. They would prefer more English in science teaching activities. Students who had more positive reflections on EMI also believed that they would do better in science.

8.3 Contribution to theory and practice

8.3.1 Contribution to theory

The present study perhaps contributes to current theories in a number of ways. First, it would extend exchange structure analysis (IRF sequences) to a macro-level. IRF analysis demonstrates the role of the teacher's modified input in talk and students' thematic understanding in science. The sheer increase in the number of IRF extended exchanges, teacher's modified inputs in scaffolding, more students' response, teacher's feedback and the increased opportunities to negotiate meaning and acquire language in science are highly facilitative for EMI students to acquire both content and language and to attain a better learning belief and self-concepts in science.

Second, this study perhaps connects Mortimer and Scott's communicative framework to the micros-level understanding of how teachers interact with

students in different types of EMI science classrooms. The examples shown in chapter five from four biology classroom reflected Mortimer and Scott's (2003) insight that learning in science classroom consists of co-constructing meaning through language. Such learning may take place through collaborative dialogue in the form of extended IRF exchange between teachers and students or monologically by a teacher through modified talk. In the analysis of classroom interactions in chapter five, I summarised the features of IRF interactions at the micro level, to provide a comprehensive account of how the teacher interacted with the students to demonstrate the ways science teachers in EMI classrooms make the scientific ideas more accessible to students, and provide students with opportunities to learn the content and language. The IRF features observed (and summarised in table 5.8) in the four biology EMI science classrooms can provide a supplement to Mortimer and Scott's four-part communicative framework.

Third, this study may apply the SLA theory (i.e. interaction hypothesis) to content-based instruction contexts. This provides empirical evidence to support Long's (1983) interaction hypothesis in SLA theory, which argues that students need to negotiate meaning through meaningful interaction with a teacher in order to acquire the form as well as the content knowledge.

Fourth, this study shows that teachers' modified input plays an important role in teacher–student interaction. The decision as to whether a teacher selected a student's answer to expand for further discussion or to acknowledge without

follow-up is controlled by the teacher. Such decision is a determining factor in shaping the nature of what Mortimer and Scott recommend as communicative approaches in science classrooms. The evidence presented in the two analyses in chapter 5 show how teacher interactions with students help develop students' thematic understanding of science. Such analysis would provide insights into how the macro-level (different communicative approaches in science classrooms) and micro-level (IRF patterns) connect.

8.3.2 Contribution to practice

The present study hopes to contribute to current practice in a number of ways. First, it may shed light on MOI issues in the sense that it details two aspects of EMI experience in different types of EMI schools. That is, it details both classroom interaction and teacher and student attitudes about the teaching and learning experience in both early–full vs late–partial EMI schools.

Secondly, the study suggests that the adoption of EMI with the aim of providing students with more English learning environments to enhance their exposure to L2, may be justified by a school-based MOI policy, as seen in the cases of late–partial EMI schools where teachers and students chose to have mixed-mode instruction and adoption of L1 use in the classroom interaction. For example, I illustrated this with three examples of biology teachers asking higher-order questions, explaining words with similar meanings and using synonyms to describe a biological concept in chapter 5.

This is particularly important in Hong Kong where the overwhelming majority of the population is Chinese, and Cantonese is often the only language spoken at home and used in the community.

Third, teacher's and students' perceptions on their teaching and learning experience in EMI science classrooms may reflect the numerous educational and practical issues that have been identified in EMI or L2 instruction in Hong Kong and worldwide. Some of these issues may include:

- the unclear role and pedagogical functions of optimal L1 use in science teaching
- different views towards the teaching responsibility of teaching both content and language (i.e. many science teachers believed EMI is just a tool for transmitting knowledge rather than preparing students to learn a second language)
- teachers' poor awareness of students' language problems;
- students' inadequate level in English for learning science through English
- students' difficulties in expressing science ideas through English
- students' poor vocabulary size (basic English, academic, scientific)
- students' diversity (different science backgrounds, English levels)

- students' orientation to rote-learning
- students' low motivation for learning science
- students' experience of being overloaded with topics in the new science curriculum
- unsystematic teaching of curriculum topics
- the expectation that teachers teach outside of their speciality (eg. teaching basic Maths or other related science concepts).

Given these many issues, perhaps there is a need to develop adequate teacher training to equip EMI teachers with practical solutions. Such professional development would need to equip these EMI teachers with the necessary pedagogical skills to integrate content and language (Othman and Saat, 2009), and develop their identity as CLIL teachers by combining content and language learning in their planned curriculum (Coyle et al, 2010). ■

Chapter 9

Conclusion: closing the gap between policy and practice

This chapter summarises the key findings of this study, shedding light on how we can most effectively inform teaching and learning processes in different types of EMI classrooms. I also explain the implications for pedagogy and EMI policy of the perceptions of teachers and students from early–full and late–partial EMI classrooms. Finally, I discuss the limitations and contributions of this study and suggest further directions for research.

9.1. Key findings

9.1.1 The nature of classroom interaction in EMI classrooms

As explained in chapter eight, the data collected for this project indicates that classroom interactions in EMI science classrooms are authoritative and less interactive, very often with teachers controlling the interactions. Interactions between teachers and students are limited, with simple IRF patterns, tending to reduce the opportunities for teacher student negotiation of meaning and understanding. Students seldom initiate interactions and are mainly invited by teachers to give a response to show their understanding of the science topic.

This suggested that the nature of classroom interaction in EMI science classrooms tended to become more teacher-centred with students' participation being inhibited when more English was used as MOI as it was the case in early–full schools. Two major reasons could be accounted for the limited teacher-student interaction were students' language proficiency and teachers' pedagogical skills. Students have limited oral English proficiency which perhaps limited their ability in negotiating meaning with their teachers and thus teachers had to use lower-order questions to ensure that their students with poor English ability still can interact in an English environment.

Teachers trying to teach science through English were not adopting the suitable pedagogical skills for delivering content through English (higher-order questions, clarification requests, confirmation checks and signals, comprehension checks) that enabled the students to arrive at concept understanding in science, thereby promoting students' deeper understanding of the science concepts and process. Instead, the teachers in this study tended to adopt lower-order pedagogical scaffolding, only 'informing' their students of the facts and subsequently encouraged students' rote-memorisation of the factual information.

9.1.2 Comparing interactions in early–full and late–partial EMI classrooms

The early–full and late–partial EMI science classrooms show similar interactional patterns at the macro-level (percentages of interaction time, distribution of time between teacher and student talk and frequency of pedagogical functions). However, when explored from the micro-level, it becomes apparent that the nature of the interactions is different. In late–partial EMI schools, overall, there are more (but shorter) student initiations and responses, more use of higher-order questions from the teachers but less direct teacher feedback to students. Teachers and students use relatively more L1 than L2 in the interactions, with the majority of interactions spoken in Cantonese. Teachers and students can freely switch back to Chinese when students had difficulties in answering questions in the late–partial EMI schools. L1 can serve as a rich semantic resource to promote higher-order thinking . For examples, teachers can ask higher-order questions, explain words with similar meanings and using synonyms to describe a science concept in L1 (See examples in chapter 5, section 5.5.2).

Thus these teachers seem to ask more cognitively challenging questions through L1 to stimulate students' higher-order thinking. These teachers can use Cantonese as the medium of instruction with English technical terms. In this way, teachers and students can work on cognitively challenging questions in Cantonese, using their rich semantic resources in their mother tongue to help

promote higher-order thinking. The use of Cantonese is likely to greatly reduce students' anxiety and lower the language barrier.

9.1.3 Comparing interactions in grades 10 and 11 in each school group

The data showed less interaction time, shorter maximum length of student turns and more L1 use in grade 11 than in grade 10 in both types of school. Perhaps this is because with the advanced level and more abstract and difficult science concepts, teachers and students become less interactive. This is observed mainly in the early–full EMI schools where teachers and students had to interact mostly in English. However, students in late–partial EMI schools were able to interact freely in their comfortable language environment when learning more abstract and difficult science topics. This is explained why there was an observable increase in L1 use from grades 10 to 11 as teachers used L1 to make science content more accessible to students with poor English abilities.

9.1.4 Teacher's perceptions of EMI teaching in science classrooms

The teachers from both the early–full and late–partial EMI schools shared similar views about their EMI teaching experiences. They welcome a mixed-mode instruction to allow optimal use of L1 in explaining and providing feedback to students with limited English. However, the late–partial EMI teachers reported that they used more Cantonese in teaching science. Although on one hand the late–partial teachers said the English language skills for learning science were demanding, on the other hand, they said these English

language skills were less important for learning science. This result was also observed in the attitudes of students in the late–partial schools.

The late–partial teachers had lower language awareness in teaching science through English. On questioning techniques, the early–full teachers prefer to use recalling questions, while the late–partial teachers prefer to use reasoning questions (i.e. mediating through Cantonese). Although the late–partial teachers had more positive reflections about EMI science teaching, they reported that their students faced more language challenges. The late–partial students also reported they used coping strategies less frequently and found these strategies less useful.

9.1.5 Students' perceptions of EMI experience in science classrooms

Students from both the early–full and late–partial schools shared similar views about many aspects of their EMI experiences, both welcoming EMI instruction but also identifying certain limitations. The late–partial students used more Cantonese in science learning activities than the early–full students. All students valued highly the role of L1 in learning science through English. They mentioned the challenges of learning vocabulary in science subjects, noting that there are too many specific science terms to remember, and that many words have multiple meanings in English, or different connotations and associated meanings outside of science. Students also found it very difficult to convey a complete meaning in science explanations, suggesting a discrepancy between

what students understood in Cantonese and what they could produce in English.

In term of English language skills, the late–partial students believed the English language skills needed for learning science were demanding. However, many of the students thought these skills were not as important as did students in the early–full EMI schools. This indicates perhaps that students in late–partial EMI schools were not expected to have fully adopted EMI as students. The reason for this may be that in some late–partial EMI schools, students with limited English ability would opt to sit the Chinese version of the pubic examination at the end of their secondary education. This attitude towards English science learning skills was also observed among teachers in the late–partial schools. The late–partial students believed they were less capable in science and reported that they encountered more language challenges in the EMI classroom. Yet, the late–partial students did not find coping strategies useful and thus used them infrequently. As a result, the late–partial students saw EMI as an opportunity to improve their English, but the early–full students believed that EMI demotivated their learning of science.

9.2. Limitations of this study

9.2.1 Sampling

This study employed purposive non-probability sampling. Thus, the reported findings are not representative of the Hong Kong school population, nor can

they be statistically generalised to that population. Moreover, it was not possible to control for the fact that participants might be receiving language support outside of their classrooms and that this could have had an effect on participants performance in the classrooms observed. For an example, many students in Hong Kong receive additional English support at tutorial centre where students can study both English and science in Cantonese, with study notes provided in English.

The number of lessons observed for this study and the number of participating schools was rather small. This limitation was due to the time and resources available for a doctoral study. In the research design phase, the eight participating schools and the lessons observed were carefully and purposively sampled so that they could be reasonably representative and be 'comparable' of the two types of EMI schools. Therefore, the two types of EMI schools studied included a range of students with similar academic ability and English proficiency. The study would have benefitted from the inclusion of more lessons and more teachers. This would increase the generalisability to the population of most EMI secondary schools in Hong Kong. Nevertheless, the actual sample was by no means an insignificant one.

9.2.2 Teacher and student effects

The naturalistic observation design of this study has inevitably brought with it some limitations. For instance, it is difficult to select classes in grades 10 and 11

from both early–full and late–partial EMI schools where students' English abilities and academic achievement are the same. I could only control the selection of schools according to their banding, which is based on students' attainment tests prior to admission. Thus, it was not possible to control for the effect of individual students and individual teachers in the classrooms observed as participation was voluntary. This might have affected the internal validity of the study as one could argue that the observed classroom interactions could also be the result of individual learning styles among students and different teaching styles among the teachers. Individual factors such as underlying academic abilities and socioeconomic status would ideally need to be taken into account or controlled for. However, it is hoped that the inclusion of the comparison group (i.e. early–full EMI schools) in the design has alleviated such effects. A longitudinal study exploring the quality of classroom interaction with the same cohort of students across a number of years after the adoption of EMI would be a more valid and rigorous research design to use in addressing the research topic.

9.2.3 Teacher's and students' English proficiency levels

Students' and teachers' English proficiency could be a factor in explaining the differences across schools. Teachers self-reported their English abilities and students reported their school English achievement in the last academic year as a sub-indicator. Teachers' and students' English proficiency was not measured

during their interactions. The measure of students' and teachers' English proficiency would provide clear evidence as to whether the observed classroom interactions were affected by the students' and teachers' English abilities, or whether there were other factors such as the teacher' teaching belief and the students' perceptions of EMI learning that played a role in shaping their classroom interaction.

9.2.4 Teacher's and students' L1 use

The 33 lessons observed in this study show that even though the use of English was expected in these classrooms, the late–partial EMI teachers were aware of their L1 use, and used English when they felt it appropriate to their students' L2 proficiency and academic ability. The student interviews revealed insights from students about whether a teacher's use of L1 could help them grasp science content and then express their science ideas through English. Future research could examine how schools implement EMI instruction from partial to full EMI instruction and when the L1 can most effectively to used in a science lesson for accessing content knowledge and facilitating L2 learning. For instance, I illustrated the three examples of biology teachers asking higher-order questions, explaining words with similar meanings and using synonyms to describe a biological concept.

9.2.5 Non-verbal language in learning science

The goal of this research has been to examine the nature of classroom interaction in different types of EMI classrooms. The primary focus has thus been on how content and language are developed through interactions. However, other research has suggested that science teachers go beyond language (oral or written), drawing on multiple semiotic systems in the form of multimodal resources to explain abstract science concepts and facilitate the deconstruction of science knowledge (Lemke, 1990; Lo & Macaro, 2012; Lo, 2015). Multimodal resources include symbols, graphs and diagrams, mind maps, tree diagrams, flow charts, crossword puzzles, whiteboards and video games. Due to the scope of this study, I was not able to analyse in details the relationship between language and multimodal resources in explaining scientific ideas. Nor was I able to examine the ways in which science teachers use multimodal resources to explain abstract scientific concepts during their interactions with students. In future research, it would be worth exploring the use of these semiotic resources to identify whether and how they help L2 learners unpack the technical, dense, abstract discourse patterns characteristic of scientific discourse.

9.2.6 Time and resources

As a result of funding structures, the planning, execution and reporting of this study was constrained to a period of three years, which made a longitudinal

approach impossible. As a result, compromises were made, with data analysis restricted to cross-sectional, naturalistic observations of 30 lessons observed in different EMI classrooms in Hong Kong, pre-and post-observation interviews with teachers, post-observation focus group interviews with students and questionnaires.

9.3 Contributions of the study

9.3.1 Contextual contribution

1. This study supplements the research findings obtained from studies conducted under the previous MOI policy in Hong Kong, when schools were classified as either English-medium or Chinese-medium schools. Research from that earlier context are not applicable to the current MOI situation in Hong Kong, where students in both Chinese-medium and English-medium schools use EMI for teaching science subjects. In the current MOI situation in Hong Kong, nearly all the CMI schools have now adopted EMI instruction at senior secondary levels.

2. This study provides updated empirical evidence of the impact of the Hong Kong government's fine-tuning policy, applied from 2010 to the teaching and learning process in secondary EMI classrooms. In addition, I examined classroom interactions in a new context—senior secondary science classrooms (physics, biology and chemistry)—in order to generate empirical evidence to explain the current MOI situation in Hong Kong. As indicated

by Chan (2014) and Poon et al. (2013), the educational values offered by the fine-tuning MOI decision appear limited. When students encounter the many language challenges of the EMI classroom, it is questionable whether the previously CMI students, particularly those with poor English proficiency, can learn effectively in an English environment.

3. Based on the data analysed in this study, I have argued that if we take into consideration the subtle differences in the nature of classroom interaction in different EMI schools, the adoption of EMI would not ultimately benefit all students. The differences in the ways teachers interacted with their students in different types of EMI science classrooms are perhaps due principally to the different extents to which these classrooms implemented a full EMI instruction or adopted a mixed-mode instruction between English and Cantonese. This study did not set out to show whether the early–full or late–partial EMI classroom is better or more successful than the other. Instead, this study explored the nature of classroom interactions in different EMI settings in order to reveal any differences that might be attributable to the pedagogical implications of adopting an EMI approach.

4. The present study adds to the empirical research on the quality of EMI teaching in Hong Kong. Although this study included only students from eight schools around Hong Kong, the classes were carefully selected to be reasonably representative of students in Hong Kong in terms of their

previous English learning experience, academic achievement prior to secondary education and socioeconomic background.

9.3.2 Methodological contribution

This study extended the methodological aspect of EMI research on classroom interactions in Hong Kong (Lo and Macaro, 2012). In analysing these classroom interactions, I considered how science was taught and its inter-relationship with language learning issues. This study also extends the long history of IRF analysis to explore current language and teaching issues. The evidence presented in the chapter 5 about the two in-depth IRF analyses of student–teacher interactions illustrated the development of students' thematic understandings in science. Such analysis provides some insights into the connections between macro-level interactional patterns (different communicative approaches in the science classroom) and micro-level interactional patterns (IRF patterns). Whether or not a student's answer is selected for further discussion is controlled by the teacher. Whether teachers expand on students' answers in a modified form or completely ignore them results in interactional patters that are perhaps a determining factor in shaping what Mortimer and Scott identify as different communicative approaches in science classrooms. Micro-level analysis shows that the teacher's modified input plays an important role in teacher–student interaction.

In addition, this study provides an insight into existing teaching methods in content learning. The teacher's modified input is an important tool in developing students' thematic understandings in science. Instead of rote-memorisation of L2 scientific words that mediate these science concepts, the teacher's modified input helps students relate the new thematic patterns (that mediate the new concepts) to their existing thematic patterns (that mediate the concepts they already know or are familiar with). Science teachers with high language awareness appear able to make new science concepts more accessible to students in L1 and mediate abstract concepts through everyday language.

9.3.3 Theoretical contributions

According to the interaction hypothesis (Long, 1983), when learners are exposed to more comprehensible input, they can produce more L2 through interactions with teachers, who in turn can give more modified input and corrective feedback to students, which ultimately contributes to their L2 learning.

Despite students' proficiency gaps, this study shows that a skilful teacher can deliver science content through modified input, providing provide interactional scaffolding (e.g. extended IRF patterns) for students to communicate science ideas through appropriate scientific language. The data shows that teachers in the late–partial EMI schools are more prepared to adapt EMI policy. Rather than implement full EMI instruction, they opt for partial EMI

instruction, using Cantonese as the matrix language within which they embed English terms. Strategies for promoting L2 interaction and production were also observed among teachers with higher language awareness. These strategies included code-switching between Cantonese and English, the use of mind-mapping, allowing group discussion, the use of higher-order questions and the use of a range of science questions that lead to a conceptual development in science (Yip, 2004). Teaching science through EMI may require specific pedagogical skills for which teachers can be prepared through training that raises teachers' language awareness to make science content more accessible in L2 and that encourages teachers to pay attention to students' L2 problems.

Teacher–student interaction and the teacher's modified input in IRF exchanges offer a social context where learners can focus on and reflect on language forms and meanings they have learned and are learning. The data in this study show that students' L2 and science content development can take place through interaction, particularly when teachers provide modified input through extended IRF exchanges.

The examples in chapter five from four biology classrooms reflected Mortimer and Scott's (2003) insight that learning in science classrooms consists of co-constructing meaning through language. Such learning may take place through collaborative dialogue (as in this example, the extended IRF exchanges) between teachers and students, or monologically by a teacher through modified

talk. If a science teacher does not make science content more accessible in L2, or pay attention to students' L2 needs, it is difficult to see how students would be able to construct meaning on their own using the lexico-grammatical resources expected in L2 scientific discourse.

Johnson and Swain (1994) argued that students in late immersion programmes face great language challenges when bridging the gap between their existing L2 proficiency level and the required threshold level. The teacher's modified input responds to students' L2 language challenge. Modified input can address the language gap in L2 content learning, provided students are given sufficient L2 learning opportunities, with 'pushed output' on students' language production. The teacher's modified input can help students develop the necessary English proficiency for content learning such as science. Modified input can help close the gap between how students conceptualise scientific knowledge in L2 and how they conceptualise it in L1, as well as closing the gap between what students can understand and what they can articulate in English.

There is also evidence that L1 use in EMI classrooms can function pedagogically to assist L2 learning (Lin, 2006; Probyn, 2001, 2009). The data in this study support the claim from Lo (2015) that most Hong Kong content–subject teachers make thoughtful use of Cantonese to facilitate their students' learning, taking into account their English abilities. In this study, both groups of students in the interviews valued highly the role of L1 in learning science

through English. In the teacher and student questionnaires, the late–partial EMI group indicated that they used more Cantonese in science teaching activities, and that teachers would mediate through Cantonese when students could not follow in English. The analyses perhaps demonstrate the role of L1 in facilitating learning and teaching in different types of EMI classrooms and provide examples to inform practical pedagogical suggestions for optimal L1 use in supporting students' language development in science. The current study provides empirical evidence of teachers and students' choices of instructional language, including code-switching, across a range of science activities. In interviews, teachers and students shared their views on how they develop content and language by moving between Cantonese and English to cope with the language demands of the EMI classroom. Empirical data of the use of code-switching by teachers and students in different EMI classrooms may help shed light on how the practical use of L1 can develop students' language abilities to be adequate to meet the content and L2 learning needs.

9.3.4 Pedagogical contributions

This study contributes to present knowledge in three important ways. First, it provides further evidence that content learning constituted by different types of EMI programs (early–full and late–partial EMI schools) influences several aspects of English learning, including classroom interaction and attitudes towards teaching and learning in EMI. The research shows that the close-up

study of teaching and learning processes in EMI classrooms is important in evaluating the quality of teaching in L2 learning.

Second, this study points to some characteristics of EMI teaching that may contribute to language development. These characteristics include an increase in the frequency of IRF exchanges, modified input by teachers in scaffolding, more opportunity for student responses, teacher feedback and increased opportunities to negotiate meaning and acquire language in science. These characteristics are highly effective in helping EMI students to acquire both content and language and may help students develop more positive beliefs about the value of learning and stronger self-concepts about their ability to succeed at learning science.

9.4. Recommendation for future research

The present study has highlighted the complicated issue of the current MOI situation in Hong Kong secondary schools. The analyses of the classroom interactions in early–full and late–partial EMI science classrooms have provided empirical evidence about the impact on teaching and learning processes of the implementation of fine-tuning policy, first introduced six years ago. To date, research has overlooked the implications of the transition in MOI at senior secondary levels.

Given that many language challenges are found in both early–full and late–partial EMI schools, a longitudinal, comparative approach would be worthwhile

in investigating whether schools should opt for a binary decision on their MOI. More studies should explore whether all Hong Kong secondary schools should adopt the same EMI policy and whether the policy is suitable for students with limited English abilities and experience in EMI. Studies should also ask whether there should be different types of EMI programs (e.g. partial EMI groups, transitional EMI groups with more L1 use) to help different groups of students gradually prepare for full EMI immersion at university. When evaluating the different EMI programs, research should include measures of the impact of EMI and the use of L1 in both language learning outcomes and content learning outcomes. A longitudinal study should be conducted to explore if EMI adoption can increase the same-cohort of students in their academic performance before and after EMI instruction, as to provide some empirical evidence on the impact of EMI on students actual English development in the content-subject areas.

Future research may indicate that there should be alternative EMI transitional programs designed to encourage optimal use of L1 in preparing students for full EMI instruction. Future research should look at the role of L1 in EMI teaching and how it mediates the language challenges students face in learning through English. The evidence from this study can help to inform further decisions in MOI policymaking. One possible implication of this study might be that policy makers should consider relaxing the government's one language for teaching policy (either English or Chinese but no mixing) to allow

mixed-mode instruction in the transitional period for the late–partial EMI schools before full EMI instruction. Future research could explore the conditions and factors involved in establishing these different EMI programs.

9.6. Concluding remarks

To summarise this thesis overall, I began by noting that the Hong Kong government's fine-tuning language policy in 2010 aimed to encourage schools to adopt English instruction for content learning at senior secondary levels. The aim of the policy was to create more English learning environments so that students with poor English ability could increase their exposure to English. Under this revised policy, most CMI schools have opted for EMI instruction, creating what I have referred to in this study as late–partial EMI schools. Although in introducing the fine-tunning policy the government stressed that the policy's aim was to maximise the educational values offered by the change of MOI, the reality appears different. The increased amount of EMI teaching has resulted in many students encountering language challenges, and has led to pedagogical and practical issues in content–subject classrooms. These issues have been demonstrated by the teachers' and students' responses in this study's questionnaire and interview data.

The data on teachers' and students' views about teaching and learning processes in the EMI context highlight the numerous pedagogical and practical challenges in implementing English instruction in science classrooms. Many of

these challenges are related to students' difficulties with English and teachers' language awareness in addressing their students' language problems. The different coping strategies suggested by teachers and students inform possible ways to address the language challenges of EMI classrooms, particularly for students in late–partial EMI schools. These students have had limited exposure to EMI and often have poor English abilities but, since the introduction of the fine tuning policy in 2010, are expected to learn most content subjects in English. The interview and questionnaire data in this study also revealed that the instructional language in EMI classrooms does not need to be in English only. Teachers move between L1 and L2 as the instructional language in teaching science activities. This reflects the fact that in practice most EMI schools inevitably develop their own school-based policy to deal with their particular situation (Chan, 2014). This suggests that there is a discrepancy between the policymakers' goals and everyday practice.

The observational data in this study has revealed that the ways teachers interact with their students in early–full and late–partial EMI science classrooms are subtly different. Such differences are mainly due to the extent to which teachers in these classrooms implement full EMI instruction or adopt mixed-mode instruction using both English and Cantonese. Teachers in both early–full and late–partial EMI science classrooms use L1 to different extents. The data has provided examples to inform practical pedagogical suggestions for optimal L1

use in supporting students' language development in science. The study shows that the choice of instructional language has an impact on the number of initiations and responses from students and on the teachers' questioning technique, indicated by the number of higher-order questions used and the amount of direct feedback provided to students. When asking if there is any evidence that use of EMI improves students' content knowledge, the late–partial EMI schools in this study have provided some empirical evidence that the classroom environment conditions (e.g. more L1 use, higher order questions, more student initiations and responses in the form of extended IRF sequences, less direct feedback to students) are critical for deeper learning in content.

Although my study cannot directly answer the question of whether there is any evidence that use of EMI improves students' English language proficiency, the analysis of classroom interaction revealed a lack of language support in content learning, perhaps reflecting a gap between the aims of the fine-tuning EMI policy and its actual implementation. The lesson transcripts reveal no incidents of the science EMI teachers and their students negotiating the meaning of lexical terms which led to L2 learning. In term of students' language production, in the early–full EMI schools, students did not appear to be able to interact with teachers as freely and fluently as their counterparts in the late–partial EMI schools. Students in the early–full EMI schools had experienced EMI for more than three years and may have become accustomed to EMI teaching.

The absence of teacher support and 'pushed output' on students' language production in both types of EMI schools from their teachers is perhaps the major challenge in achieving the goal of improving EMI students' English skills, both receptive and productive. This echoes Wannagat's (2007) views that the role of language in learning goals is not clearly explicated in the EMI curriculum, despite the fact that students are more explosed to English in EMI classrooms as compared with CLIL classrooms.

The current MOI policy seems to create more flexibility for schools to choose their own MOI, aiming to end the segregation between CMI and EMI stream, but a more flexible policy does not imply all the problems can be solved. The government is expected to reveal its assessment of the progress of the fine-tuning MOI policy in 2017, seven years after its implementation. At that time, the government should provide successful case studies of effective implementation of EMI at classroom level. These should include recognition of frontline teachers' decisions about practical teaching interventions, and approval of teachers' judicious use of L1.

In other words, rather than promoting a clear-cut binary policy of EMI versus non-EMI instruction, the government should provide clearer guidelines on ways to handle problems in actually implementing EMI in different types of schools. We need to recognize the different forms of EMI programs in most of the so-called 'EMI' secondary schools, and allow a transitional period for those

in late–partial schools switching from partial to a full EMI instruction. For instance, the teachers and students in early–full and late–partial schools in my study had different attitudes towards EMI and such differences in perceptions at different stages of EMI implementation should be recognised in formulating adequate strategies to account for their individual language challenges.

Professional development programs for frontline EMI teachers should be in place within schools so that teachers can be equipped with the necessary pedagogical skills to integrate both content and language (Othman and Saat, 2009). In these professional development programs, EMI teachers should be trained for increasing their confidence in English communication skills, and be taught about the specific scaffolding skills in delivering both content and language through English to students with different levels. Science teachers should be taught about the questioning techniques suggested by Yip's study (1999) that lead to students' misconception change in science. Science teachers should be trained in ways to integrate both content and language in planning their EMI lessons drawing from language teaching education research. For examples, the ability to unpack scientific ideas and co-construct with students (Rose & Martin, 2010), the strategies for code-switching to aid scaffolding (Macaro, 2001), and pedagogical skills to promote productive use of English, and provide students with sufficient waiting time to stimulate cognitive thinking.

These programs should also help science teachers develop their identity as CLIL teachers (i.e. teachers of both academic content and academic language) (Coyle et al, 2010). Instead of teaching technical nouns in English, teachers should recognise the differences between everyday language and disciplinary language and be able to move between the two languages (Yip et al, 2003). School should provide a more supportive culture to help frontline EMI teachers in the early stages of EMI implementation. Senior science teachers in each school could offer school-based advice and experience in subject matter development. A collaborative team with teachers from all the science departments in a school, together with internal and external support for staff development, could help to introduce and implement innovations such as new teaching interventions for conceptual change in the EMI classroom (Lo, 2014; Yip, 1999).

In conclusion, this study has yielded the following arguments:

1. The degree of similarity among the interactions in early–full and late–partial EMI schools is limited to the macro level of interactional patterns (percentages of interaction time, distribution of time between teacher and student talk, frequency of pedagogical functions).
2. The different degree of EMI adoption (e.g. early–full and late–partial) shapes the nature of classroom interaction only at the micro-level. In late–partial EMI schools, overall, there are more (but shorter) student initiations

and responses, more higher-order questions from the teachers and less direct feedback to students.

3. From grade 10 to 11 in both types of schools there was a small decrease in the percentage of interaction time and in the maximum length of student turns and a small increase in L1 use.

4. Teachers' modified input plays an important role in teacher–student interaction in developing students' content knowledge and language competence.

5. Empirical data about the role of L1 in facilitating learning and teaching in different types of EMI classrooms can provide examples to inform practical pedagogical suggestions for optimal L1 use in supporting students' language development in science.

6. Teachers from both early–full and late–partial EMI schools shared similar views about many aspects of their EMI teaching experiences, but the two groups of teachers differ in their opinions about which English language skills are most important and in their levels of language awareness. The early–full EMI teachers are more language aware and believe that English language skills are important.

7. Students in both early–full and late–partial EMI schools generally welcome EMI instruction. However, while students in late–partial EMI schools see

EMI as an opportunity to improve their English, those in the early–full EMI schools believe that EMI demotivates their learning.

This study sought to answer its research questions through a comprehensive analysis of classroom interaction. The approach taken represents a claim that in order to arrive at a real understanding of the nature of patterns in classroom interaction it is necessary to triangulate data from multiple sources. The study suggests that detailed analysis of interaction can be a great help for frontline teachers in developing their understanding of the complexity of teaching science and language. Research such as this study may thus have a valuable role in informing future EMI pedagogy and EMI teacher training. ■

References

Airey, J., & Linder, C. (2006). Language and the experience of learning university physics in Sweden. *European Journal of Physics*, *27*(3), 553–560. http://doi.org/10.1088/0143-0807/27/3/009

Airey, J., & Linder, C. (2008). Bilingual Scientific Literacy ? The Use of English in Swedish University Science Courses. *Nordic Journal of English Studies*, *7*(3), 145–161.

Alidou, H. (2004). Medium of Instruction in Post-Colonial Africa. In *Tollefson, J.W. & Tsui, A.B.M. (2004) (eds) Medium of Instruction Policies: Which Agenda? Whose Agenda?* (pp. 195–216).

Annamalai, E. (2004). Medium of Power: The Question of English in Education in India. In *Tollefson, J.W. & Tsui, A.B.M. (2004) (eds) Medium of Instruction Policies: Which Agenda? Whose Agenda?* (pp. 177–194).

Arkoudis, S. (2005). Fusing pedagogic horizons: Language and content teaching in the mainstream. *Linguistics and Education*, *16*(2), 173–187. http://doi.org/10.1016/j.linged.2006.01.006

Bartlett, M. S. (1954). A note on the multiplying factors for various χ 2 approximations. *Journal of the Royal Statistical Society. Series B (Methodological)*, 296-298.

Barnes, D. (1969) 'The language of the secondary classroom', in D. Barnes, J.N. Britton and H. Rosen (eds), *Language, the Learner and the School.* Harmondsworth: Penguin.

Barwell, R. (2005). Integrating language and content: Issues from the mathematics classroom. *Linguistics and Education*, *16*(2), 205–218. http://doi.org/10.1016/j.linged.2006.01.002

Björkman, B. (2008). 'So where we are?' Spoken lingua franca English at a technical university in Sweden. *English Today*, *24*(2). http://doi.org/10.1017/S0266078408000187

Byun, K., Chu, H., Kim, M., Park, I., Kim, S., Jung, J., & Kiyong Byun, H. C. (2010). English-medium teaching in Korean higher education: policy debates and reality. *Higher Education*, *62*(4), 431–449. http://doi.org/10.1007/s10734-010-9397-4

CDC & HKEAA. (2007a). *Science Education Key Learning Area Biology Curriculum and Assessment Guide (Secondary 4 - 6)*. Hong Kong.

CDC & HKEAA. (2007b). *Science Education Key Learning Area Chemistry curriculum and assessment guide (Secondary 4–6)*. Hong Kong.

CDC & HKEAA. (2007c). *Science Education Key Learning Area Physics Curriculum and Assessment Guide* (Vol. 2007). Hong Kong.

Census and Statistics Department. (2014). Retrieved from http://www.bycensus2006.gov.hk/en/data/data2/index.htm

Chan, J. Y. H. (2013). A week in the life of a 'finely tuned' secondary school in Hong Kong. *Journal of Multilingual and Multicultural Development*, *34*(5), 411–430. http://doi.org/10.1080/01434632.2013.770518

Chan, J. Y. H. (2014). Fine-tuning language policy in Hong Kong education: stakeholders' perceptions, practices and challenges. *Language and Education*, *28*(5), 459–476. http://doi.org/10.1080/09500782.2014.904872

Chin, C. (2006). Classroom Interaction in Science: Teacher questioning and feedback to students' responses. *International Journal of Science Education*, *28*(11), 1315–1346. http://doi.org/10.1080/09500690600621100

Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching*, *44*(6), 815–843. http://doi.org/10.1002/tea.20171

Chinese University of Hong Kong. (2007). *Final Report on Bilingualism*. Hong Kong: Chinese University of Hong Kong.

Christie, F., & Derewianka, B. (2008). *School Discourse: Learning to Write Across the Years of Schooling*. London: Continnuum International Publishing Group.

Coleman, J. a. (2006). English-medium teaching in European higher education. *Language Teaching*, *39*(1), 1. http://doi.org/10.1017/S026144480600320X

Committee on Home-School Co-operation. (2014). the current version of Secondary School Profiles. Retrieved from http://www.chsc.hk/ssp2013/chi/index.php

Cohen, J. (1988). Statistical power analysis for the behavioural sciences. Hillside. *NJ: Lawrence Earlbaum Associates*.

Corbin, J.H. & Strauss, A. L. (Ed.). (2008). *Basics of Qualitative Research: Technqiues and Procedures for Developing Grounded Theory* (3rd ed). Thousand Oaks, CA: Sage.

Costa, F. (2012). Focus on form in ICLHE lectures in Italy: Evidence from English-medium science lectures by native speakers of Italian. *AILA Review*, *25*(1), 30–47.

Council, L. (2009). *Fine-tuning the Medium of Instruction for Secondary Schools*

(Vol. 9). Hong Kong. Retrieved from http://sc.legco.gov.hk/sc/www.legco.gov.hk/yr08-09/english/panels/ed/papers/ed0115cb2-623-1-e.pdf

Coyle, D., Hood, P., & Marsh, D. (2010). *CLIL: Content and Language Integrated Learning*. Cambridge: UK: Cambridge University Press.

Crawford, C. B. (2010). Meeting the challenges of European student mobility: Preparing Italian Erasmus students for business lectures in English. *English for Specific Purposes*, *29*(4), 268–280. http://doi.org/10.1016/j.esp.2010.01.001

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Los Angeles: Los Angeles : SAGE Publications, c2011.

Cummins, J. (1979). Linguistic Interdependence and the Educational Development of Bilingual Children. *Review of Educational Research*. http://doi.org/10.3102/00346543049002222

Curriculum Development Council (CDC). (2002). *Science Education KLA Curriculum Guide (P1-S3)*. Hong Kong.

Dale, L., & Tanner, R. (2012). *CLIL Activities: A resource for subject and language teachers*. Cambridge: UK: Cambridge University Press.

Dalton-Puffer, C. (2007). *Discourse in content and language integrated learning (CLIL) classrooms* (Vol. 20). John Benjamins Publishing.

Dang, T. K. A., Nguyen, H. T. M., & Le, T. T. T. (2013). The impacts of globalisation on EFL teacher education through English as a medium of instruction: an example from Vietnam. *Current Issues in Language Planning*, *14*(1), 52–72. http://doi.org/10.1080/14664208.2013.780321

Davies, S. (2003). Content Based Instruction in EFL Contexts. *The Internet TESL Journal*, *IX*(2).

Dearden, J. (2015). *English as a medium of instruction-a growing global phenomenon*. Retrieved from https://www.britishcouncil.org/sites/default/files/e484_emi_-_cover_option_3_final_web.pdf

Demirbulak, D. (2011). A look at the Turkish and English Language in Turkey from the perspectives of tertiary undergraduate students. *Procedia - Social and Behavioral Sciences*, *15*, 4083–4088. http://doi.org/10.1016/j.sbspro.2011.04.419

Deusen-Scholl, N.V., and N.H. Hornberger. 2008. "Content-based Instruction." In *Encyclopedia of Language and Education*. 2nd ed., edited by N.H. Hornberger, 59–70. New York: Springer.

Doiz, A., Lasagabaster, D., & Sierra, J. M. (2014). What does 'international university' mean at a European bilingual university? The role of languages and culture. *Language Awareness*, *23*(1–2), 172–186. http://doi.org/10.1080/09658416.2013.863895

Doiz, A., Lasagabaster, D., Sierra, J. M., & Manuel Sierra, J. (2011). Internationalisation, multilingualism and English-medium instruction. *World Englishes*, *30*(3), 345–359. http://doi.org/10.1111/j.1467-971X.2011.01718.x

Dörnyei, Z. (2007). *Research Methods in Applied Linguistics*. *International Journal of Applied Linguistics* (Vol. 19). http://doi.org/10.5054/tj.2010.215611

Education Bureau. (2005). *Report on Review of Medium of Instruction for Secondary Schools and Secondary Schools Allocation*. Hong Kong.

Education Bureau. (2009). *Fine-tuning the Medium of Instruction for Secondary Schools* (Vol. 7). Hong Kong.

Education Bureau (2017). *Medium of Instruction for Secondary Schools Sharing Session - A Whole-school Approach to Language across the Curriculum (24 November 2012)*. Retrieved March 26, 2017, from http://www.edb.gov.hk/en/edu-system/primary-secondary/applicable-to-secondary/moi/support-and-resources/experience-sharing-sessions/read-fair-2012/24-nov-2012/presentation/index.html

Education Commission. (1981). *The Hong Kong Education System*. Hong Kong.

Education Commission. (1988). *Education Commission report no. 3* (Vol. 3). Hong Kong.

Education Commission. (1990). *Education Commission report no. 4* (Vol. 4). Hong Kong.

Education Commission. (1996). *Education Commission report no. 6* (Vol. 6). Hong Kong.

Eggins, S. & Slade, D. (1997). *Analyzing Casual Conversation*. London: Equinox Publishing Ltd.

European Commission (1992). *Education commission report no. 5* (Vol. 5). Hong Kong.

European Commission. (2000). *European Report on Quality of School Education. Sixteen Quality Indicators. Report based on the Work of the Working Committee on Quality Indicators*.

European Ministers of Education. (1999). The Bologna Declaration of 19th June 1999. Retrieved October 23, 2014, from http://www.ehea.info/Uploads/Declarations/BOLOGNA_DECLARATION

1.pdf

Evans, S. (2000). Classroom Language Use in Hong Kong's English-Medium Secondary Schools. *Educational Research Journal*, *15*(1), 19–43.

Evans, S. (2009). The medium of instruction in Hong Kong revisited: policy and practice in the reformed Chinese and English streams. *Research Papers in Education*, *24*(3), 287–309. http://doi.org/10.1080/02671520802172461

Evans, S. (2011). Historical and comparative perspectives on the medium of instruction in Hong Kong. *Language Policy*, *10*(1), 19–36. http://doi.org/10.1007/s10993-011-9193-8

Evans, S. (2013). The Long March to Biliteracy and Trilingualism: Language Policy in Hong Kong Education Since the Handover. *Annual Review of Applied Linguistics*, *33*, 302–324. http://doi.org/10.1017/S0267190513000019

Evans, S., & Green, C. (2007). Why EAP is necessary: A survey of Hong Kong tertiary students. *Journal of English for Academic Purposes*, *6*(1), 3–17. http://doi.org/10.1016/j.jeap.2006.11.005

Evans, S., & Morrison, B. (2011a). Meeting the challenges of English-medium higher education: The first-year experience in Hong Kong. *English for Specific Purposes*, *30*(3), 198–208. http://doi.org/10.1016/j.esp.2011.01.001

Evans, S., & Morrison, B. (2011b). The student experience of English-medium higher education in Hong Kong. *Language and Education*, *25*(2), 147–162. http://doi.org/10.1080/09500782.2011.553287

Evnitskaya, N., & Morton, T. (2011). Knowledge construction, meaning-making and interaction in CLIL science classroom communities of practice. *Language and Education*, *25*(2), 109–127. http://doi.org/10.1080/09500782.2010.547199

Fang, Z. (2005). Scientific literacy: A systemic functional linguistics perspective. *Science Education*, *89*, 335–347. http://doi.org/10.1002/sce.20050

Fang, Z. (2006). The Language Demands of Science Reading in Middle School. *International Journal of Science Education*, *28*(5), 491–520. http://doi.org/10.1080/09500690500339092

Ferreira, J. G. (2011). Teaching Life Sciences to English second language learners : What do teachers do ? *South African Journal of Education*, *31*, 102–113.

Field, A. (2013). Discovering Statistics using IBM SPSS Statistics. In *Discovering Statistics using IBM SPSS Statistics* (4th ed., pp. 297–321). London: Sage. http://doi.org/10.1016/B978-012691360-6/50012-4

Flanders, N. A. (1970). *Analyzing teacher behavior*. Addison-Wesley P. C.

Flowerdew, J., Li, D., & Miller, L. (1998). Attitudes Towards English and Cantonese Among Hong Kong Chinese University Lecturers. *TESOL Quarterly*, *32*(2), 201–231. http://doi.org/10.2307/3587582

Francomacaro, R. M. (2011). *English as a Medium of Instruction at an Italian Engineering Faculty: an Investigation of Structural Features and Pragmatic Functions*.

Gill, S. K. (2004). Medium-of-Instruction Policy in Higher Education in Malaysia: Nationalism Versus Internationalization. In *Tollefson, J.W. & Tsui, A.B.M. (2004) (eds) Medium of Instruction Policies: Which Agenda? Whose Agenda?* (pp. 135–152).

Glenwright, P. D. L. (2003). Education reform and policy change in Hong Kong: A critique of the post-colonial legacy. *Education and Society*, *21*(3), 67–89. Retrieved from http://repository.ied.edu.hk/dspace/handle/2260.2/6105

Graddol, D. (2006). *English Next*. *2006*. Retrieved from www.britishcouncil.org/learning-research

Halliday, M. A. K., & Martin, J. R. (1993). Writing science literacy and discursive power. London: London : Falmer Press, 1993.

Halliday, M. A. K., & Matthiessen, C. M. I. M. (2004). *An Introduction to Functional Grammar* (3rd ed.). Routledge.

Hamid, M. O., Nguyen, H. T. M., Baldauf Jr., R. B., & Baldauf, R. B. (2013). Medium of instruction in Asia: context, processes and outcomes. *Current Issues in Language Planning*, *14*(1), 1–15. http://doi.org/10.1080/14664208.2013.792130

Hoare, P. (2003). *Effective teaching of science through English in Hong Kong secondary schools*. *Dissertation Abstracts International, A: The Humanities and Social Sciences*. University of Hong Kong (Hong Kong). Retrieved from http://hdl.handle.net/10722/39139%5Cnhttp://medcontent.metapress.com/openurl.asp?genre=article&id=doi:10.1024/0301-1526.32.1.54

Hou, A. Y. C., Morse, R., Chiang, C.-L., & Chen, H.-J. (2013). Challenges to quality of English medium instruction degree programs in Taiwanese universities and the role of local accreditors: a perspective of non-English-speaking Asian country. *Asia Pacific Education Review*, *14*(3), 359–370. http://doi.org/10.1007/s12564-013-9267-8

Hu, G. (2009). The craze for English-medium education in China: driving forces and looming consequences. *English Today*, *25*(4), 47. http://doi.org/10.1017/S0266078409990472

Hu, G., Li, L., & Lei, J. (2014). English-medium instruction at a Chinese University: Rhetoric and reality. *Language Policy*, *13*(1), 21–40.

http://doi.org/10.1007/s10993-013-9298-3

Huang, J. & Normandia, B. (2008). Comprehending and solving word problems in mathematics: Beyond key words. In *Z. Fang & M.J. Schleppegrell (Eds.), Reading in Secondary content areas: A language-based pedagogy* (pp. 66–83). Ann Arbor, MI: University of Michigan Press.

Jäppinen, A.-K. (2005). Thinking and Content Learning of Mathematics and Science as Cognitional Development in Content and Language Integrated Learning (CLIL): Teaching Through a Foreign Language in Finland. *Language and Education*, *19*(2), 147–168. http://doi.org/10.1080/09500780508668671

Jiang, L., Zhang, L. J., & May, S. (2016). Implementing English-medium instruction (EMI) in China: teachers' practices and perceptions, and students' learning motivation and needs *. *International Journal of Bilingual Education and Bilingualism*, *0*(0), 1–13. http://doi.org/10.1080/13670050.2016.1231166

Johnson, R. K., & Swain, M. (1994). From core to content: Bridging the L2 proficiency gap in late immersion. *Language and Education*, *8*(4), 211-229.

Kaiser, H. F. (1970). A second generation little jiffy. *Psychometrika*, 35(4), 401-415.

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31-36.

Kim, K.R. (2011). Korean Professor and Student Perceptions of the Efficacy of English-Medium Instruction, *28*(3), *Linguistic Research*, *28*(3), 711–741.

Kim, S. K., & Sohn, S. Y. (2009). Expert system to evaluate English medium instruction in Korean Universities. *Expert Systems with Applications*, *36*(9), 11626–11632. http://doi.org/10.1016/j.eswa.2009.03.026

Kington, A., Sammons, P., Day, C., & Regan, E. (2011). Stories and Statistics: Describing a Mixed Methods Study of Effective Classroom Practice. *Journal of Mixed Methods Research*, *5*(2), 103–125. http://doi.org/10.1177/1558689810396092

Kirkpatrick, A. (2011). English as a medium of instruction in Asian education (from primary to tertiary): Implications for local languages and local scholarship. In *Applied Linguistics Review 2,* pp. 99–120.

Kirkpatrick, A. (2014a). English as a Medium of Instruction in East and Southeast Asian Universities. In N. Murray & A. Scarino (Eds.), *Dynamic Ecologies A Relational Perspective on Languages Education in the Asia-Pacific Region* (Vol. 9, pp. 15–24). Dordrecht: Springer Netherlands. http://doi.org/10.1007/978-94-007-7972-3

Kirkpatrick, A. (2014b). The language(s) of HE: EMI and/or ELF and/or multilingualism. *The Asian Journal of Applied Linguistics*, *1*(1), 4–15.

Kong, S., & Hoare, P. (2012). The Development of Academic Language Proficiency: Challenges for Middle School Immersion in Hong Kong and Xi'an. *International Education*, *41*(2), 88–109. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ978705&site=ehost-live

Krashen, S. D. (2009). *Principles and practice in second language acquisition*. *The Modern Language Journal* (Vol. 67). http://doi.org/10.2307/328293

Kwan, K.M. (1989). *An Evaluation of Students' Language Difficulties in Using History and Integrated Science Materials in Form 1 in an Anglo-Chinese Secondary School*. University of Hong Kong. Retrieved from http://hdl.handle.net/10722/51354

Lasagabaster, D., & Sierra, J. M. (2009). Immersion and CLIL in English: more differences than similarities. *ELT Journal*, *64*(4), 367–375. http://doi.org/10.1093/elt/ccp082

Lavankura, P. (2013). Internationalizing Higher Education in Thailand: Government and University Responses. *Journal of Studies in International Education*, *17*(5), 663–676. http://doi.org/10.1177/1028315313478193

Lemke, J. L. (1990). *Talking science: language, learning and values*. Norwood, New Jersey: Ablex Publishing Corporation.

Li, N., Leung, D. Y. P., & Kember, D. (2001). Medium of instruction in Hong Kong universities: the mis-match between espoused theory and theory in use. *Higher Education Policy*, *14*(4), 293–312. http://doi.org/10.1016/S0952-8733(01)00021-6

Lin, A.M., (2006). Beyond Linguistic Purism in Language-in-education Policy and Practice: Exploring Bilingual Pedagogies in a Hong Kong Science Classroom. *Language and Education*, *20*(4), 287–305. http://doi.org/10.2167/le643.0

Lin, A. M., (1997). Analyzing the 'language problem' discourses in Hong Kong: How official, academic, and media discourses construct and perpetuate dominant models of language, learning, and education. *Journal of Pragmatics*, *28*(4), 427–440. http://doi.org/10.1016/S0378-2166(97)00031-3

Lin, M.Y. and Man, Y.F. (2011). The context and development of language policy and knowledge production in universities in Hong Kong. The context and development of language policy and knowledge production in universities in Hong Kong. In Davis, KA (Ed.), *Critical Qualitative Research in Secffond Language Studies: Agency and Advocacy*, p. 99-113. Greenwich,

CN: Information Age Publishing, 2011

Lin, A. M., & Wu, Y. (2015). 'May I speak Cantonese?'–Co-constructing a scientific proof in an EFL junior secondary science classroom. *International Journal of Bilingual Education and Bilingualism*, *18*(3), 289-305.

Lin, L. H. F., & Morrison, B. (2010). The impact of the medium of instruction in Hong Kong secondary schools on tertiary students' vocabulary. *Journal of English for Academic Purposes*, *9*(4), 255–266. http://doi.org/10.1016/j.jeap.2010.09.002

Ljosland, R. (2011). English as an Academic Lingua Franca: Language policies and multilingual practices in a Norwegian university. *Journal of Pragmatics*, *43*(4), 991–1004. http://doi.org/10.1016/j.pragma.2010.08.007

Llinares, A., Morton, T., & Whittaker, R. (2012). *The roles of language in CLIL*. Cambridge University Press.

Llurda, E. (2012). *English-Medium Instruction at Universities: Global Challenges*. (A. Doiz, D. Lasagabaster, & J. M. Sierra, Eds.)*ELT Journal* (Vol. 67). Multilingual Matters. http://doi.org/10.1093/elt/cct045

Lo, Y.Y. (2010). What happens to classroom interaction patterns and teachers' code-switching behaviour when the medium of instruction changes?: an exploratory study in Hong Kong secondary schools. Unpublished DPhil dissertation. University of Oxford.

Lo, Y. Y. (2015). A glimpse into the effectiveness of L2-content cross-curricular collaboration in content-based instruction programmes. *International Journal of Bilingual Education and Bilingualism*, *18*(4), 443-462.

Lo, Y. Y. (2014). L2 learning opportunities in different academic subjects in content-based instruction – evidence in favour of 'conventional wisdom.' *Language and Education*, *28*(2), 141–160. http://doi.org/10.1080/09500782.2013.786086

Lo, Y. Y., & Lo, E. S. C. (2014). A Meta-Analysis of the Effectiveness of English-Medium Education in Hong Kong. *Review of Educational Research*, *84*(1), 47–73. http://doi.org/10.3102/0034654313499615

Lo, Y. Y., & Macaro, E. (2012). The medium of instruction and classroom interaction: evidence from Hong Kong secondary schools. *International Journal of Bilingual Education and Bilingualism*, *15*(1), 29–52. http://doi.org/10.1080/13670050.2011.588307

Lo, Y. Y., & Macaro, E. (2015). Getting used to content and language integrated learning: what can classroom interaction reveal? *The Language Learning Journal*, *43*(3), 239–255. http://doi.org/10.1080/09571736.2015.1053281

Long, M. H. (1983). Native speaker/non-native speaker conversation and the negotiation of comprehensible input. *Applied Linguistics*, *4*(2), 126–141.

Lorenzo, F. (2013). Genre-based curricula: multilingual academic literacy in content and language integrated learning. *International Journal of Bilingual Education and Bilingualism*, *16*(3), 375–388. http://doi.org/10.1080/13670050.2013.777391

Macaro, E. (2001). Analysing student teachers` codeswitching in foreign language classrooms: theories and decision making. *The Modern Language Journal*, *85*(4), 531–548. http://doi.org/10.1111/0026-7902.00124

Macaro, E., & Mutton, T. (2002). Developing language teachers through a co-researcher model. *The Language Learning Journal*, *25*(1), 27–39. http://doi.org/10.1080/09571730285200071

Mak, S. Y., Yip, D. Y., & Chung, C. M. (1999). Alternative Conceptions in Biology-Related Topics of Integrated Science Teachers and Implications for Teacher Education. *Journal of Science Education and Technology*, *8*(2), 161–169. Retrieved from http://www.jstor.org/stable/40188526

Marsh, H.W., Hau, K.T., Kong, C. K. (2000). Late immersion and languag e of instruction in HK high schools-achievement Growth in Language and Nonlanguage subjects. *Havarvd Educational Review*, *70*(3), 302–346.

Marsh, H. W., Hau, K.-T., & Kong, C.-K. (2002). Multilevel Causal Ordering of Academic Self-Concept and Achievement: Influence of Language of Instruction (English Compared With Chinese) for Hong Kong Students. *American Educational Research Journal*, *39*(3), 727–763. http://doi.org/10.3102/00028312039003727

Marsh, H. W., & Yeung, A. S. (1997). Causal effects of academic self-concept on academic achievement: Structural equation models of longitudinal data. *Journal of Educational Psychology*, *89*(1), 41–54. http://doi.org/10.1037/0022-0663.89.1.41

Martin, J. R., & Rose, D. (2008). *Genre Relations: Mapping Culture*. Equinox Publishing Ltd.

Martin, J. R., & Veel, R. (1998). Reading science critical and functional perspectives on discourses of science. London: London.

Matthiessen, C., Teruya, K., & Lam, M. (2010). *Key terms in systemic functional linguistics*. London: Continuum International Publishing Group.

Mazak, C. M. (2016). Introduction: Theorising translanguaging practices in higher education. In Mazak, C. M., & Carroll, K. S. (Eds.). *Translanguaging in higher education: Beyond monolingual ideologies (Vol. 104). Multilingual Matters.*, 1-10.

Mehan, H. (1979). *Learning Lessons: Social Organisation in the Classroom.* Cambridge.: Harvard University Press.

Mercer, N. (2004). Sociocultural Discourse Analysis: Analysing Classroom Talk as a Social Mode of Thinking. *Journal of Applied Linguistics*, *1*(2), 137–168. http://doi.org/10.1558/japl.2004.1.2.137

Mercer, N. (2010). The analysis of classroom talk: methods and methodologies. *The British Journal of Educational Psychology*, *80*(Pt 1), 1–14. http://doi.org/10.1348/000709909X479853

Mills, A. J., Eurepos, G., & Wiebe, E. (2010). *Encyclopedia of Case Study Research:... Encyclopedia of Case Study Research*. Retrieved from http://books.google.com/books?hl=en&lr=&id=WaY0OAuNIXQC&oi=fnd&pg=PA519&dq=Encyclopedia+of+Case+Study+Research&ots=6ybbOOlVtp&sig=FOmFoLM27y06TbLUpgmi6gXY_EU

Mohd. Saat, R., & Othman, J. (2010). Meeting linguistic challenges in the science classroom: pre-service ESL teachers' strategies. *Asia Pacific Journal of Education*, *30*(2), 185–197. http://doi.org/10.1080/02188791003721937

Mortimer, E., & Scott, P. (2003). *Meaning Making in Secondary Science Classrooms*. Berkshire: England: Open University Press.

Myers-Scotton, C. (1988). Code-switching as indexical of social negotiations. In H. Heller (Ed.), *Code-switching: Anthropological and Sociolinguistic Perspectives* (pp. 151–186). Berlin: Mouton de Gruyter.

Othman, J., & Mohd. Saat, R. (2009). Challenges of Using English as a Medium of Instruction: Pre-service Science Teachers' Perspective. *The Asia-Pacific Education Researcher*, *18*(2), 307–316.

Pakir, A. (2004). Medium-of-Instruction Policy in Singapore. In *Tollefson, J.W. & Tsui, A.B.M. (2004) (eds) Medium of Instruction Policies: Which Agenda? Whose Agenda?* (pp. 117–134).

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health Services Research*, *34*, 1189–1208.

Poon, A. Y. K. (2004). Language policy of Hong Kong : Its impact on language education and language use in post-handover Hong Kong. *Journal of Taiwan Normal University*, *49*(1), 53–74.

Poon, A. Y. K. (2009). in the Past 25 Years : Reflections and the Way Forward. *Educational Research Journal*, *24*(1), 7–40.

Poon, A. Y. K. (2010). Language use, and language policy and planning in Hong Kong. *Current Issues in Language Planning*, *11*(1), 1–66. http://doi.org/10.1080/14664201003682327

Poon, A. Y. K. (2013). Will the New Fine-Tuning Medium-of-Instruction Policy Alleviate the Threats of Dominance of English-Medium Instruction in Hong Kong? *Current Issues in Language Planning*, *14*(1), 34–51. http://doi.org/10.1080/14664208.2013.791223

Poon, A. Y. K., Lau, C. M. Y., & Chu, D. H. W. (2013). Impact of the Fine-Tuning Medium-of-Instruction Policy on Learning : Some Preliminary Findings. *Literacy Information and Computer Education Journal (LICEJ)*, *4*(1), 946–954.

Probyn, M. (2001). Teachers Voices: Teachers Reflections on Learning and Teaching through the Medium of English as an Additional Language in South Africa. *International Journal of Bilingual Education and Bilingualism*, *4*(4), 249–266. http://doi.org/10.1080/13670050108667731

Probyn, M. (2006). Language and Learning Science in South Africa. *Language and Education*, *20*(5), 391–414. http://doi.org/10.2167/le554.0

Probyn, M. (2009). 'Smuggling the vernacular into the classroom': conflicts and tensions in classroom codeswitching in township/rural schools in South Africa. *International Journal of Bilingual Education and Bilingualism*, *12*(2), 123–136. http://doi.org/10.1080/13670050802153137

Prophet, R. B., & Badede, N. B. (2007). Language and Student Performance in Junior Secondary Science Examinations: The Case of Second Language Learners in Botswana. *International Journal of Science and Mathematics Education*, *7*(2), 235–251. http://doi.org/10.1007/s10763-006-9058-3

Robson, C. (2002). *Real World Research: a Resource for Social Scientists and Practitioner-Researchers*.(2nd ed.). Oxford: Blackwell.

Rose, D., & Martin, J. R. (2012). *Learning to write, reading to learn: Genre, knowledge and pedagogy in the Sydney School*. Equinox.

Rollnick, M., & Rutherford, M. (1996). The use of mother tongue and English in the learning and expression of science concepts: a classroom-based study. *International Journal of Science Education*, *18*(1), 91–103. http://doi.org/10.1080/0950069960180108

Schleppegrell, M. J. (2004). The language of schooling a functional linguistics perspective. Mahwah, N.J.: Mahwah, N.J. : Lawrence Erlbaum, c2004.

Scott, P. (1997). *Developing science concepts in secondary classrooms: an analysis of pedagogical interactions from a Vygotskian perspective*. University of Leeds.

Seedhouse, P. (2004). Conversation analysis methodology. *Language Learning*, *54*(S1), 1–55. http://doi.org/10.1111/j.1467-9922.2004.00268.x

Sert, N. (2008). The language of instruction dilemma in the Turkish context. *System*, *36*(2), 156–171. http://doi.org/10.1016/j.system.2007.11.006

Sinclair, J. and Coulthard, M. (1975). *Towards an Analysis of Discourse*. Oxford: Oxford University Press.

Studer, P. (2014). Coping with English: students' perceptions of their teachers' linguistic competence in undergraduate science teaching. *International Journal of Applied Linguistics*, n/a-n/a. http://doi.org/10.1111/ijal.12062

Swain, M. (1995). Three functions of output in second language learning. *Principle and practice in applied linguistics: Studies in honour of HG Widdowson*, *2*(3), 125-144.

Swain, M. (2009). Languaging, agency and collaboration in advanced second language proficiency. In A*dvanced language learning: The contribution of Halliday and Vygotsky*, pp.95-108.

Swain, M. (2000). The output hypothesis and beyond: Mediating acquisition through collaborative dialogue. *Sociocultural theory and second language learning*, *97*, 114.

Swain, M., & Johnson, R. K. (1997). Immersion education: A category within bilingual education. In *Immersion education : international perspectives* (pp. 1–16).

Swain, M., & Lapkin, S. (2002). Talking it through: Two French immersion learners' response to reformulation. *International Journal of Educational Research*, *37*(3), 285–304.

Tamtam, a. G., Gallagher, F., Olabi, a. G., & Naher, S. (2012). A Comparative Study of the Implementation of EMI in Europe, Asia and Africa. *Procedia - Social and Behavioral Sciences*, *47*, 1417–1425. http://doi.org/10.1016/j.sbspro.2012.06.836

Tan, M. (2011). Mathematics and science teachers' beliefs and practices regarding the teaching of language in content learning. *Language Teaching Research*. http://doi.org/10.1177/1362168811401153

Tatzl, D. (2011). English-medium masters' programmes at an Austrian university of applied sciences: Attitudes, experiences and challenges. *Journal of English for Academic Purposes*, *10*(4), 252–270. http://doi.org/10.1016/j.jeap.2011.08.003

Thøgersen, J., & Airey, J. (2011). Lecturing undergraduate science in Danish and in English: A comparison of speaking rate and rhetorical style. *English for Specific Purposes*, *30*(3), 209–221. http://doi.org/10.1016/j.esp.2011.01.002

Tsui, A. B. M. (1985). Analysing input and interaction in second language classrooms. *RELC Journal*, 16(*1)*, 8–32.

Tsui, A. B. M. (2004). Medium of Instruction in Hong Kong: One Country, Two

Systems, Whose Language? In *Tollefson, J.W. & Tsui, A.B.M. (2004) (eds) Medium of Instruction Policies: Which Agenda? Whose Agenda?* (pp. 97–116).

Tsui, A. B. M. (2007). Language policy and the construction of identify: the case of Hong Kong. In *Tsui, & J.W. Tollefson (Eds.) Language policy, culture, and identity in Asian context* (pp. 121–141).

Tung, P., Lam, R., & Tsang, W. K. (1997). English as a medium of instruction in post- 1997 Hong Kong: What students , teachers , and parents think. *Journal of Pragmatics*, *28*, 441–459.

Vu, N. T. T., & Burns, A. (2014). English as a Medium of Instruction: Challenges for Vietnamese Tertiary Lecturers. *The Journal of Asia TEFL*, *11*(3), 1–31.

Walker, E. (2010). Evaluation of a Support Intervention for Senior Secondary School English Immersion. *System: An International Journal of Educational Technology and Applied Linguistics*, *38*(1), 50–62. http://doi.org/10.1016/j.system.2009.12.005

Wannagat, U. (2007). Learning through L2 – Content and Language Integrated Learning (CLIL) and English as Medium of Instruction (EMI). *International Journal of Bilingual Education and Bilingualism*, *10*(5), 663–682. http://doi.org/10.2167/beb465.0

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology*, 54(6), 1063.

Wellington, J., & Osborne, J. (2001). *Language and Literacy in Science Education*. Philadelphia: USA: Open University Press.

Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. *Systems thinker* (Vol. 9). Cambridge: UK: Cambridge University Press. http://doi.org/10.2277/0521663636

Wilkins, J. M. (2004). Maematics and Science Self- Concept : An International Investigation. *The Journal of Experimental Education*, *72*(4), 331–346.

Wong, K. H. (2012). *Implementation of problem-based learning in junior secondary science curriculum*. University of Hong Kong. Retrieved from http://hdl.handle.net/10722/193087

Yip, D. Y. (1999). Implications of students' questions for science teaching. *School Science Review*, *81*(294), 49–53.

Yip, D. Y. (2001). Promoting the development of a conceptual change model of science instruction in prospective secondary biology teachers. *International Journal of Science Education*, *23*(7), 755–770. http://doi.org/10.1080/09500690010016067

Yip, D. Y. (2003). *The Effects of the Medium of Instruction on Science Learning of Hong Kong Secondary Students*. Doctoral dissertation: University of Nottingham.

Yip, D. Y. (2004). Questioning skills for conceptual change in science instruction. *Journal of Biological Education*, *38*(2), 76–83. http://doi.org/10.1080/00219266.2004.9655905

Yip, D. Y., Coyle, D., & Tsang, W.-K. (2007a). Evaluation of the Effects of the Medium of Instruction on Science Learning of Hong Kong Secondary Students: Instructional Activities in Science Lessons. *Education Journal*, *35*(2), 77–107.

Yip, D. Y., Coyle, D., & Tsang, W. K. (2007b). Medium of Instruction on Science Students : Instructional Activities in Science Lessons. *Education Journal*, *35*(2), 77–107.

Yip, D. Y., & Tsang, W. K. (2007). Evaluation of the Effects of the Medium of Instruction on Science Learning of Hong Kong Secondary Students: Students' Self-Concept in Science. *International Journal of Science and Mathematics Education*, *5*(3), 393–413. http://doi.org/10.1007/s10763-006-9043-x

Yip, D. Y., Tsang, W. K., & Cheung, S. P. (2003). Evaluation of the Effects of Medium of Instruction on the Science Learning of Hong Kong Secondary Students: Performance on the Science Achievement Test. *Bilingual Research Journal*, *27*(2), 295–331. http://doi.org/10.1080/15235882.2003.10162808

Yu, R. D. (2002). Integrating Language and Content: How Three Biology Teachers Work with Non-English Speaking Students. *International Journal of Bilingual Education and Bilingualism*, *5*(1), 40–57. http://doi.org/10.1080/13670050208667745

Zhao, T., & Macaro, E. (2014). What works better for the learning of concrete and abstract words: teachers' L1 use or L2-only explanations? *International Journal of Applied Linguistics*, *26*(1), 75-98. http://doi.org/10.1111/ijal.12080 ■

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Appendix A
The chosen analytical frameworks

a) Classroom discourse model (Sinclair, J. and Coulthard, 1975)

The primary goal of this study is to compare the classroom interactions between different groups of science classrooms in both the late and the very late EMI secondary school. To achieve this goal, several analytical frameworks or descriptive classroom discourse models have to be used for comparison which will yield meaningful data on the types and frequency of interaction patterns in the observed lessons. According to a review by Mercer on different methods and methodologies used in the analysis of classroom talk (2010), a number of analytical frameworks have been suggested for unpacking the classroom interaction, including the Sinclair & Coulthard discourse analysis model (1975), Causal Conversation analysis, using a functional systemic linguistics approach[1] (Eggins & Slade, 1997); Seedhouse's Conversation Analysis (Seedhouse, 2004).

Some specific models have been proposed by different fields of researchers when examining a range of classroom talks. For example, the Mercer's (2004) model aims to understand how classroom talk is used for the joint construction of knowledge, tackling problems collaboratively and discussing how they construct contextual foundation of their talks. In this model, three archetypical forms of talk are identified: 'disputational' talk, cumulative talk and exploratory talk[2]'

[1] The functional linguistic approach considers how the special educational functions of classroom language relate to its grammatical structure and its textual organization (for example, Gibbons, 1998)

[2] 'Disputational (disagreement and individualised decision making), cumulative (when speakers construct positively but uncritically a common knowledge of what others have said through repetitions,

The seminal work by Sinclair & Coulthard (1975) has influenced many later investigations of classroom discourse, because this model showed in the teacher-centred lessons that the language had characteristics, which marked it as a distinct, situated language variety, and one which assigned particular roles to speakers. Under this model, the classroom talk in a lesson is categorised in a hierarchical system of 'act, moves, exchange, and transaction' and the basic unit of teacher-student talk is identified as 'IRF exchange', where a teacher initiates an interaction by asking a question, the student responds by providing an answer, and the teacher further follows up or provides feedback to the student's answer. The exchange sequence is not always followed by a feedback, in which a teacher can provide an evaluation of the student's answer. In Mehan's (1979) model, the normal sequence is IRE, where 'E' means evaluation. The pattern of IRF/E continue to be the focus of investigation in much classroom research and many researchers have explored variations on this pattern or different ways of enhancing teaching and learning quality (Mercer, 2010).

Pedagogical functions of the observed interaction **(Tsui, 1985)**

In this study, we also use Tsui's framework of further describing and explaining the structural organisations and patterns of turn-taking in classroom talk at three levels: speaker, pattern of interaction and pedagogical functions, building on Sinclair & Coulthard's model (1975) and others (Barnes, 1969; Flander, 1970). Under this framework, each utterance in classroom talk can be first identified as either teacher or student. Secondly, the utterance is then categorised in initiation, responses, feedbacks or evaluation. Thirdly, all the identified utterances are classified in seventeen acts according to their

---

conformation, elaborations) and exploratory (where partners offer statements and suggestions for a joint consideration)

pedagogical functions. The seventeen acts are derived from the Sinclair & Coulthard's model with some acts eliminated from the Tsui data .

The seventeen categories by Tsui provide a series of subsequent classifications of each utterance in classroom interaction by looking into different types of initiation and response provided by the teacher, as well as those by students, in a second-language classroom. The Seventeen-Category System for coding the functions of teacher and student talk: Inform, factual questions, accept, direct, students' response, restating-elicit, comment, read aloud.....etc. (Tsui, 1985:11). Table 1 summarises the seventeen-category system for analysing the acts in teacher-student interactions based on the Sinclair and Coulthard's IRF model. See Table 1 for all the definitions and examples of the seventeen categories of the acts from Tsui's study (1985).

Table 1 The Seventeen-category system (after Tsui, 1985, p.11)

	IRF sequence	Acts	Sub-categorisations	
Teacher talk	Initiation (I)	1. Elicit	A. Display questions	i. Factual questions
				ii. Yes/No questions
				iii. Reasoning questions
				iv. Explanation questions
			B. Genuine questions	i. Opinion
				ii. Information
			C. Re-stating elicit	
		2. Direct		
		3. Nominate		
		4. Inform		
		5. Recapitulate		
		6. Frame		
		7. Starter		
		8. Check		
Student talk	Response (R)	9. Evaluate	a. Encouraging/positive	
		10. Accept	b. Negative	
		11. Comment		
		12. Clue		
	Response (R)	13. Reply	a. Restricted	
		14. Apologise	b. Expanded	
	Initiation (I)	15. Request		
		16. Elicit		
		17. Interrupt		

b) Teacher's feedback to students' response in science classroom

Chin (2006), in her analysis of teacher-student interaction in junior (Year 7) science classrooms in Singapore, has further extended the 'F' in the IRF sequence model by classifying different types of feedbacks that teachers give to students' responses. In Chin's view, teacher's feedbacks in the science classroom are distinctive moves in which they engage students in thinking

about the conceptual content which allows the construction of scientific knowledge.

There are four types of teacher's feedback in the follow-up or F-move of the IRF sequence identified in Chin's study. A teacher's follow-up or feedback (F) in the IRF sequence can be in the form of a comment or statement followed by either another question, or further statements that expound more scientific content.

Chin categorized these four major teacher's feedbacks into: a) affirmation-direct instruction (C-Q, C-S), b) extension by responsive questioning: Focusing and Zooming (C-Q), c) Explicit correction–Direct instruction (S-Q or S), and d) Constructive challenge (C-Q or Q). Each of these teacher's feedbacks has a predominant nature of exchange utterance. In other words, "comment–question" (C–Q) or "statement–question" (S–Q) couplet are where the question component of the couplet might be regarded as overlapping with the initiation or "I" move of the next IRF sequence. However, if no questions were asked, it took the form of a "comment–statement" (C–S) couplet. At times, feedback consisted of only comments (C) or statements (S). Table 2 summarizes these different types of teacher's feedbacks to students' responses, their definitions and coding. See Table 2 for further information on the worked-out example of Chin's analysis (2006) of different teacher's feedbacks and the conditions in which these feedbacks were used by teachers in facilitating science-teaching in Chin's study.

Nature of student's response	Type of feedback	Predominant nature of key utterances	Description
Correct	(a) Affirmation-Direct instruction	C-Q, C-S	Affirm and reinforce response followed by further exposition and direct instruction
Mixture of correct and incorrect	(b) Extension by responsive questioning: Focusing and Zooming	C-Q	Accept response followed by a series of related questions that build on previous ones to probe or extend conceptual thinking
Incorrect	(c) Explicit correction–Direct instruction	S-Q, S	Explicit correction followed by further expounding of the normative ideas
	(d) Constructive challenge	C-Q, Q	Evaluative or neutral comment followed by reformulation of the question or challenge via another question

Table 2 Types of feedback to student response in the 'F'move of the IRF exchange model in the science classroom (Chin, 2006: 1326)

Note: C, teacher comment; Q, teacher question; S, teacher statement.

c) Types of science classrooms (Mortimer & Scott, 2003)

The classroom interaction will be analysed based on the elements in the analytical framework proposed by Mortimer & Scott (2003) to capture and characterise different talks in the science classroom. In their framework, five components: teaching purposes, content, communicative approach, pattern of discourse, and teacher interventions can be considered when examining science-teaching interactions. Figure 1 summarises the framework and their relationships. While nearly all the components contribute to categorising the speech genre of the science classroom, the different types of spoken language used by teacher and students when communicating about science, the second component, the content of science matter is related to the school science social language. When students get the opportunity to use the language of learning by

engaging with subject-specific terminology, they get to learn through language by activating thinking processes to understand and apply the knowledge of science during the class. They are developing their instructional register in science (Llinares, Morton, & Whittaker, 2012, p. 34).

Figure 1 The analytical framework for analysing and planning science teaching interactions (Mortimer & Scott, 2003, p. 25)

	ASPECT OF ANALYSIS	
FOCUS	1.teaching purpose	2 content
APPROACH	3 communicative approach	
ACTION	4 pattern of discourse	5 teacher interventions

c1) Teaching purpose:

This component is about the purposes served in relation to the science being taught, at each phase of the observed lesson. 'What is the teacher trying to achieve in the lesson?' In many science classes, the teacher is mainly responsible for introducing and developing scientific ideas with the students. But very often, the teacher also helps students to talk through ideas on the social plane of the classroom, and works with the students those developing ideas, gradually allowing the students to take responsibility for their independent scientific investigation. Mortimer & Scott identified that there are six major teaching purposes in a science lesson based on their observations of high schools in both England and Brazil, as described in Table 3. These purposes are important in that are significant and substantive interactions between teachers and students are observed. Each purpose can be related to a particular phase of a lesson or a sequence of lessons.

	Teaching purpose	*Focus*
a	*Opening up the problem*	Engaging students intellectually, and emotionally, in the initial development of the scientific story.
b	*Exploring and working on students' views*	Probing students' views and understandings of specific ideas and phenomena.
c	*Introducing and developing the scientific story*	Making the scientific meanings (including conceptual, epistemological, technological, social and environmental themes) available on the social plane of the classroom.
d	*Guiding students to work with scientific ideas and supporting internalisation*	Providing opportunities for students to talk and think with new scientific meanings, individually, in groups or in whole-class situations. At the same time, supporting students in making individual sense of, and internalizing, those meanings.
e	*Guiding students to apply, and expand on the use of, the scientific view, and handing over responsibility for its use*	Supporting students in applying taught scientific meanings in a range of contexts and handing over responsibility for using those meanings to the students.
f	*Maintaining the development of the scientific story*	Providing a commentary on the unfolding scientific story, to help students to follow its development and to see how it fits into the wider science curriculum.

Table 3 Teaching purposes (Mortimer & Scott, 2003, p. 29)

c2) Content:

The second component is related to the content of classroom interactions. According to Mortimer & Scott, many of the interactions between teacher and students are related to content matter, for examples, the scientific story being taught, the procedural account of doing science, and management and organisational issues in a classroom. Each of these aspects of content are important for a science lesson. But only the content related to the science subject matter is key for analysis, as this is highly related to the quality of how scientific story is being taught and how much science knowledge the students gain in the lessons.

Mortimer & Scott categorised three different dimensions when identifying the content of the classroom interactions in a science lesson.

Everyday-specific

→ *Description, explanation, generalisation*

→ *Empirical-theoretical*

The first, *everyday-specific,* serves as the general social language used by teacher or students to talk about science. The second dimension is related to the common types of the scientific social language that are fundamental when communicating about science. These are *description, explanation* and *generalisation.* Their specific descriptions are summarised in Table 4. Each of these can be further categorised either *empirically* or *theoretically* based on the third dimension. For example, an empirical description provides an account of the phenomenon in terms of observable features. (i.e. salt dissolves in water). A theoretical description goes beyond the phenomena by referring to the theoretical entities that are not observable in the phenomena (i.e. sodium ions dissolve in water. It is characterised as empirical because the word 'ions' is used to create the theoretical discourse of science). These dimensions provide an important categorisation to understand the kind of knowledge, which the teacher and students are communicating at different phases of the observed lesson.

Description	Description involves statements that provide an account of a system, an object or a phenomenon in terms of its constituents, or the spatiotemporal displacements of those constituents. (it provides an account of the phenomenon in terms of observable features)
Explanation	Explanation involves importing some form of theoretical model or mechanism to account for a specific phenomenon. (it establishes relationships between physical phenomena and concepts, using some form of model or mechanism to account for a specific phenomenon.)
Generalisation	Generalisation involves making a description or explanation that is independent of any specific context (it goes beyond a description and an explanation in that it is not limited to a particular phenomenon but expresses a general property of scientific entities, matter or class of phenomena.)

Table 4 Definitions of the foundational features of the scientific social language (Mortimer & Scott, 2003, p. 30)

c3) Communicative approach

The third component is central to Mortimer & Scott's analytical framework, which pays attention to the ways in which the teacher guides the students in addressing different ideas developed in a lesson. In other words, it explores whether the teacher interacts frequently or has limited interactions with the students and whether or not the teacher takes account of students' developing ideas in the on-going lesson. In their framework, four fundamental types of communication approaches are defined in Table 5. Depending on the intensity and nature of the talk between teacher and student, each of these approaches can be further divided into two dimensions on a continuum, between dialogic and authoritative talk, and between interactive and non-authoritative talk. These categorisations of communication approach can inform how the teacher works with students in addressing ideas present in the class at different phases of an observed science lesson.

a. *'Dialogic'* means when attention is paid to more than one point of view and more than one voice is heard. In this science classroom, the teacher considers the student's point of view regardless of whether the ideas are scientifically related or not. More importantly, the teacher considers the student's view even if the responses are not related to the views of the teacher.
b. *'Authoritative'* means when attention is paid only to one point of view and only one type of voice is heard. In this science classroom, the teacher has no interest in exploring different ideas other than those in his or her own mind. The teacher tries to direct the student's attention to a particular aspect of science ideas or concepts and the students' unrelated ideas are often ignored.
c. *'Interactive'* means that the participation of other people is allowed. In this science classroom, the teacher actively engages and interacts with students in exploring science ideas. More than one point of view is represented and different ideas are explored and developed by groups of students.
d. *'non-interactive'* means that the participation of other people is limited. The teacher controls the talk. Only one point of view is presented and produced by an individual student who shares the same idea as that of the teacher.

Table 5 The four communicative approaches in Mortimer & Scott's framework

	Interactive	*Non-interactive*
Dialogic	A. Interactive-dialogic *Teacher listen to, take account of the student's point of view.* *Together with students, he/she explores different views , generates new meanings, asks real questions, works on different points of view on a science phenomena.*	B. Non-interactive-dialogic *Teacher considers different points of view, guiding students to explore, work on different views of a science phenomena without any turn-taking interactions with the students*
Authoritative	C. Interactive-authoritative *Teacher leads students through a great deal of interaction, by a sequence of questions and answers to achieve one specific view on a science phenomena*	D. Non-interactive-authoritative *Teacher presents only one specific view of a science phenomena without any interactions with students*

c4) Patterns of discourse:

The fourth component is the simple but distinctive patterns of interactions observed between teacher and students during classroom talk. Their talks are classified in two main types in the framework: a) IRF/ IRE pattern and b) Extended IRF pattern.

e. IRF (Initiation-Response-Feedback) or IRE (Initiation-Response-Evaluation)

In this pattern of interaction, the teacher first initiates the talk, normally through a question, and then a student responds. This is followed by either a teacher's evaluation of the student's answer or his or her feedback to the student.

f. Extended IRF or IRFRF (Initiation-Response- Feedback- Response-Feedback)

This extended chain of interaction pattern is when an elaborative feedback (F) from the teacher is followed by a further response from the student (R); in addition to a normal IRF sequence. In other words, the teacher provides feedback or elaboration on the student's answer, the student then further develops his or her own point of view and produces a second response. Comparing the two types of interaction patterns, the extended IRF offers more opportunities for teacher and student to interact. Lo & Macaro (2012) compared the IRF sequence between Arts and Science subject lessons. Their study found that the number of extended IRF sequences observed in science classrooms is relatively lower than those in arts classes. It can therefore be argued that lessons with a more extended IRF are more interactive than those consisting only of mainly simple IRF/ IRE patterns. In the analysis, the teacher-student interactions observed in both Grades 10 and 11 in the two types of school will be compared and analysed with reference to the two distinctive patterns of interaction identified by Mortimer & Scott.

c5) Teacher's intervention:

The fifth component is about what the teacher intervenes with in order to develop the scientific story and to make it accessible to all the students in the lesson. There are five typical teacher's interactions identified in the framework based on Scott's work (Scott, 1997). Table 6 illustrates the typical kinds of interactions made by the science teacher when introducing science phenomena.

Teacher intervention	Focus	Action the teacher might take
1.Shaping ideas	Working on ideas, developing the scientific story	Introduce a new term; paraphrase a student's response; differentiate between ideas
2.Selecting ideas		Focus attention on a particular student response; overlook a student response
3.Marking key ideas		Repeat an idea; ask a student to repeat an idea; enact a confirmatory exchange with a student; use a particular intonation of voice
4.Sharing ideas	Making ideas available to all the students in a class	Share individual student ideas with the whole class; ask a student to repeat an idea to the class; share group findings; ask students to prepare posters summarizing their views
5.Checking student understanding	Probing specific student meanings	Ask for clarification of student ideas; ask students to write down an explanation; check consensus in the class about certain ideas
6. Reviewing	Returning to and going over ideas	Summarize the findings from a particular experiment; recap on the activities of the previous lesson; review progress with the scientific story so far

Table 6 Teaching interventions (Mortimer & Scott, 2003, p. 45)

d) Science teacher's questioning style

One important aspect that shapes the teacher-student interaction is the teacher's questioning style. As discussed in the literature chapter (Chapter 2), the teacher's questioning skills play a major role in promoting a better understanding of science. A number of studies in CLIL context (Content-language integrated learning) explored the different types of questions used by CLIL teacher, and studied the relationship between teacher's questions and their pedagogical functions and goals in learning the subject content. For instances, (Dalton-Puffer, 2007, p. 98) identified five types of questions used by CLIL teachers. They are: 1) questions for facts (asking for objective happenings); 2) questions for explanation (asking for how something happened); 3) questions for opinion; 4) metacognitive questions (which engage the learner in extended

dialogues). Lo & Macaro (2012) built on Tsui's (1985) Seventeen-Category System for analysing interactions in second language classrooms and Mehan's work (1979) on the typology of classroom questions. They identified two major types of teacher's questions in Hong Kong MOI-switching schools. They are display questions and genuine questions. This general categorisation provides an overall picture of studying teacher's questions and identifying their functions and goals in a content lesson. However, this broad categorisation fails to determine what type of questions or what combinations of questions that leads to the understanding of science. It is necessary to have another typology of questions that categorises different types of science teacher's questions and distinguish their functions and goals in constructing science knowledge and comprehension of science phenomena.

Thus, I will use the broad categorisation (Table 19) when I first analyse the observation data in quantitative manner (Section 3.9.1.2). Then, when I analyse the observation data in qualitative manner (Section 3.9.1.3), I will use a specific categorisation of teacher's questions (Table 8) developed by researchers in science education when analysing science teacher's questions in Hong Kong classrooms.

A) Display Questions	**1) Yes/No Questions**	
	2) Alternative Questions	
	3) Wh-Questions	a) factual questions
		b) reasoning
		c) explanation of word meaning
B) Genuine Questions	1) Opinions	
	2) Information	

Table 7 Types of questions in the Seventeen-Category System (after Tsui, 1985, p.11)

Yip (2004) conducted a study to examine the kinds of questions teachers used in Hong Kong science classrooms. He observed 14 biology teachers and compared their questions. Ten types of question were identified. Yip provides a good framework for analysing the science teacher's questions in a Hong Kong science classroom. These questions are aimed at: 1) checking students' understanding of factual information and their ability to explain a science phenomenon (low order), 2) evaluating their higher cognitive skills (higher order); 3) investigating students' learning motivation and, 4) putting questions that lead to conceptual change in students' science knowledge. See Table 8 for a comprehensive review of the different types of question used by science teachers.

Yip's study revealed that science teachers in Hong Kong were skilful in questioning, but only used questions with lower cognitive demand that rarely promoting their students' higher-order thinking or creating a successful conceptual-change in science topics. These lower cognitive questions could not help reduce misconception or promote meaningful learning in science. The study also shows that teachers' questioning skills are essential to students' understanding of complex science ideas.

The quantitative analysis of the teacher's questioning skills can show the proportions of different types of question asked by the teachers and their pedagogical functions in a science classroom. In the analysis, the teacher's questioning technique in the observed lessons will be compared between the two types of school, and through this analysis, the differences in the quality of the science teacher's questioning skills in different classrooms can be found.

Type	Question types	Functions
Lower order	1-Recalling	Factual information
	2-Explanation	A phenomenon or process
Higher order	3-Analysis	Breaking down material into its components. This may involve comparing parts and identifying their relationships.
	4-Evaluation	Judging the value and implications of material.
	5-Synthesis	Relating existing concepts to construct a new idea or formulate a new pattern.
Motivation	6-Motivation	Focusing attention; establishing a set for a new topic.
Conceptual change	7-Eliciting	Preconceptions or alternative conceptions
	8-Challenging	Students to review and resolve inconsistent ideas.
	9-Extending	Guiding students to construct new ideas from existing knowledge
	10-Application	Using learned material in novel and concrete situations

Table 8 The nature of the questions asked by the science teacher (Yip, 2004, p. 78)

e) The choice of instructional languages, the proportions of L1 and L2 use

The language used by teachers and students in the observed lessons will be analysed based on two methods: Timed analysis and Turn analysis.

Timed analysis (Macaro, 2001)

The choice of instructional language observed in the classroom was analysed using the two approaches used for analysing code-switching patterns in previous studies. Firstly, Timed Analysis was done by sampling the interactions every five seconds and then the code according to the speaker and the language being spoken (Macaro, 2001). Table 9 shows an example of Timed analysis. This time-sampling method offers a direct and fast approach to analysing the languages spoken and provides a comprehensive view of the proportions of the teacher's talk and student's talk in L1 or L2 in a lesson.

	Lesson 1 (total time:___)		**Lesson 2 (total time:___)**	
	% of whole lesson	% of the interaction	% of whole lesson	% of the interaction
Total 1:30 interaction time				
Total non-interaction time				
Total teacher talk				
Total Teacher L2				
Total Teacher L1				
Total Student L2				
Total Student L1				
Total Video Recorder				
Pair Work				
Reading or Writing activity				

Table 9. An example of Timed Analysis (Macaro & Mutton, 2002).

Secondly, the mean length of each speaker's turn was calculated by using the Turn analysis (Macaro & Mutton, 2002). Unlike the Timed analysis, the Turn analysis can reveal the turn-taking behaviours between teacher and students, especially in the case where two lessons consist of the same proportion of teacher and student talks but share very different interactive patterns (i.e. one lesson has long talks but very few turns between teacher and students, while in another lesson where teacher and students interact more frequently). Turn analysis is supplementary to Timed analysis. In this approach, the distribution and allocation of talk between teacher and student in a lesson was calculated. Macaro, 2001). Table 10 shows an example of Turn analysis.

	Total length of sequence	Total & Mean length of teacher turns	Total & Mean length of student turns	Longest student turn	Number of student turns	Range of length of student turns
Sequence 1						
Sequence 2						

Table 10. An example of Turn Analysis (Macaro & Mutton, 2002).

f) The L1 use, code-switching patterns

For those segments in the above analysis that identified as L1, an additional analysis of the actual use of L1 will be further examined. The code-switching pattern between L1 and L2 will be explored according to the observed utterances by each speaker, and sub-categorised into 'intra-' or 'inter-sentential code-switching patterns (Myers-Scotton, 1988). The intra-sentential pattern means code switching occurs within a sentence, mixing two languages in a sentence. *(e.g. Our focus today is 中和作用 (neutralisation) that we briefly discussed yesterday).* The inter-sentential pattern refers to code-switches that happen in

between sentences, mixing L1 and L2 sentences *(e.g. Neutralisation is a chemical reaction in which an acid and a base react quantitatively with each other to form salts and water. 中和作用是指酸和鹼反應生成鹽和水的反應。)*

The code-switching patterns will be further coded, either 'intra' or 'inter-sentential' will be analysed with references to the following table 23, is derived from previous studies that examined the code-switching patterns in content-subject lessons (Lin, 2006; Lo & Macaro, 2012; Probyn, 2009). Each utterance of code-switches will be coded according to the table, and the results will inform whether there are any differences in the ways the teachers code-switched in the observed lessons in the two types of school.

g. The overall analytical frame

Based on the explained frameworks, here is the overall analytical frame adapting Mortimer & Scott's analytical framework for analysing science classrooms, in addition to other analyses for unpacking the emerging patterns and features of the observed science classrooms (See Table 11). In this analytical frame, specific attention is paid to the following aspects of analysis: 1) teaching purpose, 2) content, 3) communicative approach, 4) patterns of interaction, 5) functions, forms of interaction, 6) teaching interventions, 7) teacher's question types, 8) the choices of instructional languages, proportion of teacher and student talk, 9) distribution and allocation of teacher and student turns, and 10) code-switching patterns.

ASPECT OF ANALYSIS	
1. Teaching purposes ***(Mortimer & Scott, 2003)***	*a) Opening up the problem;* *b) Exploring and working on students' views; introducing and developing the scientific story;* *c) Guiding students to work with scientific ideas and supporting internalisation* *d) Guiding students to apply, and expand on the use of, the scientific view, and handing over responsibility for its use* *e) Maintaining the development of the scientific story*
2. Content ***(Mortimer & Scott, 2003)***	*a) Everyday-specific* *b) Description, explanation, generalisation* *c) Empirical-theoretical*
3.Communicative approach ***(Mortimer & Scott, 2003)***	*a) Interactive/ non-interactive* *b) Authoritative/ dialogic*
4. Patterns of interaction ***(Mortimer & Scott, 2003)***	*a) IRF vs extended IRF*
5a Forms of interaction	*a) IRF/E (Initiation-Response-Feedback/Evaluation)* *b) IRFRF (Initiation-Response- Feedback- Response- Feedback)*
5b Functions of interaction	Tsui (1985) The seventeen categories of acts in classifying second-language classroom talk Chin (2006) Taxonomy of teacher's feedbacks to students' responses in science classroom
6. Teaching interventions ***(Mortimer & Scott, 2003)***	*a) shaping ideas; b) selecting ideas; c) marking key ideas; d) sharing ideas; e) checking student understanding; f) reviewing*
7.Teacher's question types ***(Yip 2004)***	*1) Recalling; 2) Explanation; 3)Analysis; 4)Evaluation; 5)Synthesis; 6)Motivation; 7)Eliciting; 8)Challenging; 9)Extending; 10)Application*
8. The choice of instructional language (L1/L2), proportion of teacher/student talk	*Timed analysis (Macaro, 2001)---sampling the interactions every five seconds and then code according to speaker and the language being spoken*
9. The distribution and allocation of teacher/student turns	*Turn analysis (Macaro & Mutton, 2002)---calculating the mean length of each speaker's turn)*
10.Type of code-switching patterns; ***(Myers-Scotton, 1988)***	*a) Intra-sentential (within a sentence); b) Inter-sentential (between sentences)*

Table 11 The proposed coding frame for analysing the observation data

Appendix B

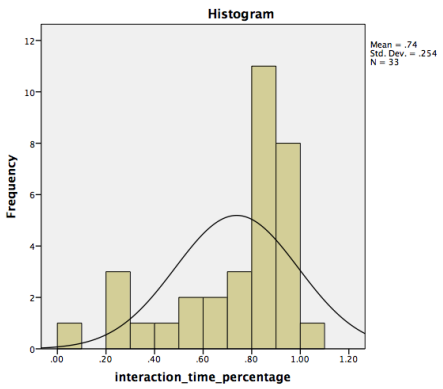
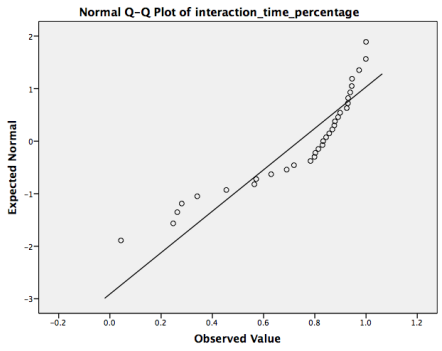
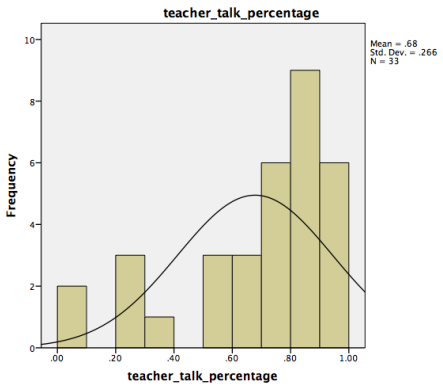
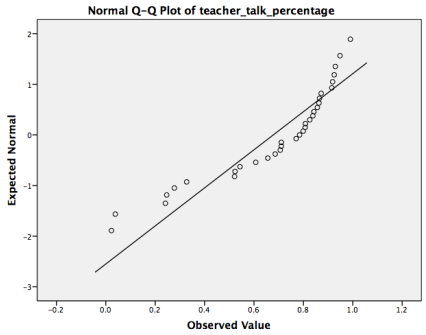
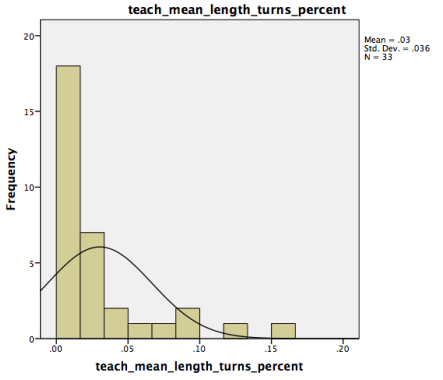
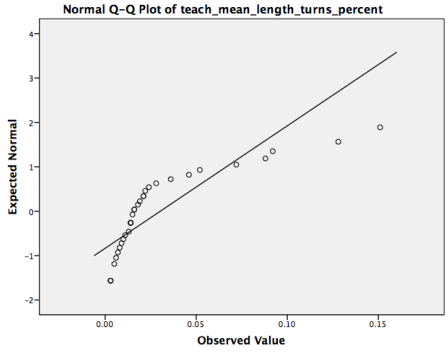
Checking normalities for the variables used in chapter 4 and 7

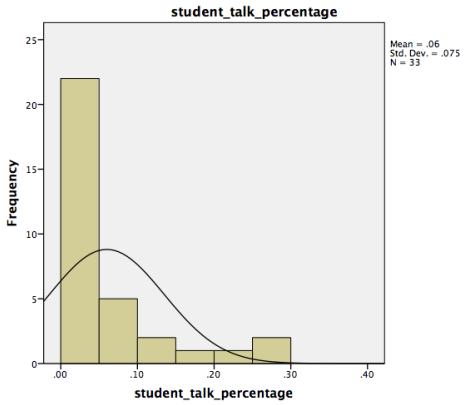
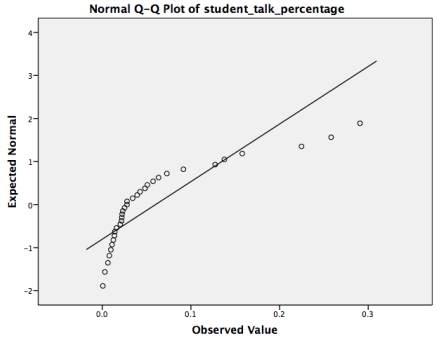
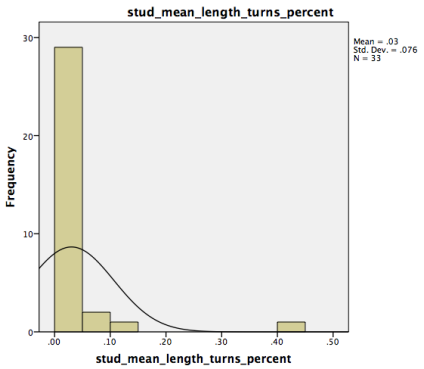
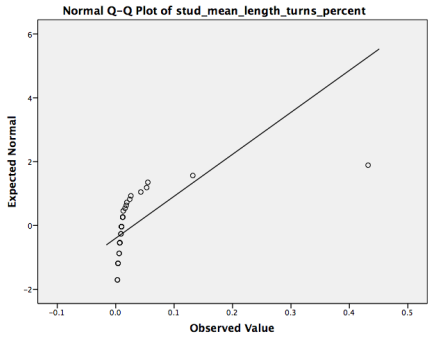
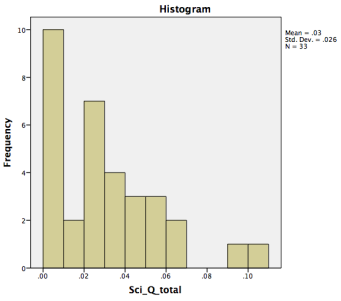
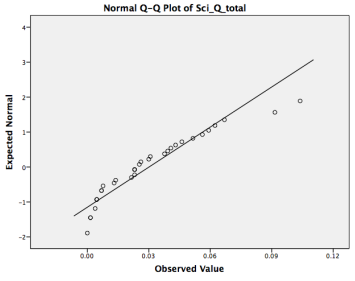
1. The following section is for the variables in chapter 4 which were about the classroom interactions.

The histograms, Q-Q plots, skewness and kurtosis values[3], Kolmogorov-Smirnov (K-S) test results of all the variables.

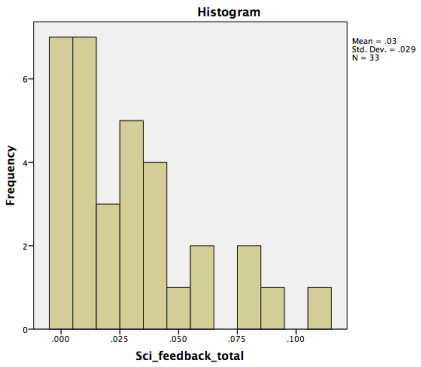
[3] The values for asymmetry and kurtosis between -2 and +2 are considered acceptable in order to prove normal univariate distribution (George & Mallery, 2010). George, D., & Mallery, M. (2010).

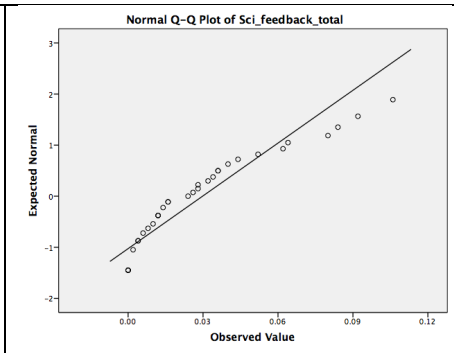
	Kolmogorov-Smirnov	Skewness		Kurtosis	
	Sig.	statistics	Std. Error.	statistics	Std. Error.
1.% of interaction time	p<.0001 (sig.)	-1.302	.409	.742	.798
2.% of teacher talk	.007	-1.186	.409	.478	.798
3.% of length in teacher turns	p<.0001 (sig.)	2.116	.409	4.045	.798
4.% of student talk	p<.0001 (sig.)	1.950	.409	3.139	.798
5.% of length in student turns	p<.0001 (sig.)	4.956	.409	26.118	.798
6. Science teacher questions (total)	.127(non-sig.)	1.092	.409	.976	.798
7. Science teacher feedback (total)	.019 (sig.)	1.138	.409	.527	.798
8. Teacher questions (total)	.097(non-sig.)	.854	.409	-.190	.798
9. pedagogical functions (total)	.030 (sig.)	.988	.409	.850	.798
10. Wait time	p<.0001 (sig.)	4.017	.409	19.147	.798
11.L1 use	.015 (sig.)	.154	.409	-1.350	.798
12. L2 use	.025 (sig.)	-.238	.409	-1.018	.798
13. inter-sentinel CS	.066 (non-sig.)	-.093	.409	-1.023	.798
14. intra-sentinel CS	.2 .(non-sig.)	-1.01	.409	-.650	.798

Histograms	Q-Q plots
1.% of interaction time	
	
2.% of teacher talk	
	
3.% of length in teacher turns	
	

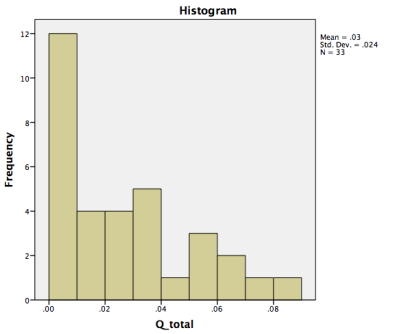
Histograms	Q-Q plots
4.% of student talk	
	
5.% of length in student turns	
	
6.Science teacher questions (total)	
	

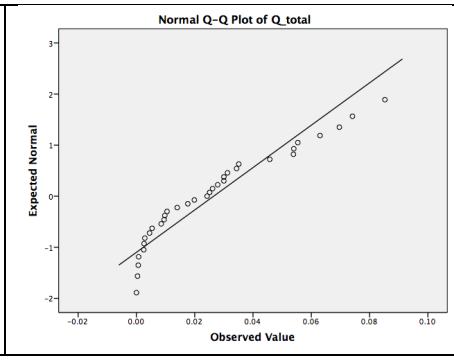
7.Science teacher feedback (total)



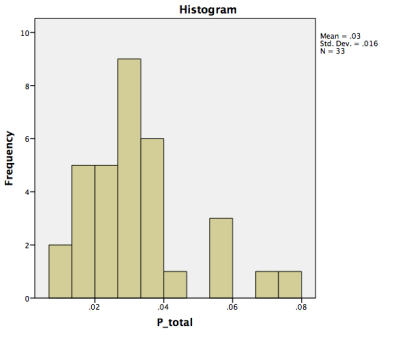


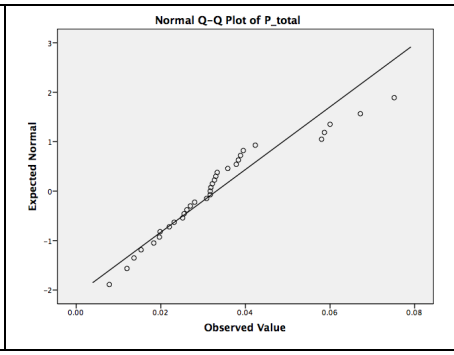
8.Teacher questions (total)



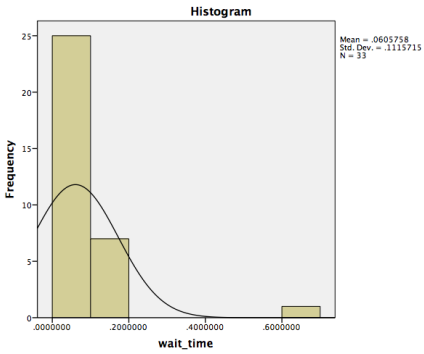


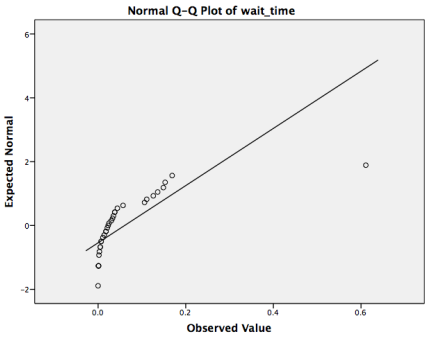
9. Pedagogical functions (total)



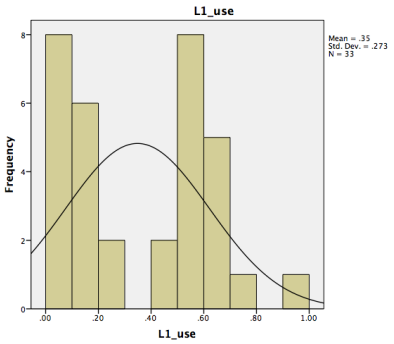


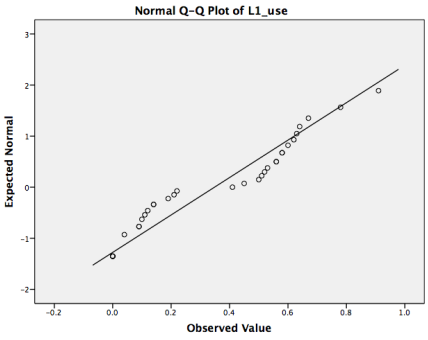
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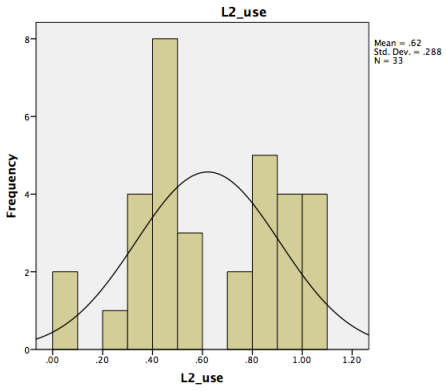


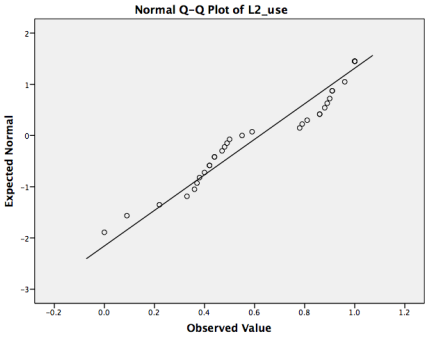
11.L1 use



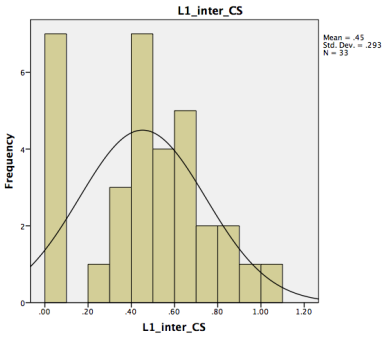


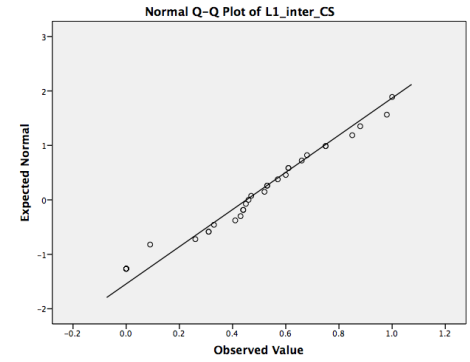
12.L2 use



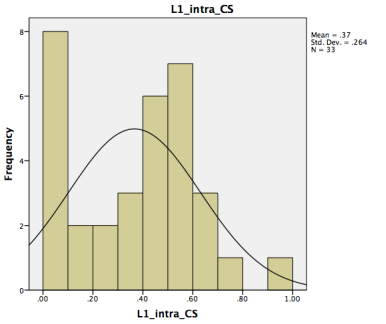


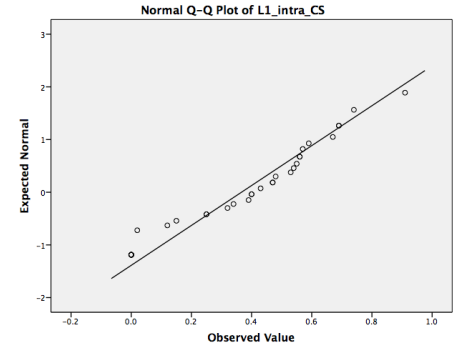
13.inter-sentinel CS



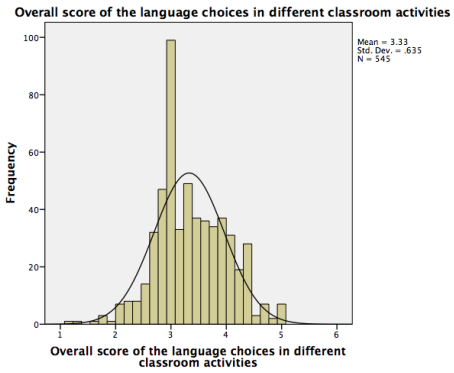
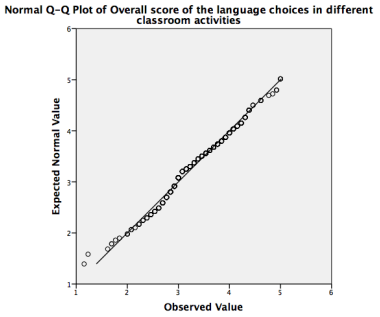
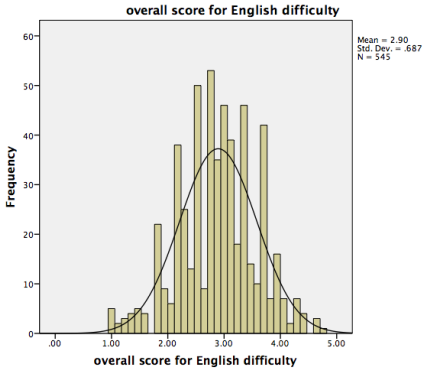
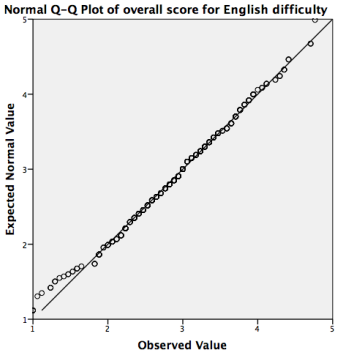


14.intra-sentinel CS

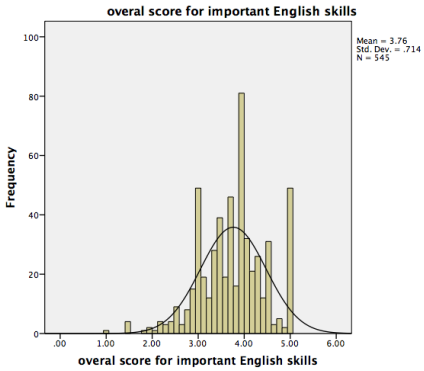
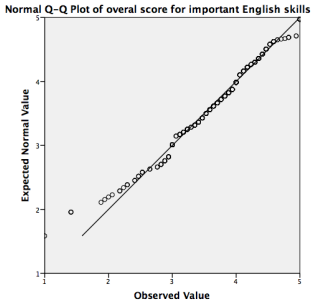
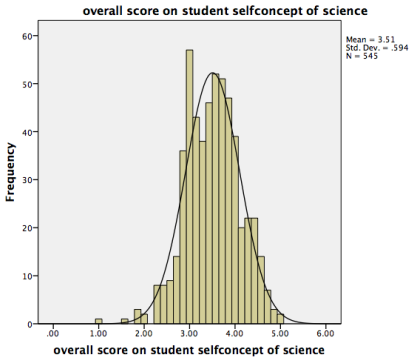
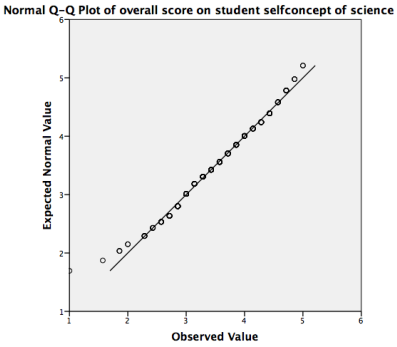
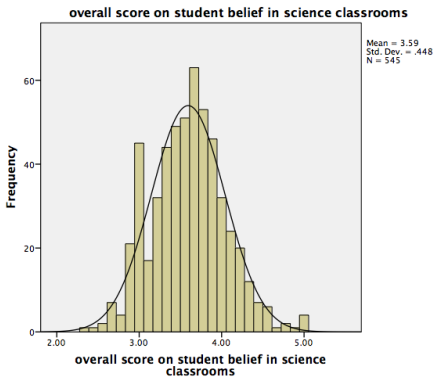
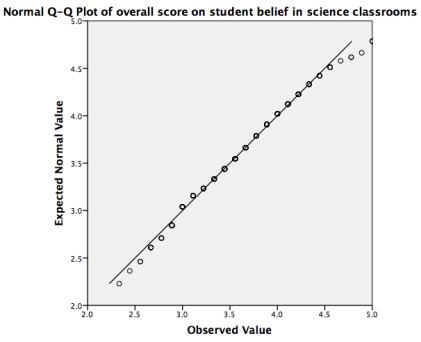


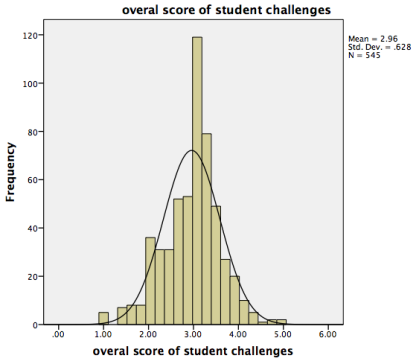
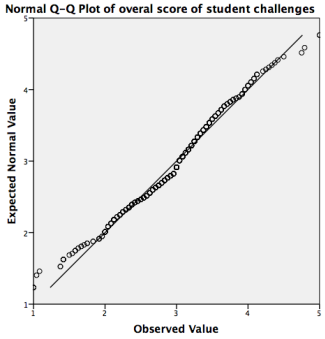
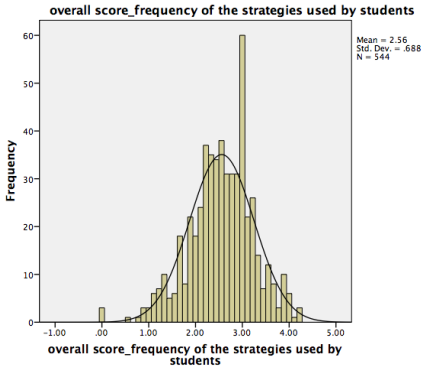
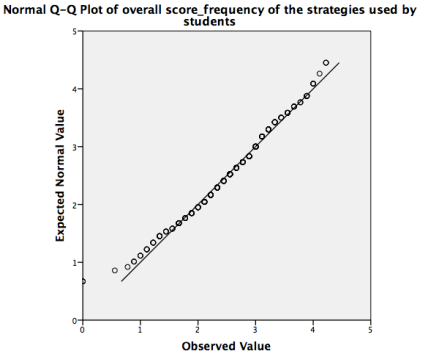
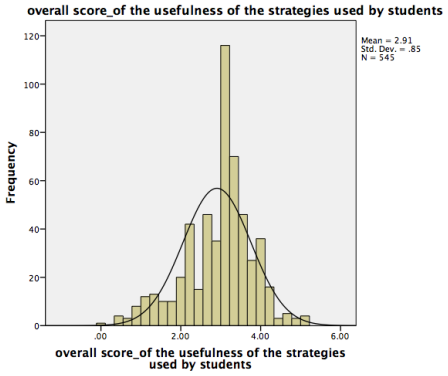
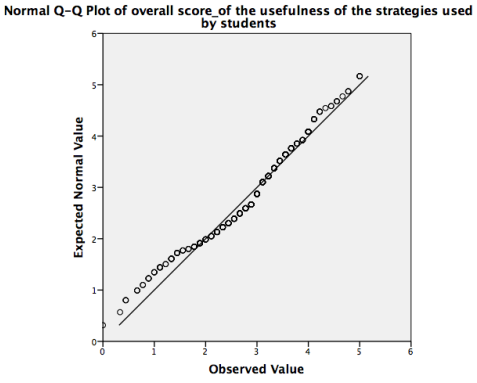


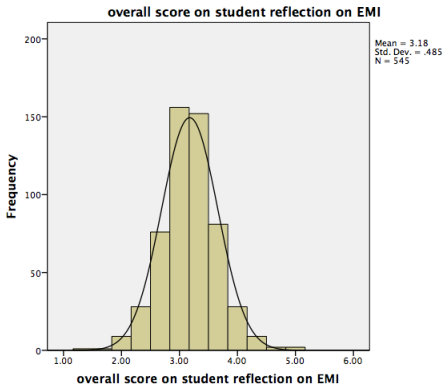
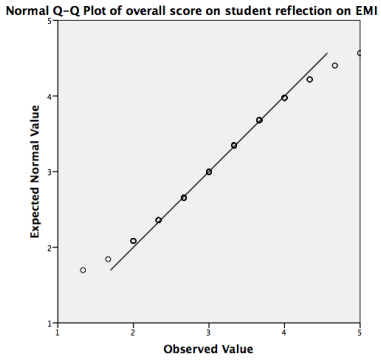
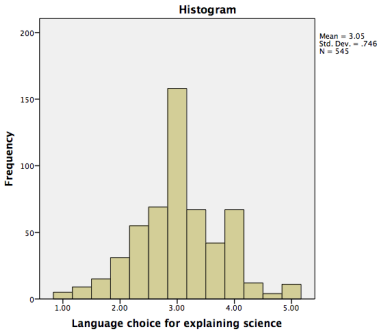
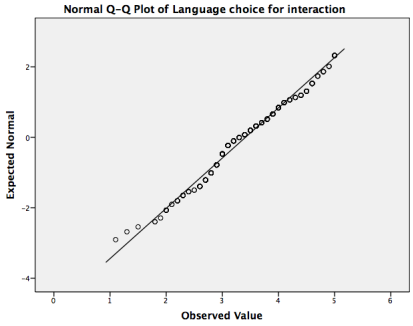
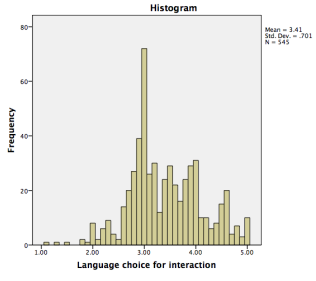
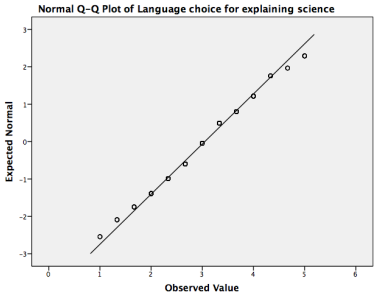
2. The following section is for the variables in chapter 7 which were about the students' questionnaire variables. The histograms, Q-Q plots, skewness and kurtosis value (K-S) [4] of all the variables.

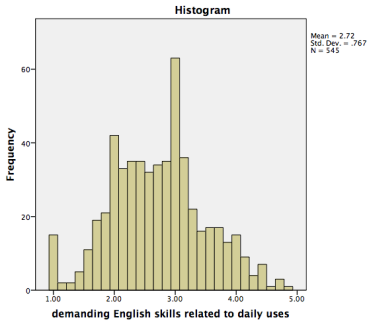
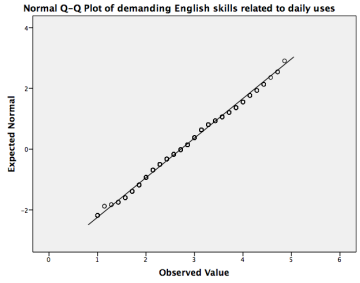
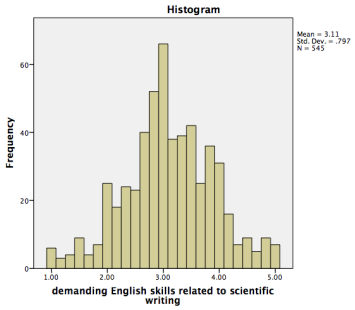
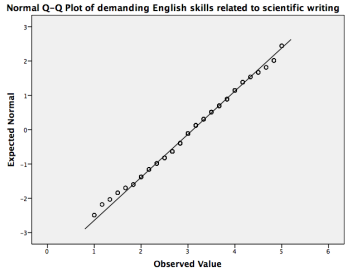
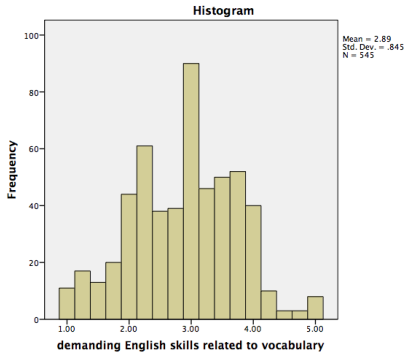
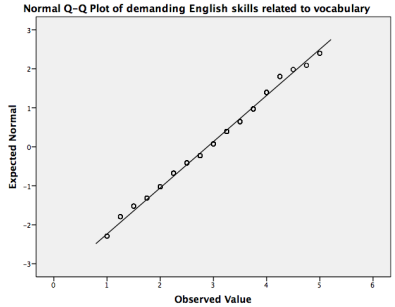
MOI. sci. activities [Histogram]	[Q-Q plot] K-S value: S=.107; K=.086
	
Demand. Eng. Skills [Histogram]	[Q-Q plot] K-S value: S=.123; K=.122
	

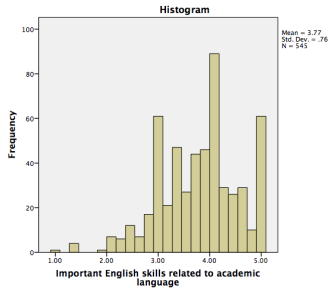
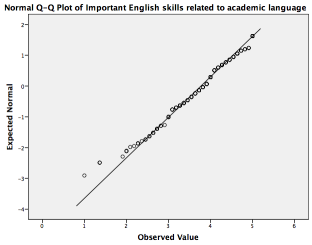
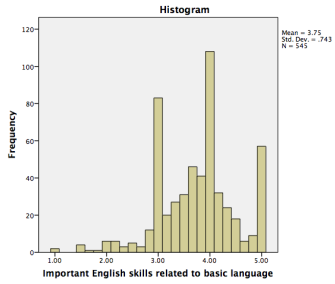
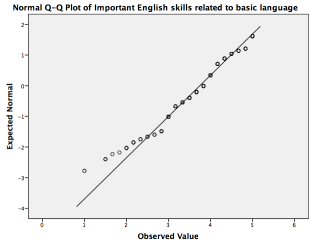
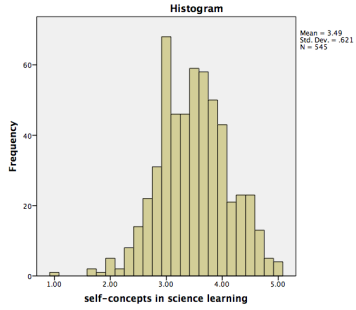
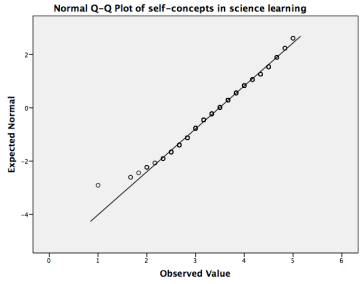
[4] The values for asymmetry and kurtosis between -2 and +2 are considered acceptable in order to prove normal univariate distribution (George & Mallery, 2010). George, D., & Mallery, M. (2010).

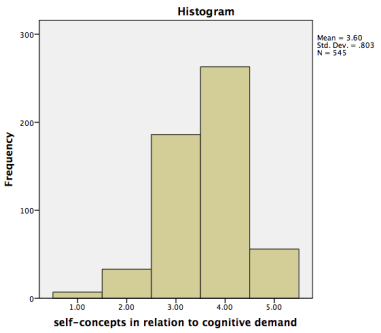
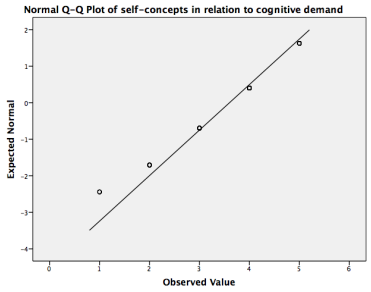
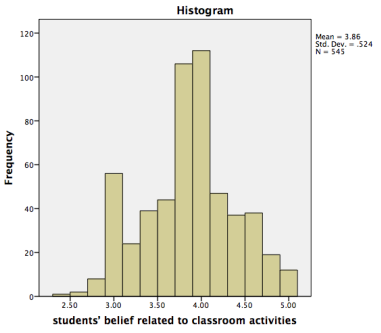
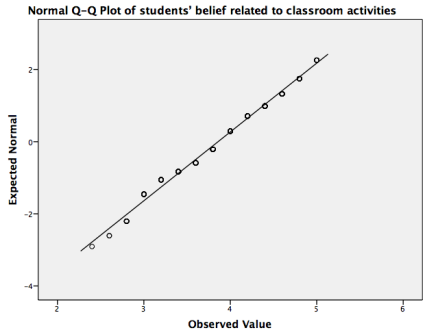
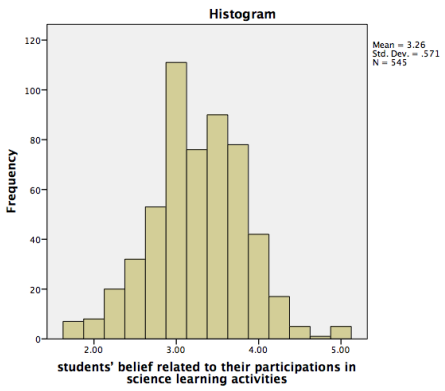
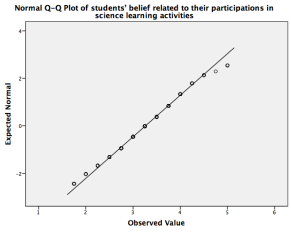
Import. Eng. Skills [Histogram]	[Q-Q plot] K-S value: S=-.365, K=.122
	
Student's self-concept [Histogram]	[Q-Q plot] K-S value: S=-.165, K=.281
	
Student's beliefs [Histogram]	[Q-Q plot] K-S value: S=-.193, K=.142
	

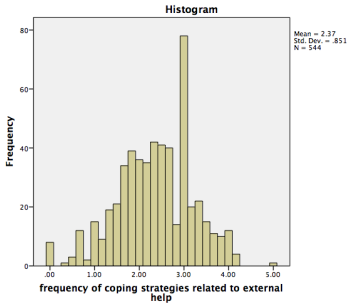
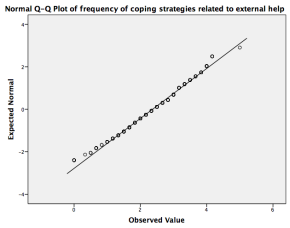
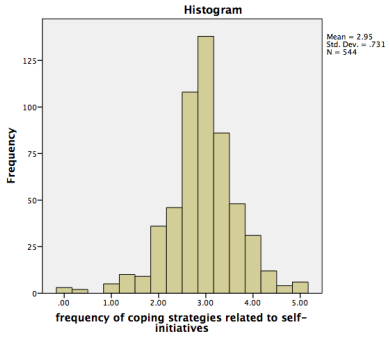
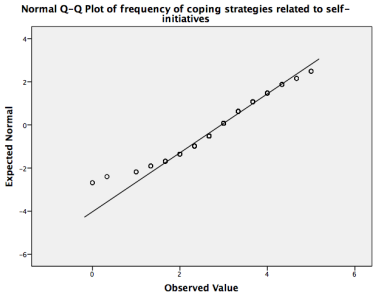
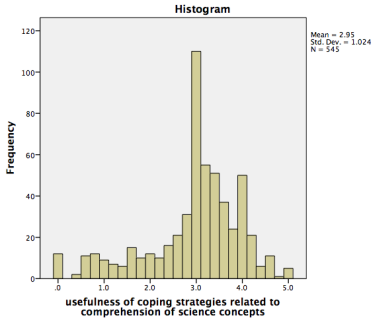
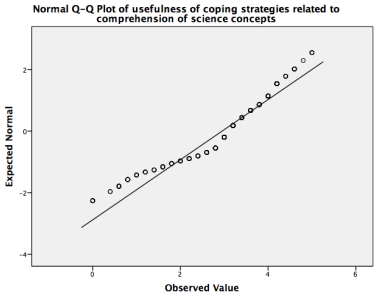
Lang. Challenges [Histogram]	[Q-Q plot] K-S value: S=-.265, K=.698
	
Freq. strategy [Histogram]	[Q-Q Plot] K-S value: S=-403, K=.640
	
Useful. Strategy [Histogram]	[Q-Q Plot] K-S value: S=-590, K=.594
	

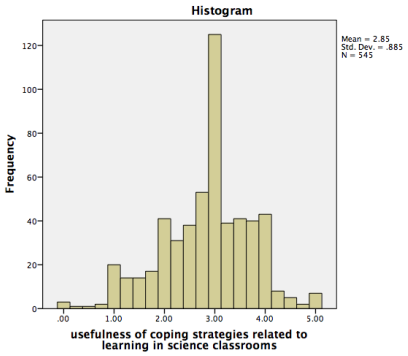
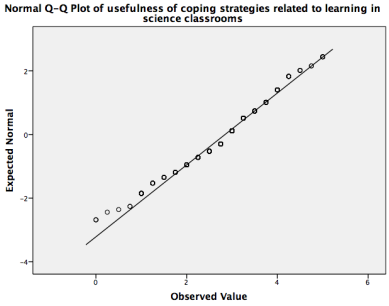
Reflection. MOI [Histogram]	[Q-Q Plot] K-S value: S=-.105, K=.985
	
Factor **1a Language choice for interactions** [Histogram]	[Q-Q Plot] K-S value: S=-.176, K=.160
	
Factor 1b: Language choice for explaining science	[Q-Q Plot] K-S value: S=.026, K=.308
	

Factor 2a: Demanding Eng. (daily uses)	[Q-Q Plot] K-S value: S=.129, K=.181
	
Factor 2b: Demanding Eng. (scientific writing)	[Q-Q Plot] K-S value: S=-.074 K=.043
	
Factor 2c: Demanding Eng. (vocabulary)	[Q-Q Plot] K-S value: S=-.084; K=-.352
	

Factor 3a: Important Eng.(academic)	[Q-Q Plot] K-S value: S=-.355; K=-.095
	
Factor 3b: Important Eng.(basic)	[Q-Q Plot] K-S value: S=.-.380; K=.485
	
Factor 5a: Self-concept (science)	[Q-Q Plot] K-S value: S=-.084, K=.144
	

Factor 5b: Self-concept (cognitive. demand)	[Q-Q Plot] K-S value: S=-.463, K=.487
	
Factor 6a: Belief (classroom activities)	[Q-Q Plot] K-S value: S=-.078, K=.377
	
Factor 6b: Belief (science activities)	[Q-Q Plot] K-S value: S=-.028, K=.275
	

Factor 8a: Freq. strategies (external help)	[Q-Q Plot] K-S value: S=-.257, K=.008
	
Factor 8b: Freq. strategies (self-initiatives)	[Q-Q Plot] K-S value: S=-.425, K=1.926
	
Factor 9a: Useful. Strategies (comprehension. Science concept)	[Q-Q Plot] K-S value: S=-.959, K=.775
	

Factor 9b: Useful. Strategies (learning in science)	[Q-Q Plot] K-S value: S=-.404, K=.274
	

Appendix C

Participant information sheets, invitation letter, consent forms



Information sheet to teachers

Dear Teachers,

My name is Jack Pun. I am a doctoral research student at Oxford University, supervised by Professor Ernesto Macaro, (Professor of Applied Linguistics) and Dr Jane McNicholl (Associate Professor of Science Education). In my research project, *A study of students' language challenges in learning science through English*, I will investigate the language challenges of teaching and learning Science through the medium of English medium in Hong Kong secondary schools.

I would like to invite you to participate in a research study. It is important that you should understand what the study is and what you are being asked to do, before deciding whether to participate. May I ask you to read this sheet carefully, and to ask me questions about anything that is not clear?

The data collection process will take place between late March 2014 and January 2017, so that it will not clash with the examination period in your school. I anticipate that the data collection will last for a maximum of only one week.

The research will involve senior science teachers and students from Grade 10 to 12. The research consists of four parts: Firstly, a questionnaire survey is conducted with all science teachers and students about their language challenges of learning science through English. Secondly, a semi-structure interview with you and a group of your students about the language problems and strategies. These interviews will be audio-recorded. Thirdly, I will observe some of the science lessons to identify the characteristics of teacher-student talk, the language related issues and how the mode of instruction in English shapes

the teacher-student interactions in different science learning activities.

These observations will be audio-recorded. Video recording will only apply to teachers who agree to be video-recorded. The video camera will focus on the teachers and any incidental images of students will be immediately deleted from the recording and not stored. Finally, I will ask you for a sample of anonymous science writings from those students who have parental consent and who have agreed to take part in the study; and I will ask to see their textbooks. This is for text analysis in order to give examples of the typical types of language in science.

You can choose whether to participate or not, and can withdraw from the study, or any part of it, without penalty at any time by advising me of your decision. Before beginning the research, I would inform parents and guardians about the research and offer students, parents and guardians the opportunity to refuse to participate.

I understand that the process of data collection in these lessons to some extent might be a little intrusive. However, the aim of this research is not to "evaluate" or "assess" you or your students. Rather the primary objective is to investigate the language challenges of science students' learning through English.

This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee. The data collected is subjected to the Data Protection Act, which protects you and all the other participants' data. All data will be treated confidentially; all names will be made anonymous in all research reports to avoid identification of the school, the teachers and the students. The data collected would be kept strictly confidential, available only to my supervisors and myself, and not used other than specified. All data will be stored in an encrypted external hard disk with password protected. The disk and all other research materials will be put in a locked cabinet which only accessible to me.

At the end of the project, I will be happy to provide you and your school with a copy of the written report of my research. This research project will form part of my doctoral thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. It will be openly available to the public in online form. However, please note that I cannot communicate any information about any individual child to you the school.

I sincerely hope that you are able to agree to participate in this my research. The findings will provide insights into the challenges that students have in learning

science through English, which in turn will hopefully have some implications for policy implementation by the HKSAR government in the future.

Whether or not you would participate or not, I would be grateful if you would complete the attached consent form and return it to me. If you need more information about what is involved, please contact me: kwok.pun@education.ox.ac.uk. If you have concerns about the project at any point, you can contact my supervisors: jane.mcnicholl@education.ox.ac.uk or ernesto.macaro@education.ox.ac.uk.

Yours faithfully,

Jack Pun

Doctoral research student, Department of Education, University of Oxford

Name of the study: A study of students' language challenges in learning science through English

Researcher: Jack Pun, a doctoral student

Contact: (mobile) +44(0)7501910908 (email) kwok.pun@education.ox.ac.uk

Purpose of the study: To investigate the language challenges of teaching and learning Science through the medium of English medium in Hong Kong secondary schools

TEACHER CONSENT FORM

Please tick as appropriate

☐	I have read the information contained in the information sheet
☐	I have had the opportunity to ask questions about the study and had received satisfactory answers to questions, and any additional details requests.
☐	I understand that I may withdraw from this study without penalty at any time by advising the researcher of this decision.
☐	I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.
☐	I understand who will have access to personal data provided, how the data will be stored; and what will happen to the data at the end of the project.
☐	I understand how the data will be stored and published, and how to raise a concern or make a complaint.
☐	I understand that direct access to the data is restricted to the researcher and his supervisors
☐	I **agree** to participate in this study
☐	I **do not want** to participate in this study

Teacher name (block capitals):…….. ……

Teacher signature: ……Date: ……..

Researcher name: ……Jack Pun……..…..

Researcher signature…….……...Date: ……..

Thank you for your help.

Please return this form to the researcher.



Information sheet to Parents or Guardians

Dear Parents or Guardians,

An invitation to participate in a research project

My name is Jack Pun. I am a doctoral research student at Oxford University, supervised by Professor Ernesto Macaro, (Professor of Applied Linguistics) and Dr Jane McNicholl (Associate Professor of Science Education). In my research project, *A study of students' language challenges in learning science through English*, I will investigate the language challenges of teaching and learning Science through the medium of English medium in Hong Kong secondary schools.

I would like to invite your child to participate in this research study. It is important that you should understand what the study is and what your child is being asked to do, before deciding whether to participate. May I ask you to read this sheet carefully, and to ask me questions about anything that is not clear?

What are the research activities?

The data collection process will take place between late March 2014 and January 2017, so that it will not clash with the examination period in your child's school. I anticipate that the data collection will last for a maximum of only one week.

The research will involve senior science teachers and students from Grade 10 to 12. The research consists of four parts: Firstly, a questionnaire survey is conducted with all science teachers and students about their language challenges of learning bescience through English. Secondly, semi-structure interviews will be conducted with teachers and some students about the language problems and strategies. I may ask to conduct a short interview with your child. These interviews will be audio-recorded. Thirdly, I will observe some of the science lessons to identify the characteristics of teacher-student talk, the language related issues and how the mode of instruction in English shapes the teacher-student interactions in different science learning activities. These observations will be audio-recorded. In some classes, the teacher may be video recorded. The video-camera will focus on the teachers only and any incidental images of students will be immediately deleted from the recording and not stored. Finally, a sample of students' science writings and their textbooks will be collected for text analysis in order to give examples of the typical types of language patterns in science.

What will happen if your child takes part?

Before beginning the research, I would inform all participants about the research and offer them the opportunity to refuse to participate. Throughout the study, you can withdraw your child from the study, or any part of it, at any time, without penalty at any time, by advising me of your decision. If you choose to withdraw your child after having initially agreed to participation, that there will be no academic penalty for this.

When conducting any interviews, questionnaire survey or observations, I will always explain to the children what research they are doing and why, and ask each child if they would like to be involved or not. Every child always has the right to say no – and they can always pull out of the interview or stop answering the questions if they don't want to go on.

What happens to the results of the studies?

This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee. The data collected is subjected to the Data Protection Act, which protects you and all the other participants' data.

Any answers or information given by individual children are kept strictly confidential. Your child's name will not be recorded. All names will be made anonymous in all research reports to avoid identification of your child. The aim of this research is not to "evaluate" or "assess" you or your child. Rather the primary objective is to investigate the language challenges encountered by general science students.

The data collected would be kept strictly confidential and available only to my supervisors and myself. All data will be stored in an encrypted external hard disk with password protected. The disk and all other research materials will be put in a locked cabinet which only accessible to me.

This research project will form part of my doctoral thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The online version will be available to the general public. However, please note that I cannot communicate any information about any individual child to you or your child's school or teacher.

What should you do next?

If you are happy in principle for your child to take part in this research then you do not need to do anything more now. Later your child will be sent the information sheet and asked for participating this study.

If you would **not** like your child to be involved in this study while he or she is at this school, then please fill in the form attached to this letter, and return it to your child's class teacher. If I do not receive an opt-out form from you, your child may be invited to take part in this study. If you do opt your child out, I will make sure that your child is not included in any parts of this project. This decision will not affect your child's education in any way.

If you feel you would need more information about what is involved, please contact me: kwok.pun@education.ox.ac.uk.

If you have concerns about the project at any point, you can contact my supervisors: jane.mcnicholl@education.ox.ac.uk or ernesto.macaro@education.ox.ac.uk.

Yours faithfully,

Jack Pun

Doctoral research student, Department of Education, University of Oxford

If you DO NOT want your child to participate in the research, [A study of student's language challenges in learning science through English], please fill out the form below and return it to the school by [DATE]. If I do not receive an opt-out form from you, your child may be invited to take part in this study, as described in the accompanying information sheet.

PARENT/ GUARDIAN OPT OUT FORM

Name of the study: A study of students' language challenges in learning science through English

Researcher: Jack Pun, a doctoral student

Contact: (mobile) +44(0)7501910908 (email) kwok.pun@education.ox.ac.uk

Purpose of the study: To investigate the language challenges of teaching and learning Science through the medium of English medium in Hong Kong secondary schools

I have read the information sheet of this research project, and I have had the opportunity to ask questions about it. However, **I**, the undersigned, hereby **DO NOT** give permission for my child to take part in this study.

Name of child:_____

Name of parent:_____

Signature of parent:_____

Date:_____

Name of the researcher: __Jack Pun_____

Date:_____



Information sheet to Students

Dear Students,

An invitation to participate in a research project

My name is Jack Pun. I am a doctoral research student at Oxford University, supervised by Professor Ernesto Macaro, (Professor of Applied Linguistics) and Dr Jane McNicholl (Associate Professor of Science Education). In my research project, *A study of students' language challenges in learning science through English*, i will investigate the language challenges of teaching and learning Science through the medium of English medium in Hong Kong secondary schools.

I would like to invite you to participate in this research study. It is important that you should understand what the study is and what you are being asked to do, before deciding whether to participate. May I ask you to read this sheet carefully, and to ask me questions about anything that is not clear?

What are the research activities?

The data collection process will take place between late March 2014 and January 2017, so that it will not clash with the examination period in your school. I anticipate that the data collection will last for a maximum of only one week.

The research will involve senior science teachers and students from Grade 10 to 12. The research consists of four parts: Firstly, a questionnaire survey is conducted with all science teachers and students about their language challenges of learning science through English. Secondly, semi-structure interviews will be conducted with teachers and some students about the language problems and strategies. I may conduct a short interview with you. These interviews will be audio-recorded. Thirdly, I will observe some of your science lessons to identify the characteristics of teacher-student talk, the language related issues and how the mode of instruction in English shapes the teacher-student interactions in different science learning activities. These observations will be audio-recorded. In some classes, the teacher may be video recorded. The videocamera will focus on the teachers only and any incidental images of you or other students will be immediately deleted from the recording and not stored. Finally, a sample of students' science writings (without their names) and their textbooks will be collected for text analysis.

What will happen if you take part?

Before beginning the research, I will talk to you about the research and offer you the opportunity to refuse to participate. Throughout the study, you can decide to withdraw from the study, or any part of it, at any time, without penalty at any time simply by telling me. If you choose to withdraw after having initially agreed to participation, that there will be no academic penalty for this.

When conducting any interviews, questionnaire survey or observations, I will always explain to you what research I am doing and why, and ask you if you would like to be involved or not. You always have the right to say no – and you can always pull out of the interview or stop answering the questions if you don't want to go on.

What happens to the results of the studies?

This project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee. The data collected is subjected to the Data Protection Act, which protects you and all the other participants' data.

Any answers or information that you give are kept strictly confidential. Your name will not be recorded. All names will be made anonymous in all research reports to avoid identification of you. The aim of this research is not to "evaluate" or "assess" you. Rather the primary objective is to investigate the language challenges encountered by general science students.

The data collected will be kept strictly confidential, available only to my supervisors and myself, and not used other than specified. All data will be stored in an encrypted external hard disk with password protected. The disk and all other research materials will be put in a locked cabinet only accessible to me.

This research project will form part of my doctoral thesis. On successful submission of the thesis, it will be deposited both in print and online in the University archives, to facilitate its use in future research. The online version will be available to the general public.

What should you do next?

If you are happy in principle for taking part in this research then please complete the attached consent form and return it to me.

If you would **not** like to be involved in this study, please inform your decision in the attached form. I will make sure that you will not be included in any parts of this project. This decision will not affect your study in any way.

If you feel you would need more information about what is involved, please contact me: kwok.pun@education.ox.ac.uk.

If you have concerns about the project at any point, you can contact my supervisors: jane.mcnicholl@education.ox.ac.uk or ernesto.macaro@education.ox.ac.uk.

Yours faithfully,

Jack Pun

Doctoral research student, Department of Education, University of Oxford

Project: A study of students' language challenges in learning science through English

Researcher: Jack Pun, a doctoral student

Contact: (mobile) +44(0)7501910908 (email) kwok.pun@education.ox.ac.uk

Purpose of the study: To investigate the language challenges of teaching and learning Science through the medium of English medium in Hong Kong secondary schools

STUDENT CONSENT FORM

Please tick as appropriate

☐	I have read the information contained in the information sheet
☐	I have had the opportunity to ask questions about the study and had received satisfactory answers to questions, and any additional details requests.
☐	I understand that I may withdraw from this study without penalty at any time by advising the researcher of this decision.
☐	I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.
☐	I understand who will have access to personal data provided, how the data will be stored; and what will happen to the data at the end of the project.
☐	I understand how the data will be stored and published, and how to raise a concern or make a complaint.
☐	I understand that direct access to the data is restricted to the researcher and his supervisors
☐	I **agree** to participate in this study
☐	I **do not want** to participate in this study

Student name (block capitals):…….. ……

Student signature: ……Date: ……..

Researcher name: ……Jack Pun……..…..

Researcher signature……..……...……...Date: ……..

Thank you for your help. Please return this form to the researcher.

[A Chinese version of Information sheet to Parents or Guardians]

致家長／監護人的資料聲明

敬啟者：

一項有關學生於英語環境下學習科學的教育研究

誠邀請參與這研究項目：

本人名為潘國雄，現為牛津大學教育系應用語言學博士生，本人的指導老師是 Professor Ernesto Macaro，應用語言系教授，和 Dr. Jane McNicholl ，科學教育系副教授。本人正進行一項有關以英語學習科學的教育研究，是次研究將會作為本人博士論文的一部分。

本人現誠邀閣下同意 貴子女參與此項研究。在作出決定前，請了解有關本研究的內容，以決定是否參與，如有任何疑問，歡迎查詢。

研究內容？

本研究將會於 貴子女就讀的學校進行，2014 年 3 月底至 2017 年 1 月期間。資料搜集將**不會**在學校考試期間進行。每次訪校搜集資料最長為一星期。

貴子女將獲邀參與一項有關以英語學習科學的研究。此研究目的為了解香港學生以英語學習科學（如：化學，生物，物理）所面對的讀寫問題，以及老師應如何運用特別的教學方法去協助學生應付於英語學習環境下所產生的困難。此項研究會特別探討老師與學生於課堂上的互動，從而了解老師如何提升學生使用英語學習科學的能力。

主要研究項目會透過錄音(老師及學生)或錄影(只限於老師，不包括學生)去記錄老師與學生於課堂上的互動，從而了解老師與學生們說話的類別，包括問題的種類，次數，長度等。目的是用於分析在英語環境的各種科學學習活動中，學生面對的語言問題，以及老師於教學上的應對方法。部分課堂，老師的教學會被錄影。在課堂結束後，老師和部分學生會被邀請進行問卷調查和會談，目的是用於了解受訪者對英語環境下學習科學的個人觀察和看法。部分學生的科學寫作樣本和教科書將會被收集以作分析及了解一般學生用英語寫作科學習作會遇上的問題。

如果我同意子女參與：

於每次收集數據前，本人會向有關人等說明研究內容，受訪者可自行決定參與或拒絕參與是次研究。閣下可以決定讓子女是否參與是次研究，閣下與 貴子女有權拒絕參與所有，或部分研究項目，亦可於任何時間退出本研究項目。無論參加與否，都不會有任何懲罰，也不會對 貴子女學業成績有任何負面影響。當進行

任何採訪，問卷調查或觀察，我會詳細向每一位學生解釋研究內容，讓參加者明白研究目的，他們的權利，並有自由去選擇參與或在過程中退出。

收集資料期間可能為課堂帶來些微不便。本研究目的是了解學生如何應付英語環境下學習科學的語言困難，所以本研究**不會**對任何參與者，包括老師及學生，作任何考核或評估。

研究完成後：

是次研究計劃書通過了牛津大學研究倫理委員會的審查。所收集的數據會跟據數據保護法，保護 貴子女和所有其他參與者。所有數據將被保密處理，並儲存於加密及以密碼保護的外置硬盤。該磁盤及所有其他研究材料將被放置於一個只有研究員才可以開啟的資料櫃。所有參與者的名字將被匿名，以避免影響任何參與的學校，教師和學生。已匿名的數據將只有本人和本人的指導老師才能參閱。研究結果將被寫作成本人的**博士**論文。在成功提交論文後，**本人的論文會可能會被出版**成文章和儲存在牛津大學檔案館中，以促進未來有關方面的研究。此項研究將會為未來香港特區政府教育局及其他研究香港教學語言政策問題的學者，提供寶貴的數據以設計或改良課程及教學方法，以幫助學生應付英語環境下學習科學的語言困難。

如批准 您的子女**參與是項研究，下一步應該：**

如果閣下同意 貴子女參與此研究，閣下毋須作出任何特別安排，因 貴子女將被邀請參與是項研究。

若閣下**不希望** 貴子女參與此研究，請填寫附於本函的回條，並交回班主任。本人將確保 貴子女不會包括在本研究項目中的任何部分。此決定將不影響 貴子女的學業。如果研究員沒有收到閣下填妥的退出回條， 貴子女可能會被邀請參加此項研究。

本人誠意邀請閣下同意貴 子女參與是次的研究。

如若閣下對本研究有任何疑問，請隨時與本人聯繫
kwok.pun@education.ox.ac.uk

如果閣下對本研究有任何疑慮，歡迎聯繫本人的**指導老師**：
jane.mcnicholl@education.ox.ac.uk or ernesto.macaro@education.ox.ac.uk

此致

貴家長／

監護人

牛津大學教育系博士生　潘國雄　謹啟

若閣下<u>不希望</u> 貴子女參與此研究。[學生於英語環境下學習科學的語言挑戰], 請填妥以下表格，並交回學校[日期]. 如果

研究員未能收到閣下的**退出表格**， 貴子女將被邀請參加是項研究。

[學生於英語環境下學習科學的語言挑戰] 資料收集<u>退出表格</u>

研究名稱: 學生在英語環境下學習科學的語言挑戰

***研究員:* 潘國雄, 牛津大學教育系博士生**

聯繫: (電話) +44(0)7501910908 (電郵) kwok.pun@education.ox.ac.uk

研究目的: 了解英語授課對教學及學習上的語言挑戰

我已閱讀本研究項目的資料。我已有機會作出有關是次研究的提問。然而，我<u>不同意</u>我的子女參加此項研究。

學生姓名:_____

家長姓名:_____

簽名:_____

日期:_____

研究員: <u>潘國雄</u>

日期:_____

[A Chinese version of Information sheet to Students]



致學生的資料聲明

敬啟者：

一項有關學生於英語環境下學習科學的教育研究

誠邀請參與這研究項目：

本人是潘國雄，牛津大學教育系博士生，現正修讀牛津大學教育系應用語言學。本人的指導老師是 Professor Ernesto Macaro 應用語言系教授和 Dr Jane McNicholl 科學教育系副教授。本人正進行有關一項用英語教學來學習科學的教育研究，是次研究是作為本人博士論文的一部分。

本人現邀請閣下 參與此項研究。在作出決定前，請了解有關本研究的內容，才決定是否參與，如有任何疑問，請向本人查詢。

研究內容？

本研究會在您就讀的學校進行，2014 年 3 月尾至 2017 年 1 月期間。來校不會在學校考試期間進行。每次訪校時間最長為一星期。

閣下 獲邀參與一項有關一項用英語教學和學習科學的研究。本人希望明白香港學生用英語學習科學（如：化學，生物，物理）所面對的英語讀寫問題，以及老師們如何運用特別的教學方法去

幫助學生應付這些英語學習環境產生的語言困難。這項研究會特別探討老師和學生在課堂上的互動，從中了解老師如何提升學生使用英語學習科學的能力。

主要研究項目是透過錄音(老師和學生)或(只限於老師，不包括學生)去記錄老師和學生在課堂上的互動，從中去了解老師和學生們說話的類別，包括問題的種類，次數，長度等。目的是用來分析在英語環境和各種科學學習活動中，學生面對的語言問題，以及老師在教學上的應對方法。部分課堂，老師的教學會被錄影。在課堂結束後，老師和部分學生會被邀請進行問卷調查和會談，目的是用來了解他們對英語環境下學習科學的個人觀察和看法。部分學生的科學寫作樣本和教科書會被收集和分析，用來了解一般學生用英語寫作科學集作的問題。

如果我同意參與：

在每次收集數據前，我會重新向所有參加者再一次說明有關研究內容，讓他們自行決定參與或拒絕參與是次研究。您可以決是否參與是次研究，您有權拒絕參與所有，或部分研究項目，在任何時間也能退出本研究項目。無論參與與否，都不會有任何懲罰，也不會對您子女學業成績有任何負面影響。當進行任何採訪，問卷調查或觀察，我會詳細向每一位參加者解釋研究內容，讓他們明白研究目的，他們的權利，並有自由去選擇參與或在過程中退出。

收集資料期間可能為課堂帶來一些不便。本研究目的是了解學生如何應付英語環境下學習科學的語言困難，所以本研究不會對每位參與的老師和學生作任何考核和評估。

研究完成後：

是次研究已送牛津大學研究倫理委員會，並通過了審查。所收集到的數據會跟據數據保護法，保護您和所有其他參與者。所有數據將被保密處理，並儲存在有加密功能和密碼保護的外置硬盤。該磁盤和所有其他研究材料將被放在一個上鎖的櫃子，只有研究員才可以開啟。所有的名字將被匿名，以避免鑑定任何學校，教師和學生。已匿名的數據將只有本人和本人的指導老師才能參閱。研究結果將被寫作成本人的**博士**論文。在成功提交論文後，**本人的論文會可能會被出版**成文章和儲存在牛津大學檔案館中，以促進未來的研究。這項研究會為未來香港特區政府教育局和其他研究香港語言政策問題的學者，提供寶貴的數據去設計一些新的課程和教學方法，幫助學生應付英語環境下學習科學的語言困難。

如果我想參與，下一步應該：

如果您同意參與這研究，那麼請填妥隨附的同意書，並交回研究員。

如果您**不希望**參與這項研究，請在隨附的回條答知你的決定。研究人員將確保你不會被包括在本項目的任何部分。這一決定將不會以任何方式影響你的學習。

我真誠地希望你能同意貴 子女參與是次的研究。

如果您對本研究有任何疑問，請隨時與我聯繫 kwok.pun@education.ox.ac.uk

如果您對本研究有任何顧慮，您可以聯繫我的**指導老師**：
jane.mcnicholl@education.ox.ac.uk or ernesto.macaro@education.ox.ac.uk

此致

學生

牛津大學教育系博士生　潘國雄　謹啟

研究名稱: 學生於英語環境下學習科學的語言挑戰

研究員: **潘國雄, 牛津大學教育系博士生**

聯繫: (電話) +44(0)7501910908 (電郵) kwok.pun@education.ox.ac.uk

研究目的: 了解英語授課對教學和學習上的語言挑戰

學生同意書

請在適當地方選擇✓

☐	我已閱讀**資料聲明的內容。**
☐	我有機會發問，並獲得了滿意的答案，以及任何額外的細節要求。
☐	我明白，我可以隨時退出參與此項研究、該決定不會有任何懲罰，也不會對我的學業有任何負面影響。
☐	我知道是次研究已通過了牛津大學研究倫理委員會的審查。
☐	我知道誰有權接觸本研究的數據，儲存數據的方法，以及研究結束後數據的處理。
☐	我知道研究項結果的儲存和發布方式, 以及提出問題或投訴的途經。
☐	我知道研究的數據的存取權僅限於研究員及他的指導老師。
☐	我**同意**參與是次研究。
☐	我**不同意**參與是次研究。

學生姓名:……..……

學生簽名: ……..……

日期: ……..

研究人員: ……潘國雄…….…..

研究人員簽名…….……..……...

日期: ……..

感謝你的幫助。 請將此表格填妥及交回給研究員。

Appendix D
CUREC application and approval

University of Oxford

CENTRAL UNIVERSITY RESEARCH ETHICS COMMITTEE (CUREC)

CUREC/1A Checklist for the Social Sciences and Humanities

The University of Oxford places a high value on the knowledge, expertise, and integrity of its members and their ability to conduct research to high standards of scholarship and ethics. The research ethics clearance procedures have been established to ensure that the University is meeting its obligations as a responsible institution. They start from the presumption that all members of the University will take their responsibilities and obligations seriously and will ensure that their research on human subjects is conducted according to the established principles and good practice in their fields and in accordance, where appropriate, with legal requirements. Since the requirements of research ethics review will vary from field to field and from project to project, the University accepts that different guidelines and procedures will be appropriate. Please check the CUREC website to ensure that you have the correct form for your project.

This form does not cover research governance, satisfactory methodology, compliance with the requirements of publishers when administering their tests or questionnaires, or the health and safety of employees and students. As principal investigator, it is your responsibility to ensure that requirements in these areas are met. Please carry out a risk assessment of the project, in consultation with all researchers involved, using the checklist and CUREC's other documentation.

The use of an asterisk in this form indicates a phrase defined in the glossary. The glossary and further information on the University's research ethics procedures are available from the CUREC website:

www.admin.ox.ac.uk/curec

This form is designed largely for research that falls within the Divisions of Social Sciences and Humanities and which does not involve a high level of risk to the subjects. Elite interviews, field work and oral history are included in the CUREC process. Please take a moment to read through it and if you have any questions or doubts as to whether it is the appropriate form, please review Section A or consult the CUREC website.

Note on anonymised data and audit: you do not need to obtain ethical approval for your study if:

- you are using previously collected **anonymised data** about people which neither you nor anyone else involved in your study can trace back to the individuals who provided them

(e.g. census data, administrative data, secondary analysis). Please refer to the definition of *personal data in the glossary and FAQ A4 for further guidance; or

- you are conducting research on behalf of or at the request of a service provider that matches the definition of *audit in the glossary.

If your research is audit or uses prior-anonymised data, please check this box: ☐

You do not need to seek ethical approval from CUREC, and you do not need to complete any more of this form. However, please check with your department's requirements, as some departments require you to lodge this form with them.

Office use only: IDREC Ref. No. _____

Date of confirmation that checklist accepted on behalf of IDREC: // //

SECTION A	Yes	No
1) Are you using research methodologies commonly used in biomedical or behavioural laboratory sciences?		✓
2) Is there a significant risk that the research will induce anxiety, stress or other harmful psychological states in participants that might persist beyond the duration of any test or interview in which they are participating?		✓
3) Will the research involve human participants recruited by means of their status as present or past NHS patients or their relatives or carers?		✓
*4) Does the research involve *human participants aged 16 and over who do not have *capacity to consent for themselves? See the Mental Capacity Act 2005*		✓
5) Is the study to be funded by the US National Institutes of Health or another US federal funding agency?		✓

If you answered 'yes', please **stop** work on this checklist and

for questions 1 and 2, complete CUREC/1 instead (available from www.admin.ox.ac.uk/curec);

for questions 3 and 4, submit your proposal to the appropriate NHS ethics committee (see www.nres.nhs.uk and www.admin.ox.ac.uk/researchsupport/=ctrg for further information);

for question 5, or if you answered 'yes' to questions 1, 2 or 4 and your research will take place outside the EU and is a biomedical study, submit your proposal to OXTREC, which uses separate documentation. Applications to OXTREC using this form will not be accepted. If your research is not a biomedical study and does not have US funding, but will take place outside the EU, you may use this form to submit your application for approval to the Social Sciences and Humanities IDREC.

If you have answered 'no' to all questions in Section A, please complete Sections B-E. This form and any supporting materials should be typewritten.

SECTION B

Principal investigator/ supervisor/student researcher (title and name):	Jack PUN, Kwok Hung DPhil student researcher in Education
Name of supervisor (STUDENT RESEARCH PROJECTS ONLY):	Professor Ernesto Macaro, Dr. Jane McNicholl
Degree programme, e.g. DPhil, MPhil, MSc (STUDENT RESEARCH PROJECTS ONLY):	DPhil in Education

Department or institute:	Department of Education
Address for correspondence (if different):	15 Norham Gardens, Oxford, OX2 6PY, United Kingdom
Email and phone contact:	email: kwok.pun@education.ox.ac.uk moblie: 07501 910908
Title of research project:	A study of students' language challenges in learning science through English

Title and brief lay description of *research (about 150 words), plus description (about 200 words) of the nature of participants (including the criteria for inclusion/exclusion & method of recruitment, how professional guidelines are being applied (if applicable) and use to which the results/data will be put.

Please describe how you will obtain informed consent, citing and attaching, where applicable, documentation produced in support of your application such as generic recruitment and advertisement material, participant information sheet(s), consent form(s) and defriefing document(s).

Research: This project is to investigate the language challenges in learning science through English as the medium of instruction (EMI) of senior secondary (Grade 10-12) students in Hong Kong. For the data collection, it includes questionnaire surveys, semi-structured interviews, classroom obervations with audio recording (students and teachers) or video recording (teachers) and text analysis of students' textbooks and writings.

Firstly, the questionaire surveys are to get the self-evaluations from teachers and students about the language-related problems of teaching and learning in EMI science classrooms. Secondly, science teachers and a group of their students in each school will be randomly selected to participate in semi-structured interviews, in order to collect their views on their strategies to overcome the challenges in teaching/ learning science in EMI settings; these interviews will be audio-recorded. Thirdly, classroom observation will be used to capture teacher-stduent interactions. With permission from the Principal of each school, the teachers and the students, audio recordings will record these interactions. Only those teachers who have agreed will be video-recorded in order to capture their teaching styles. Fourthly, a sample of students' science writings and their textbooks will be collected for detailed text analysis in order to identify the language patterns in the written science discourse.

Description of nature participants:The participants include science teachers and students in Hong Kong senior secondary schools (Grade 10-12; age 16-19). Only schools sharing similar demographic backgrounds and students' academic achievements (reflected by the banding of their school) will be included for this study in order to reduce the effects of confounding factors such as students' socio-economic status, previous educational background and family educational levels.

These schools will be selected randomly and separated into two groups (early English immersion and late English immersion) according to their students' number of years exposed to English medium and students' academic achievement. For instance, I will select schools with students that use early immersion and schools that use late immersion at Grade 10 and 11 with school banding from 2 to 3. The recruitment process in the first instance will be based on the school contact list provided by the Education Bureau, Hong Kong Special Adminstrative Region Government; this will be used to make the first contact with suitable schools for the data collection. If these schools reply, I will visit the school to speak to the Principal and individual science teachers informally and obtain their written approval and consent forms. An interview and classroom observation timetable will be negotiated with the teachers before data collection.

Prior to data collection, an information sheet will be distributed to all teachers (see P.2-3 of the supplementary document), students (P.8-10) and their parents (P.5-7) informing them about the nature of study, the data collection processes and how the study will comply with ethical procedures. A Chinese version of the same set of information sheets and consent forms checked by a bilingual speaker will be available to parents and students (see P.11-16). The contact details of the researcher and the researcher's supervisors are provided to all participants in case they have futher enquiries about the study or have a complaint.

Parents will be fully informed by the information sheet about the study and provided with an opt-out form this research. Opt-out will be used since this research will involve typicaly developing students and does not put them at any educational risk (see P. 7). They are under no obligation to let their children participate. Parents can choose for their children not to participate, or withdraw from this study at any stage with no academic penality for such a decision. The researcher will ensure those students whose parents refuse to give permission willl not be involved in any part of this study.

After reading the information sheet and receiving a verbal explanation from the researcher, teachers and students who want to participate will be asked to

return their written consent forms. They will be informed that their participation is at all times voluntary. They can choose to participate or not, and can withdraw from the study, or any part of the study, without penalty at any time by advising the researcher of their decision. Participants who refuse to give their assent will not take part in any stage of this study. The recorded data of those who withdraw from this study at the later stage will be deleted.

For questionnaire surveys, two sets of questionnaires with similar questions (see P.17) will be developed and distributed to all science teachers and students in each school who have agreed to participate. A bilingual version will be provided to the students.

For interviews, all science teachers will be invited to have one-one interviews with the researcher. For students, a stratified sample of 10% of each science class will be invited for group interviews with similar questions for the teacher group (see P.17). All interviews will be audio-recorded. If any of the participants disagree, researcher will check with the participant for possible one-one interview or change it to note-taking. All interview data will be recorded anonymously and all names will be de-identified.

For the classroom observation, at the beginning of each observation, the researcher will verbally inform all students and teacher(s) about the purpose of the study and ask if they agree to be audio-recorded during the lesson. Digital audio recorders will only be placed on the desks of students willing to take part in the study. Any video-recording will only apply to those teachers who agree to be video-recorded. The camera will be focussd upon teachers. No identifiable images of students will be intentionally recorded or stored. Any images of students that are accidentally captured will be obscured immediately on the original video recording immediately after the recording session.

For analysis of students' written artefacts, a sample of students' science writings and their textbooks will be collected from the teachers. The analysis does not focus on individual students and will only used to give depth and full information about what was being done in the lesson, not as records of individual learning. The writing samples of normal work produced in the lesson will be collected from students who have given their consent and this will be anonymised or coded by the teacher before being handed to the researcher.

Confidentiality will be maintained by ensuring that all data are recorded anonymously, pseudonyms will be used throughout. During the project, all

video/audio data will be stored in an encrypted external hard disk with password protected. The disk and all other materials will be put in a locked cabinet which only accessible to the researcher. Researcher will ensure all data will be stored securely and destroyed at the end of the DPhil research project. All data in which individual participant can be identified will be destroyed, and only anonymised data will be made available to research publication. Assurances will be given that images of teachers would not be shown in any publication, without gaining permission from the participants.

List actual or probable location(s) where project will be conducted, if known:	Hong Kong
If your research involves overseas travel or fieldwork, have you completed and returned a travel risk assessment form? (Bear in mind that this may be necessary to ensure that the travel or fieldwork is covered by the University's travel insurance – see http://www.admin.ox.ac.uk/finance/insurance/travel/.)	**YES / ~~NO / N/A~~**
Anticipated duration of project:	__34_ months
Anticipated start date:	20 / MAR / 2014
Anticipated end date:	31 / JAN / 2017
Name and status (e.g. 3rd year undergraduate; post-doctoral research assistant) of others taking part in the project:	Jack, Pun kwok hung, 1st year DPhil student
Please indicate what training on research ethics the researchers involved with this study have received, e.g. the title of the online or in-person course, and date completed (online training available at www.admin.ox.ac.uk/researchsupport/integrity/human/):	Researcher in this project had received ethics training in a number of contexts: The online training offered by the Faculty of Social Science--Research Integrity: Social and Behavioural Sciences; A talk in one of the foundation of educational research course on research ethics given by the chair of departmental research ethics committee, Dr. Nigel Fancourt and Dr. David Mills.

SECTION C

Methods to be used in the study (**tick** as many as apply: this information will help the committee understand the nature of your research and may be used for audit).

	Please tick
Interview	✓
Questionnaire	✓
Analysis of existing records *(students' work)*	✓
Participant performs verbal/paper and pencil/computer based task	
Measurement/recording of motor behaviour	
Audio recording of participant	✓
Video recording ~~or photography~~ of participant	✓
Physiological recording from participant	
Participant observation	
Covert observation	
Systematic observation	✓
Observation of specific organisational practices	
Other (please specify)	

SECTION D

Have you read one or more of the following professional guidelines and do you undertake to use the principles listed there as a guide for your own work? Please note that this is not intended to be an exhaustive list. Links to the guidelines listed below are included on the CUREC website.

	Please tick
British Society of Criminology: Code of Ethics for Researchers in the Field of Criminology [www.britsoccrim.org/codeofethics.htm]	

British Educational Research Association Ethical Guidelines for Educational Research [www.bera.ac.uk/guidelines]	✓
Academy of Management's Code of Ethics [www.aomonline.org/aom.asp?ID=&page_ID=242]	
Association of American Geographers Statement on Professional Ethics [www.aag.org/cs/resolutions/ethics]	
Oral History Society of the UK Ethical Guidelines [http://www.oralhistory.org.uk/index.php]	
American Political Science Association (APSA) Guide to Professional Ethics in Political Science (Section H) [www.apsanet.org/content_9350.cfm]	
Political Studies Association Guide to Good Professional Conduct [www.psa.ac.uk/psa]	
British Psychological Society Code of Ethics and Conduct [www.bps.org.uk/what-we-do/ethics-standards/ethics-standards]	
Ethics Guidelines of the Association of Social Anthropologists of the UK and Commonwealth [www.theasa.org/ethics/guidelines.shtml]	
Social Research Association: Ethical Guidelines [http://the-sra.org.uk/sra_resources/research-ethics/ethics-guidelines/]	
Statement of Principles of Ethical Research Practice from the Socio-Legal Studies Association [www.slsa.ac.uk/content/view/247/270/]	
Statement of Ethical Practice for the British Sociological Association [www.britsoc.co.uk/about/equality/statement-of-ethical-practice.aspx]	
Other professional guidelines (please specify):	

SECTION E

Please put a tick in the yes/no column as appropriate to indicate your response.

1) Will you obtain informed consent according to good practice in your discipline before participation?	**Yes**	**No**
	✓	
*2) Will you ensure that *personal data collected directly from participants or via a *third party is held and processed in accordance with the provisions of the Data Protection Act?*	**Yes**	**No**
	✓	

*3) Does the research involve as participants *people whose ability to give free and informed consent is in question?* *Note: participants aged under 16 are generally considered to require consent of a parent or guardian (only answer 'no' to this question if you can cite one of the protocols listed under 'children'). For participants aged 16-17, consult FAQ C13* For those students who are under 18, researcher will ask for their parental consent.	**Yes** ✓	**No**
4) As a consequence of taking part in the research, will participants be at serious risk of rendering themselves liable to criminal prosecution (e.g. by providing information on drug abuse or child abuse)?	**Yes**	**No** ✓
*5) Does the research involve the *deception of participants, as part of the investigation/experiment?*	**Yes**	**No** ✓
If any of your answers above are in a shaded box, please indicate whether those aspects of your project are fully covered by the following.		
6) Research protocol(s) which has/ve received IDREC/CUREC approval? *If yes, please give protocol number(s):* Protocol 15 (Type B Activities)	**Yes** ✓	**No**
7) Professional guidelines that you will be following, as noted under Section D?	**Yes** ✓	**No**

If any of your answers in Section E are in a shaded box and are not covered by a protocol or by professional guidelines, please complete CUREC/2, available to download from the CUREC website. Then submit both this form (you need not complete section F) and the CUREC/2 to the Social Sciences and Humanities IDREC.

If all your answers in Section E are in the unshaded boxes or your answers in shaded boxes are covered by a protocol or professional guidelines, complete Section F and submit this form and any accompanying documents to the Social Sciences and Humanities IDREC or to the relevant officer/committee at departmental level (see notes and address below).

FINAL CHECK

Please check each of the following before submitting the checklist. If the appropriate supporting documentation is not included with your application,

you will then be asked to provide this separately. This may well delay the ethical review process, and thus the start of your research.

Have you completed Sections A-E? ☒

Have you defined all technical terms and abbreviations used? ☒

If you have produced any documentation in support of your application (which might include questionnaires, participant information, consent forms/form or note of procedure for recording oral consent, advertisements and surveys), have you attached a copy of these? ☒

Are all pages (including appendices and attachments) numbered? ☒

SECTION F

You can submit this checklist by email and/or as a signed hard copy; if it is being sent by email only, the checklist, and any email from the head of department or nominee separately endorsing its submission, must be sent from a University of Oxford email address (i.e. as a minimum, the checklist and supporting documents must be submitted by the head of department or nominee indicating his/her approval from a University of Oxford email account).

Complete this section only if you do not need to submit form CUREC/2.

I understand my responsibilities as principal researcher/supervisor/student researcher as outlined in the CUREC glossary and guidance on the CUREC website.

I declare that the answers above accurately describe my research as presently designed and that I will submit a new checklist should the design of my research change in a way which would alter any of the above responses so as to require completion of CUREC/2 (involving full scrutiny by an IDREC). I will inform the relevant IDREC if I cease to be the principal researcher on this project and supply the name and contact details of my successor if appropriate.

Signed by ~~principal researcher/supervisor~~/student researcher:……

Date:… 10 February 2014……

Print name (block capitals)……PUN KWOK HUNG, JACK……

Signed by supervisor:…… …(for student projects)

Date:…10 February 2014……

Print name (block capitals)…… DR JANE MICNICHOLL……

I understand the questions and answers that have been entered above describing the research, and I will ensure that my practice in this research complies with these answers, subject to any modifications made by the principal researcher properly authorised by the CUREC system.

Signed by associate/other researcher: …….

Print name (block capitals)……

Date …….

I have read the research project application named above. On the basis of the information available to me, I:

(i) consider the principal researcher/supervisor/student researcher to be aware of her/his ethical responsibilities in regard to this research;

(ii) consider that any ethical issues raised have been satisfactorily resolved or are covered by relevant professional guidelines and/or CUREC approved protocols, and that it is appropriate for the research to proceed without further formal ethical scrutiny at this stage (noting the principal researcher's obligation to report should the design of the research change in a way which would alter any of the above responses so as to require completion of a CUREC/2 full application);

(iii) am satisfied that the proposed project has been/will be subject to appropriate *peer review and is likely to contribute something useful to existing knowledge and/or to the education and training of the researcher(s) and that it is in the *public interest.

(iv) [FOR DEPARTMENTS/FACULTIES WITH A DEPARTMENTAL RESEARCH ETHICS COMMITTEE (DREC) OR EQUIVALENT BODY - PLEASE DELETE IF NOT APPLICABLE] confirm that this checklist (and associated research outline) has been reviewed by the Department's Research Ethics Committee (DREC)/equivalent body, and attach the associated report from that body.

Signed:……..
(Head of department or nominee e.g Chair of DREC, Director of Graduate Studies for postgraduate student projects)

Print name (block capitals)……

Date:……

If your research involves participants recruited by means of their status as current or former NHS staff, or the research will, in whole or in part, be carried out on NHS premises, use NHS facilities or assess NHS facilities or services, please see FAQ B3 (www.admin.ox.ac.uk/curec/faqs/).

Please check with your department about its procedures for the approval of CUREC forms. If your department indicates that the checklist should be submitted directly to the IDREC, please send it, together with any supporting documentation, to the following address(es), keeping a copy for yourself:

Secretary of the Social Sciences and Humanities IDREC Email: ethics@socsci.ox.ac.uk

University of Oxford Social Sciences Division

Hayes House, George Street

Oxford, OX1 2BQ

IDRECs and/or CUREC will review a sample of completed checklists and may ask for further details of any project.

Revised July 2013

From: **Catherine Walter** catherine.walter@education.ox.ac.uk
Subject: CUREC application
Date: 15 March, 2014 2:21 am
To: Kwok Pun kwok.pun@education.ox.ac.uk
Cc: Jane McNicholl jane.mcnicholl@education.ox.ac.uk, Ernesto Macaro ernesto.macaro@education.ox.ac.uk, Education Research Office research.office@education.ox.ac.uk

Dear Jack,

Application Approval

Title: A study of students' language challenges in learning science through English

The above application, as per the attached documents, has been considered on behalf of the Departmental Research Ethics Committee (DREC) in accordance with the procedures laid down by the University for ethical approval of all research involving human participants.

I am pleased to inform you that, on the basis of the information provided to DREC, the proposed research has been judged as meeting appropriate ethical standards, and accordingly, approval has been granted.

If your research involves participants whose ability to give free and informed consent is in question (this includes those under 18 and vulnerable adults), then it is advisable to read the following NSPCC professional reporting requirements for cases of suspected abuse

http://www.nspcc.org.uk/Inform/research/questions/reporting_child_abuse_wda74908.html

Should there be any subsequent changes to the project which raise ethical issues not covered in the original application you should submit details to research.office@education.ox.ac.uk for consideration.

Good luck with your research study.

Yours sincerely,

Catherine Walter

Dr Catherine Walter
Associate Professor of Applied Linguistics
Vice Principal, Linacre College

Oxford University Department of Education
15 Norham Gardens, Oxford OX2 6PY UK
tel +44 (0)1865 274010

Appendix E
Teacher's questionnaire



Teacher Questionnaire

Dear teacher,

As a doctoral research student at the University of Oxford, United Kingdom, I am now conducting a research project on exploring how secondary students learn science through English. I would like to ask for your help by completing a questionnaire survey. I would be most grateful if you could return the completed questionnaire to me at your earliest convenience.

The estimated time for completing this questionnaire is 15 minutes.

Your answers will be treated in total confidence and the information collected from this questionnaire is available to the researcher for ***research purposes only***, but not to your colleagues or principal.

Your name and school will not be used and will be kept anonymous. Please answer the questions as honestly and accurately as you can. Your help is highly valued and appreciated, and your participation is a contribution to a better understanding of science students language issues in Hong Kong. If you have any queries, please do not hesitate to contact me. My email address is: kwok.pun@education.ox.ac.uk

Thank you for your time and help.

Jack Pun

Doctoral student at Department of Education

The University of Oxford

CONSENT

I _____ (Name of Participant) understand the procedures described above and agree to participate in this study.

Signature:_____ Date: _____

Subject:(Phy/ Chem/ Bio) Grade: (F4/F5/F6)

The information that you provided will be treated in the strictest confidence. Please answer each question by ticking the most appropriate boxes or filling the required information in the empty space.

A) Please tick the most appropriate
1. Gender: ☐ Female ☐ Male 2. Age: ☐20-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 3. University degree: ☐Physics ☐ Biology ☐ Chemistry ☐ Other:_____ (please specify) 4. Teaching qualification: ☐ Yes, Postgraduate Diploma in Education (PGDE)→name of the course:_____ (please specify) University:_____ (please specify) ☐ Yes, Other:_____ (please specify) ☐No 5. Have you received any training to teach in EMI? ☐Yes:_____ (please specify) ☐No 6. Please estimate your current English proficiency when teaching senior science classrooms in the following language skills: Listening: ☐1 (poor) ☐2(fair) ☐3(moderate) ☐4(good) ☐5 (excellent) Speaking: ☐1 (poor) ☐2(fair) ☐3(moderate) ☐4(good) ☐5 (excellent) Writing: ☐1 (poor) ☐2(fair) ☐3(moderate) ☐4(good) ☐5 (excellent) Reading:: ☐1 (poor) ☐2(fair) ☐3(moderate) ☐4(good) ☐5 (excellent)
B) Please fill in the blanks and tick the appropriate boxes.
7. Years of total teaching experiences: _____(years)
8. Years of teaching **in English medium**: _____(years)
9. At ***junior*** levels (F.1-3):
a. Years of teaching Integrated science: _____(years)
b. What other subjects do you teach? ☐Yes→☐English ☐ Chinese ☐Maths ☐ Geography ☐ History ☐Liberal Studies ☐ Religious Studies ☐other:_____ (please specify) ☐ No
10. At ***senior*** levels (F.4-6):
a. which science subject do you teach? ☐Physics ☐ Biology ☐ Chemistry ☐ Combined science ☐ Integrated science
b. Years of teaching **science**: ____(total years); c. HKDSE:_____(years); d. CE: _____(years); e. A-Level: _____(years)
f. What other subjects do you teach? ☐Yes→☐English ☐ Chinese ☐Maths ☐ Geography ☐ History ☐Liberal Studies ☐ Religious Studies ☐other:_____ (please specify) ☐ No

C) In your current senior science classroom, which language(s) do you personally speak when….?					
	Always English	Usually English	Code-switching between English & Cantonese	Usually Cantonese	Always Cantonese
11. Teaching the whole class	☐	☐	☐	☐	☐
12. Giving instructions to the students	☐	☐	☐	☐	☐
13. Answering students' questions in front of the whole class	☐	☐	☐	☐	☐
14. Discussing ideas with the whole class	☐	☐	☐	☐	☐
15. Managing the classroom	☐	☐	☐	☐	☐
16. Talking to individual students about their work	☐	☐	☐	☐	☐
17. Taking part in teacher-student interactions	☐	☐	☐	☐	☐
18. Explaining the definition of scientific vocabulary	☐	☐	☐	☐	☐
19. Explaining a science phenomenon	☐	☐	☐	☐	☐
20. Explaining a science phenomenon using everyday experience	☐	☐	☐	☐	☐
21. Giving instructions to students for a lab experiment	☐	☐	☐	☐	☐
22. Clarifying students' science misconception in a lab experiment	☐	☐	☐	☐	☐

D) From your current experience in your current senior science classroom, how **demanding** (A) and **important** (B) the following English language skills are for your students when they are….? (eg. Least (1) ←→Most (5))	(A) demanding					(B) important				
	1	2	3	4	5	1	2	3	4	5
23. Speaking (dialogue, eg. whole class interaction between teacher and classmates)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
24. Speaking (monologue, eg. presentation)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
25. Writing (scientific reports, with specific purpose, structures, language style)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
26. Writing (daily assignments)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27. Reading (science textbooks)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
28. Listening (science teacher's oral explanations in English)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
29. Understanding the meaning of technical vocabulary (e.g. oxidation, electrolysis, ionic bond, electrochemical series…etc)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
30. Understanding the meaning of abstract vocabulary (e.g. inert, displacement, reduction, oxidizing…etc)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
31. Understanding the meaning of academic English Vocabulary (e.g. examine, account for, describe, explain…etc)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
32. Understanding the style of science writing (e.g. the language style, language choice in a lab report)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
33. Recognising the organisation of a science text (e.g. the format of a lab report, its components, sub-sections)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
34. Writing scientific texts with accurate English grammar	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
35. Writing scientific texts with appropriate English vocabulary	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
36. Choosing the correct technical terms in expressing a science concept	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
37. Distinguishing between English Vocabulary for explanation and technical terminology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
38. Expressing the right answers in simple spoken English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
39. Expressing the right answers in simple written English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

E) Based on your experience in your current senior science classroom, please select the most appropriate option that reflects your teaching practices.						
		untrue of me	somewhat untrue of me	Neutral	somewhat true of me	very true of me
40.	I use special teaching methods to help my students understand the English vocabulary I use in my science teaching.	☐	☐	☐	☐	☐
41.	I always pay a lot of attention to the teaching of vocabulary in my science lessons because it is conducted in English.	☐	☐	☐	☐	☐
42.	I regularly ask my students to read their English science textbooks on their own.	☐	☐	☐	☐	☐
43.	I regularly ask my students to read other science resources in English	☐	☐	☐	☐	☐
44.	In my science teaching, I pay a lot of attention to help students develop their English while they learn science.	☐	☐	☐	☐	☐
45.	I use a number of teaching strategies in teaching science through English that I would not use if I taught in Chinese.	☐	☐	☐	☐	☐
46.	I find it helpful to use my knowledge of English grammar to support my students in learning science through English.	☐	☐	☐	☐	☐
47.	I find it helpful to use my knowledge of English vocabulary to support my students in learning science through English.	☐	☐	☐	☐	☐
48.	In my science lessons, I try to use English in ways that will help my students to learn English as they learn science.	☐	☐	☐	☐	☐
49.	In my science lessons, I regularly try to give my students opportunities to talk in English in order to help them learn both science and English.	☐	☐	☐	☐	☐
50.	I try to help my students use English when they speak to me (eg. answering questions) in my science classes.	☐	☐	☐	☐	☐
51.	I regularly require my students to write long answers in English (one sentence or more) as part of their learning of science.	☐	☐	☐	☐	☐

F) According to your teaching practices in your current senior science classroom, please indicate to what extent you agree or disagree with the following statements.						
		Strongly agree	Agree	Neutral	Dis-agree	Strongly disagree
52.	It is important for English medium science teachers to find ways of helping their students to deal with the English vocabulary they meet in science lessons.	☐	☐	☐	☐	☐
53.	English medium students need specialised help to understand the English vocabulary they used in science learning.	☐	☐	☐	☐	☐
54.	Reading the English science textbooks is an important way for students to learn the English they need for studying science.	☐	☐	☐	☐	☐
55.	Developing students' English proficiency is not an important part of a science teacher's role in an English medium school.	☐	☐	☐	☐	☐
56.	Helping students to understand English they use in science is one of the most important responsibilities for a science teacher in an English medium school.	☐	☐	☐	☐	☐
57.	All English medium science teachers need to know how to support their students in understanding the use of English in a science classroom.	☐	☐	☐	☐	☐
58.	It is important for science teachers to have some knowledge about the English language (eg grammar, phonology, semantic, genre) in order to support students' learning of science through English.	☐	☐	☐	☐	☐
59.	Knowing how students can learn English effectively through science is useful to science teachers in an EMI school.	☐	☐	☐	☐	☐
60.	Teachers who speak fluent English will motivate students to improve their uses of English in a science class.	☐	☐	☐	☐	☐
61.	Teachers who write good English will motivate students to improve their uses of English in a science class.	☐	☐	☐	☐	☐
62.	In English medium science lessons, students need regular opportunities to talk about science in English.	☐	☐	☐	☐	☐
63.	It is important for students to do learning tasks in science that require them to produce long spoken answers in English.	☐	☐	☐	☐	☐
64.	It is important for students to do learning tasks in science that require them to produce long written answers in English.	☐	☐	☐	☐	☐

G) Based on your experience in your current senior science classroom, please rank the following challenges related to studying science through English. E.g. Least (1) ←→Most (5) challenging					
	1	2	3	4	5
65. Transmitting content knowledge through English	☐	☐	☐	☐	☐
66. Explaining abstract scientific ideas in English	☐	☐	☐	☐	☐
67. Explaining complex scientific ideas in English	☐	☐	☐	☐	☐
68. Teaching students to distinguish vocabulary and technical terminology in English	☐	☐	☐	☐	☐
69. Making students answer my questions in English	☐	☐	☐	☐	☐
70. Making students discuss science concepts themselves in English	☐	☐	☐	☐	☐
71. Evaluating students' science understanding in English	☐	☐	☐	☐	☐
72. Transmitting scientific knowledge and skills to students in English	☐	☐	☐	☐	☐
73. Providing opportunities for giving corrective feedback for consolidation in English	☐	☐	☐	☐	☐
74. Using questions to prompt students for higher-order cognitive thinking in English	☐	☐	☐	☐	☐
75. Developing students' scientific skills for investigation study (*testing hypothesis, designing working procedures, gathering data, performing calculation, drawing conclusion*)	☐	☐	☐	☐	☐
76. Encouraging students to generate new knowledge through group work.	☐	☐	☐	☐	☐
77. Initiating students to apply existing knowledge to unfamiliar situations in English	☐	☐	☐	☐	☐
78. Preparing teaching content for presentations in English	☐	☐	☐	☐	☐
79. Dealing with different levels of English language proficiency/skills of the students	☐	☐	☐	☐	☐

H) Based on your experience in your current senior science classroom, please rank the following challenges related to studying science through English. E.g. Least (1) ←→Most (5) challenging					
	1	2	3	4	5
80. Dealing with different levels of science achievements of the students	☐	☐	☐	☐	☐
81. Dealing with diversity of existing science knowledge among students	☐	☐	☐	☐	☐
82. Choosing appropriate language style for explaining a science concepts	☐	☐	☐	☐	☐
83. Choosing appropriate vocabulary for explaining a science concepts	☐	☐	☐	☐	☐
84. Choosing appropriate text organization for explaining a science concepts	☐	☐	☐	☐	☐
85. Explaining topics after reading materials	☐	☐	☐	☐	☐
86. Designing a test/ an exam with consideration for the English demand for students (eg. writing, M.C.)	☐	☐	☐	☐	☐
87. Deciding the levels of difficulty in a science test or an exam	☐	☐	☐	☐	☐
88. Writing exam questions in English with consideration for students' English level	☐	☐	☐	☐	☐
89. Assessing English language mistakes in written exams	☐	☐	☐	☐	☐
90. Assessing students' understanding of the subject content	☐	☐	☐	☐	☐
91. Making a balance between correcting students' mistakes in English and in science concepts	☐	☐	☐	☐	☐

I) Based on the situation of your senior science classroom, please indicate how **frequent** (A) do you use the following strategies in your current teaching practice and how **useful** (B) they are for helping students to study science in English (e.g. Least useful(1)←→most useful(5))

	(A) frequency					(B)useful				
	never	rarely	sometimes	often	always	1	2	3	4	5
92. Providing Chinese translation of technical vocabulary	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
93. Providing Chinese translation of abstract English vocabulary (not technical, eg. metaphor)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
94. Providing more definitions and exemplification of technical words in English but not necessary to translate them into Chinese	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
95. Providing students with more English language instructions from their current English teachers	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
96. Providing students with additional English language course	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
97. Science teachers should receive more training on EMI teaching and the knowledge of English language	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
98. Providing additional English explanations and inputs from science teachers	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
99. Providing teaching notes to students in both Chinese and English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
100. Providing students with more feedback and corrections on their English use in science	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
101. Collaborative teaching between English language teachers and science teachers on the same science topic	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
102. Students attending tutorials and/or seeking for study assistants outside school about their science and English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

-Thank you for completing the questionnaire! (The End)-

Appendix F
Student's questionnaire

Student Questionnaire

Dear students,

As a doctoral research student at the University of Oxford, I am now conducting a research project on exploring how secondary students learn science through English. I am writing to ask for your participation by completing a questionnaire survey. I would most grateful if you could return the completed questionnaire to your class teacher or me at your earliest convenience.

The questionnaire consists of four parts:

- The first part asks general questions about your background information.
- The second part is about language choice(s) in previous education, science activities and your self-reported academic achievements
- The third part is about your self-concepts and beliefs in learning science through English.
- The last part is about your language challenges and adopted strategies.

The estimated time for completing this questionnaire is 15 minutes.

Your answers will be treated in total confidence and the information collected from this questionnaire is available to the researcher for ***research purposes only***, but not to your teachers

Your name and school will not be used and will be kept anonymous. Please answer the questions as honestly and accurately as you can. Your help is highly valued and appreciated, and your participation is a contribution to a better understanding of science students language challenges in Hong Kong. If you have any queries, please do not hesitate to contact me. My email address is: kwok.pun@education.ox.ac.uk

Thank you for your time and help.

Jack Pun, Doctoral student at Department of Education, The University of Oxford

---

SIGNATURE

I _____ (Name of Participant) understand the procedures described above and agree to participate in this study.

Signature:_____ Date: _____

Current studying science subject(s):（Physics／Biology／Chemistry）Grade 10 / 11

The information that you provided will be treated in the strictest confidence. Please answer each question by ticking the most appropriate box or filling in the blanks.

A) Please provide your personal information

1. Gender: ☐ Female ☐ Male
2. Age: ☐14(0)☐15 (1)☐ 16 (2)☐ 17 (3)☐ 18 (4)☐ 19 or above(5)
3. Grade: ☐ F.4 ☐ F.5 ☐ F.6 ☐ other:_____(please specify)
4. First language: ☐ Cantonese ☐ Putonghua ☐ other:_____(please specify)
5. Place of primary education:
   ☐ Hong Kong ☐ Mainland China ☐ Elsewhere: :_____(please specify)

B) From your past experience, which language(s) did you generally speak when learning science or science-related subject at different grades?

	Always English	Usually English	Code-switching between English & Cantonese	Usually Cantonese	Always Cantonese
6. Kindergarten	☐	☐	☐	☐	☐
7. Primary school (Grade 1 to 6):	☐	☐	☐	☐	☐
8. Junior secondary (Grade 7)	☐	☐	☐	☐	☐
9. Grade 8	☐	☐	☐	☐	☐
10. Grade 9	☐	☐	☐	☐	☐
11. Senior secondary (Grade 10)	☐	☐	☐	☐	☐
12. Grade 11 (only for those students at Grade 11)	☐	☐	☐	☐	☐

C) In your current senior science classroom, which language(s) do you personally speak when….?

	Always English	Usually English	Code-switching between English & Cantonese	Usually Cantonese	Always Cantonese
13. Answering the teacher's questions	☐	☐	☐	☐	☐
14. Asking the teacher questions	☐	☐	☐	☐	☐
15. Taking part in whole-class discussions	☐	☐	☐	☐	☐
16. Taking part in teacher-student interactions	☐	☐	☐	☐	☐

C) Cont'd					
17. Answering the teacher's questions	☐	☐	☐	☐	☐
18. Taking part in student-student interactions	☐	☐	☐	☐	☐
19. Taking part in pair-work activities	☐	☐	☐	☐	☐
20. Taking part in group-work activities	☐	☐	☐	☐	☐
21. Discussing classwork with classmates	☐	☐	☐	☐	☐
22. Explaining the definition of scientific vocabulary	☐	☐	☐	☐	☐
23. Explaining a science phenomenon	☐	☐	☐	☐	☐
24. Explaining a science phenomenon using everyday experience	☐	☐	☐	☐	☐
25. Giving instructions to your teammates for a lab experiment	☐	☐	☐	☐	☐
26. Responding to your teammates about a lab experiment	☐	☐	☐	☐	☐
D) Please tell us your academic achievements from your last year school examination results	**A**	**B**	**C**	**D**	**E**
27. Overall average grade in Chinese language last year	☐	☐	☐	☐	☐
28. Overall average grade in English language last year	☐	☐	☐	☐	☐
a. sub-grade in English Speaking	☐	☐	☐	☐	☐
b. sub-grade in English Reading	☐	☐	☐	☐	☐
c. sub-grade in English Writing	☐	☐	☐	☐	☐
d. sub-grade in English Listening	☐	☐	☐	☐	☐
29. If you studied integrated science last year, what is the overall average grade? OR	☐	☐	☐	☐	☐
If you studied individual science subject(s) (ie. Physics, Chemistry or Biology), what is the average grade of each individual subject(s)?					
a. Biology	☐	☐	☐	☐	☐
b. Chemistry	☐	☐	☐	☐	☐
c. Physics	☐	☐	☐	☐	☐
d. other (please specify:_____)	☐	☐	☐	☐	☐

E) From your current experience in your senior science classroom, how **demanding** (A) and **important** (B) the following English language skills are when……? (e.g. Least (1) ←→Most (5))	demanding					important				
	1	2	3	4	5	1	2	3	4	5
30. Speaking (dialogue, eg. whole class interaction between teacher and classmates)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
31. Speaking (monologue, eg. presentation)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
32. Writing (scientific reports, with specific purpose, structures, language style)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
33. Writing (daily assignments)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
34. Reading (science textbooks)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
35. Listening (science teacher's oral explanations in English)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
36. Understanding the meaning of technical vocabulary (e.g. oxidation, electrolysis, ionic bond, electrochemical series…etc)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
37. Understanding the meaning of abstract vocabulary (e.g. inert, displacement, reduction, oxidizing…etc)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
38. Understanding the meaning of academic English Vocabulary (e.g. examine, account for, describe, explain…etc)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
39. Understanding the style of science writing (e.g. the language style, language choice in a lab report)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
40. Recognising the organisation of a science text (e.g. the format of a lab report, its components, sub-sections)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
41. Writing scientific texts with accurate English grammar	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
42. Writing scientific texts with appropriate English vocabulary	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
43. Choosing the correct technical terms in expressing a science concept	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
44. Distinguishing between English Vocabulary for explanation and technical terminology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
45. Expressing the right answers in simple spoken English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
46. Expressing the right answers in simple written English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

F) Based on your experience in your current senior science classroom, please select the most appropriate one to reflect your own learning practices.					
	untrue of me	somewhat untrue of me	Neutral	somewhat true of me	very true of me
47. *Before studying at my secondary school,* I felt confident that my level of English would meet the demand of using EMI to study science subjects.	☐	☐	☐	☐	☐
48. I felt I was at disadvantage to study science in EMI during junior levels.	☐	☐	☐	☐	☐
49. I now feel confident my level of English meets the demands of using EMI to study science.	☐	☐	☐	☐	☐
50. My achievement in science is better than in other subjects.	☐	☐	☐	☐	☐
51. My performance in science is always good.	☐	☐	☐	☐	☐
52. I like attending science lessons.	☐	☐	☐	☐	☐
53. I think science subject is interesting and challenging	☐	☐	☐	☐	☐
54. I think science subject demand a lot of memory work	☐	☐	☐	☐	☐
55. I think that science is easy	☐	☐	☐	☐	☐
56. I understand the spoken explanation given by my science teacher(s).	☐	☐	☐	☐	☐

G) Based on your experience in your current senior science classroom, please indicate to what extent you observe the following?					
	Never	Rarely	Sometimes	Often	Always
57. Students listening to teachers' explanation of subject content.	☐	☐	☐	☐	☐
58. Teachers asking students questions related to the subject.	☐	☐	☐	☐	☐
59. Students asking teachers questions related to the subject.	☐	☐	☐	☐	☐
60. Students conducting group discussion.	☐	☐	☐	☐	☐
61. Teacher managing classroom order.	☐	☐	☐	☐	☐
62. Students watching teachers' demonstration in the laboratory.	☐	☐	☐	☐	☐
63. Students following instructions of manual to conduct experiments.	☐	☐	☐	☐	☐
64. Students designing the procedures of experiment themselves	☐	☐	☐	☐	☐
65. Teacher checking the answers on the work sheets with us.	☐	☐	☐	☐	☐

Based on your experience in your current senior science classroom, please rank the following challenges related to studying science through English. (e.g. least (1)←→most (5))	Challenging				
	1	2	3	4	5
66. Understanding the meaning of technical terminology in English	☐	☐	☐	☐	☐
67. Understanding the science concepts in English	☐	☐	☐	☐	☐
68. Comprehension of the acquired science knowledge	☐	☐	☐	☐	☐
69. Application of the acquired science knowledge	☐	☐	☐	☐	☐
70. The teaching styles of an individual teacher	☐	☐	☐	☐	☐
71. Discussing with other classmates about science in English	☐	☐	☐	☐	☐
72. Explaining abstract science ideas in English	☐	☐	☐	☐	☐
73. Explaining complex science ideas in English	☐	☐	☐	☐	☐
74. Answering a question from my science teacher in English	☐	☐	☐	☐	☐
75. Finding the appropriate Chinese glossary for reference	☐	☐	☐	☐	☐
76. Understanding my science teacher's speaking in English	☐	☐	☐	☐	☐
77. Understanding my science teacher's writing in English	☐	☐	☐	☐	☐
78. Explaining a science concept in English after reading materials	☐	☐	☐	☐	☐
79. Explaining a science concept in written English after reading materials	☐	☐	☐	☐	☐
80. Distinguishing the basic English vocabulary and technical terminology	☐	☐	☐	☐	☐
81. Studying to meet teacher's expectations in a science topic	☐	☐	☐	☐	☐
82. Reading my English science textbooks	☐	☐	☐	☐	☐
83. Understanding exam questions in English	☐	☐	☐	☐	☐
84. Expressing the right answers in spoken English	☐	☐	☐	☐	☐
85. Expressing the right answers in written English	☐	☐	☐	☐	☐
86. Solving a science problem in spoken English	☐	☐	☐	☐	☐
87. Solving a science problem in written English	☐	☐	☐	☐	☐
88. Using the correct English vocabulary in my writing	☐	☐	☐	☐	☐
89. Using the correct English technical terms in my writing	☐	☐	☐	☐	☐

Based on your experience in your current senior science classroom, please indicate how **frequent** (A) do you use the following strategies and how **useful** (B) they are when you study science in English? (eg. Least (1) ←→Most (5))

	(A) Frequency					(B) Usefulness				
	never	rarely	sometimes	often	always	1	2	3	4	5
90. Checking the Chinese translation of scientific vocabulary	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
91. Checking the meanings of the English vocabulary (non-scientific, academic English)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
92. Understanding the science concept from more examples and rephrasing but without the need to translate them into Chinese	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
93. Seeking support from English language teachers on learning science through English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
94. Requesting additional English explanations from my science teacher	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
95. Requesting additional Chinese explanations from my science teacher	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
96. Attending tutorials and seeking study assistance outside school	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
97. Requesting lesson materials printed in bilingual languages (Chinese and English)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
98. Asking my science teachers for feedback on and corrections of my science writing in English	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

-Thank you for completing the questionnaire! (The End)-

Appendix G

Interview questions for teachers and students

A. Pre-observation interviews with teachers (some guided questions)

1. What are the aims/purposes of this lesson?
2. what content is to be covered and what do you want the students to learn
3. What are the students like? Can you tell me some background of the students in this class? (English and science levels of the students?)
4. What is the prior knowledge that the students need to know before this teaching unit?
5. How will you achieve these aims e.g. materials, strategies and resources?
6. What are the teaching materials to be used for this teaching unit?

B1. Follow-up interview with teachers

Part A: discussion about the observed lessons

1. How do you feel the lesson went?
2. Do you think you have achieved the learning objective (s) as planned? If yes, where do you think you have you succeeded? If not, where do you think you need to do something differently/change and why?
3. During the lesson, did you experience any particular challenge(s) with teaching and learning related to the medium of instruction? Please state specific incidents.
4. What specific incidents/events did you need to clarify?
5. Do you think the medium of instruction made any difference in term of classroom interactions (teacher-student; student-student), and in what way?
6. What do you think about the impact of the medium of instruction on your teaching?

Part B: Perceptions of EMI teaching, language challenges, coping strategies

1. What do you think about your teaching experience in science classrooms, and the use of English as medium of instruction? (in terms of teaching objectives, students' learning outcomes)
2. What are the language challenges you encounter in your classrooms?
3. What are your coping strategies when dealing with these challenges?

4. Do you observe any language challenges specifically in different science disciplines (ie. Biology/Chemistry/Physics)?
5. What are the coping strategies to these specific challenges?
6. How do you react to a student when he/she encounters difficulty of expressing himself/herself with limited English?
7. What kinds of questions do you usually ask your students during the lessons? (recall, high-order question, reasoning)
8. What kind of vocabulary is essential for teaching science? (technical, academic, basic)
9. What are your expectations of your students' English proficiency in learning science?

B2: Follow-up interview with students

Part A: discussion about the observed lessons

1. What do you feel about this lesson?
2. Can you use a few sentences to describe what you learned in this lesson?
3. What is your understanding of the science covered in the lesson?
4. What are the most difficult/most interesting parts of this lesson? if any, critical incidents (related to medium of instruction) need to be clarified?
5. Do you think the medium of instruction made any difference in term of classroom interactions (teacher-student; student-student), and in what way?
6. What do you think about the impact of the medium of instruction on your learning?

Part B: Perceptions of EMI learning, language challenges, coping strategies

1. What are the language challenges have you encountered in your science classrooms?
2. What are your coping strategies when dealing with these challenges?
3. Do you observe any language challenges specifically in different science disciplines (ie. Biology/Chemistry/Physics)?
4. What are the coping strategies to these specific challenges?
5. How do you respond to a teacher's questions or discuss among your classmates if you encounter difficulties expressing yourselves in English?
6. Why types of questions does your teacher ask? How do you respond to your teacher's questions? (reluctant /quick) Do you think these questions help you to understand the key science concept introduced in that lesson? What sorts of questions are most helpful, did your teacher provide useful support for developing your understanding?
7. What kind of vocabulary is essential for learning science? (technical, academic, basic)
8. What are your expectations of your English proficiency in learning science?

Appendix H
Classroom observation sheet

This observation sheet is to record science lesson in terms of the *lesson structures, objects of learning*. Follow-up interviews with the observed teacher will be conducted to check the comments I made in my observation note, ask for clarifications about the lessons.

PART 1: Background information

Teacher		Date of observation:	
Grade:		Time:	
Science subject:		Duration:	
Science Topic:		Recording file name:	
Learning targets in this lesson			
Learning outcomes for students			
Learning activities the teacher cover in this lesson?			

PART 2: observation note:

Procedures	Comment:

Appendix I

Challenges getting access to HK schools

In the main data collection, I encountered a number of problems in getting access into secondary schools in the first two months. There were a number of challenges I encountered during my fieldwork in Hong Kong:

1. No local connections to school principals. A high rejection rate came from the 143 eligible schools. Most schools that agreed to participate were via a contact.

It was extremely difficult to get access to the local schools. There were 143 eligible schools that could be contacted for recruitment. In the first month, I first sent emails to school principals and did not have any replies. Some of the email addresses I discovered were for administrative staff and did not reach the principals. Then, I printed out letters with information about the study, its purpose, in both English and Chinese and sent them to 143 schools in January 2015. Having had one response from the population of 143 schools, I realized that it was not obviously possible to find schools by sending letters. I got two school contacts through personal contacts but unfortunately both schools ultimately withdrew because the teachers felt uncomfortable about their teaching performance being recorded.

I spent the rest of January in exploring any possible connections in both private and public sectors hoping that I would get enough schools (n=8) in February. I contacted all the professors I knew in Hong Kong from the Departments of Linguistics, Education, and Language Studies. I also talked to the Education Bureau from the HKSAR government, the Legislative council members who

were in charge of education policy, and of course the Oxford China Office and Oxford University Press China office. From there, I received a few key contact points--a few school principals who showed sympathy for educational research and welcomed junior researchers from outside Hong Kong. I then visited those schools and had meetings with a few other school principals negotiating for possible access. Eventually, 6 more schools agreed to participate. Another 2 schools responded to my invitation letter through mail and telephone calls.

2. There is no interest in educational research amongst Hong Kong secondary schools. Those who were keen to research had already established strong connections with the three faculties of education from the universities in Hong Kong (HKU, CUHK and HKIEd) where all schoolteachers were trained and obtained their PGDE diploma. From the 20 rejection letters I received from school principals, two stressed that they would not want to work with any overseas institutions for educational research even if a university with high international ranking.

4. Recording (audio/video) is the primary reason for a teacher's rejection to my invitation. A significant number of teachers who were interested rang me to ask about my study. These teachers originally showed interest but once they were asked if they could be recorded in their classrooms, about one third immediately declined.

5. School principals and teachers expected additional support from the researcher in return for taking part in the study. I made it explicit to school principals and teachers that participation was on a voluntary basis. I promised that we would share the research findings once the project was completed and that teachers would receive a letter of appreciation from the researcher. However, I received a number of replies from school principals asking for: a replacement teacher for a week, tutorial classes for their students, remedial

classes for poor-English students, professional development courses for all science teachers on teaching pedagogy, and photographs with the researcher to be printed in their school newsletter. I had to reject some schools given these unexpected demand.

Appendix J. Summary of the participating teacher's background and qualifications

School Type	Early-full EMI						Partial-late EMI											
School	A	B	B	C	D	D	E	E	F	G	G	G	G	G	G	H	H	H	H
Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19
Name (pseudo)	*Wong*	*Lui*	*Lai*	*Wong*	*Lam*	*Chow*	*Yu*	*Leung*	*Law*	*Lee*	*Kwok*	*Tse*	*Lau*	*Leung*	*Ng*	*Leung*	*Chu*	*Chik*	*Ng*
Sex	M	M	M	M	M	F	M	F	M	M	M	M	M	M	M	M	M	M	F
Age (range)	20-30	41-50	20-30	20-30	31-40	31-40	31-40	51-60	41-50	31-40	51-60	31-40	41-50	41-50	51-60	31-40	31-40	51-60	41-50
University degree	Biochem	Phy	Phy,	Bio	Chem	Bio,	Chem	Bio	Bio +MEd	Bio	Chem	Chem	Phy	Phy	Bio	Phy	Chem	Phy	Chem
Postgraduate Diploma in Education (PGDE), University@	Bio CU	Phy HKU	Phy, UST	Bio, HKU	Chem HKU	Bio, CU	Chem HKU	Bio HKU	Bio+ HKU	Bio CU	Chem CU	Chem CU	Phy HKU	Phy CU	Bio CU	Phy HKU	Chem HKU	Phy CU	Chem HKU

@: HKU (University of Hong Kong), CU (Chinese University of Hong Kong), UST (Hong Kong University of Technology)

&:RE: Religious Studies; Comp: Computing; Lib.: Liberal Studies; Maths: Mathematics

Appendix K. Summary of the participating teacher's teaching experience

School type:	Early-full EMI						Late-partial EMI												
School	A	B	B	C	D	D	E	E	F	G	G	G	G	G	G	H	H	H	H
Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19
total year of	6	22	4	2	12	15	17	32	24	6	35	11	19	15	35	14	8	35	20
teaching *in EMI Schools*	6	15	4	5	5	15	17	9	24	6	40	4	19	15	35	3	8	35	20
teaching Integrated science subject at junior levels (Grades 7-9)	6	5	4	5	10	15	15	3	24	2	15	11	3	3	15	2	0	35	3
teaching *in science subject in senior levels (Grades 10-12)*	6	22	4	1	12	15	17	32	24	2	35	10	19	15	35	14	6	35	20
Teaching the new HKDSE curriculum	6	4	4	1	4	6	4	3	4	6	5	3	4	3	5	3	4	5	4
Teaching the old curriculum (Cert. Level, Grades 9-10)	0	18	0	0	8	9	13	32	20	2	15	6	4	3	15	4	2	30	16
Teaching the old curriculum (A-Level, Grades 11-12)	0	18	0	0	8	9	13	28	20	5	20	8	17	15	20	4	0	30	16
Teaching other disciplines or subject areas	RE	Comp	N	N	N	RE	N	N	N	Math	Lib.	N	Lib.	Lib.	Lib.	Comp.	N	Math	Math

Appendix L. Summary of the participating teacher's self-reported English levels

School type	Early-full EMI						Late-partial EMI												
School	A	B	B	C	D	D	E	E	F	G	G	G	G	G	G	H	H	H	H
Code	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19
Received EMI training?	N	Y#	N	N	N	Y ^	N	N	N	N	N	N	N	N	N	N	N	N	N
Self-reported English levels* (Listening)	4	4	3	4	4	4	4	4	4	4	3	3	3	3	4	2	3	4	3
(Speaking)	4	4	3	4	3	4	3	4	4	3	3	3	3	3	4	2	3	4	3
(Writing)	4	3	3	4	4	3	2	3	4	4	3	3	3	3	4	3	3	4	3
(Reading)	4	4	3	4	4	4	3	4	4	4	3	3	4	3	4	3	3	4	3

Note: self-reported English levels: 1 (poor) 2(fair) 3(moderate) 4(good) 5 (excellent); ^(2-week professional development);

#3: school based development;

Appendix M

Transcription conventions

The analyses presented in this thesis are mainly about the actual spoken utterances produced and the language expressions used when negotiating meaning between teachers and student during interactions. In transcribing these authentic classroom data, I have tried to capture their spontaneity and informality but not at much of their readability. This suggests that I ignore the finer details of transcriptions like length of pauses, pitch direction, and other meta-linguistic features, unless these features have been expressly singled out for my discussion. Under the same view, I adopted Thornbury & Slade (2006:3-4)'s transcription convention which provides classifications and linguistic descriptions of spoken conversation in varies contexts. The transcription devices are as the following:

Participants:

T1, T2, T3…= Teacher 1, Teacher 2, Teacher 3…

S1, S2, S3…= Student 1, Student 2, Student 3…single student

S= whole class

Interactions:

full stops . = indicate completion of a turn, usually realised by falling intonation.

commas , = these are used to separate clauses in order to make utterances more readable

question mark ? = these are used to indicate utterances in their contexts that function as questions, irrespective of their grammatical form or their intonation.

exclamation marks ! = these are used conservatively to indicate the expression of surprise.

quotation marks 'XXX'= single quotation marks are used to signal that the speaker is directly quoting speech or emphasis?

empty parentheses ( ): these mean non-transcribe segments of talk

filled parentheses (XXX): word within parentheses indicate the transcriber's best guess as to a doubtful utterance.

(*italics)*= words that are originally in Cantonese.

square brackets [ ]= suggest information about relevant non-be speaker's gestures, such as laugh, rising hand.

Capital letters: words in capital letters are used conservatively to indicate emphasis

Dots… : three dots indicate a hesitation within an utterance

Dash --: a dash represents a false start

Equal sign: a double equal sign is used to represent overlap phenomena, such as simultaneous utterances (where two speakers are speaking at the same time), overlapping utterances (the point where the second speaker begins talking is shown by == preceding the point in the first speaker's turn), contiguous utterances (when there is no interval between adjacent utterances produced by different speakers).

Appendix N

An example of the translation procedure of lesson transcripts

The majority of the video-recorded science lessons were transcribed in English. For those spoken utterances that occurred in Cantonese, I would provide both the pronunciation in Cantonese using the Yale Romanisation system (1), and the wordings of the actual expressions produced by speakers using the modern traditional Chinese characters (2). The meanings of these Cantonese utterances were than translated using 'word-to-word' approach into English (3). Below is an example of the translation of student-student interactions from a Grade 11 Physics classroom at one of the MOI-switching school.

Speaker	*Talk*
S1	(1) hai6 aa1 (2)係呀。 (3) Yes.
T	Can you see this? (*pointed to the meter)*
S1	(1) wa1, jau5 jat1 go3 (2) 嘩，有一個。 (3) Wow, there is one (rotation).
S2	(1) hai6 bin1 dou3 (2) 係邊到？ (3) Where is that?
S3	(1) zik1 hai6 ji4 dung6 gan2 (2) 即係移動緊？ (3) It that means the meter is rotating?
S4	(1) Ji4 dung6 gan2 (2) 移動緊。 (3) it's rotating
S5	(1) jing1 goi1 m4 sik1 (2) 應該唔熄。 (3) should not be (switching) off
S6	(1) ji4 dung6 gan2 zik1 hai6 sam6 (2) 移動緊即係什麼？ (3) What does it mean by rotating?

Appendix O

The Seventeen-Category System of acts in classroom by Tsui (1985)

Here is the description of the acts from the Seventeen-Category System based on Tsui's definitions (Tsui, 1985, pp. 12–16) for analysing interaction in second language classroom in Hong Kong. Additional 7 categories were suggested by Lo & Macaro (2012) and they are indicated by Italics. Figure 2 summarises the twenty four-Category of *acts* in Tsui's and Lo & Macaro's framework. The following section describes the meaning of each *act*, followed by examples from Tsui's study and Lo & Macaro's study.

Figure 2.Summary of the Seventeen-Category System with additional 7 categories from Lo & Macaro (2012, p.52)

		Acts	Sub-categorisations
Teacher Talk	Initiate	1. Elicit	A. Display Qs a) Factual Q. b) Yes/No Q. c) Reasoning Q. d) Explanation of word meaning B. Genuine Qs a) Opinion. b) Information. C. Re-stating elicit *a) Repetition* *b) Modification*
		2. Direct 3. Nominate 4. Inform 5. Recapitulate 6. Frame 7. Starter 8. Check 9. *Read aloud* 10. *Translate*	

		11. *Reprimand / applaud* 12. *Self-utterance*	
	Respond	13. Evaluate	a) Encouraging/positive b) Negative
		14. Accept 15. Comment 16. Clue 17. *Answering questions* 18. *Pardon*	
Pupil Talk	Respond	19. Reply	a) Restricted b) Expanded
		20. Apologise	
	Initiate	21. Request 22. Elicit 23. Interrupt 24.*Express opinions*	

I. 'Teacher-Initiate'

The first category is '***ELICIT***', and it further divided into three major types of display questions.

A. Display Questions: This type requires students to display their knowledge, and to which the teacher already has an answer in mind. Different types of questions will elicit different types of responses. For example, a factual question 'What's that book you're reading?' is likely to elicit a short, restricted response whereas a reasoning question 'Why are you reading that book?' is likely to get an expanded, evaluative one. Therefore finer distinctions based on the type of response elicited are made.

a) Factual Question: Realized by What-, When-, Where- questions. This type of question asks for information and usually has only one acceptable answer.

b) Yes-No Question: Realized by subject auxiliary-verb inversion. This type of question usually elicits a brief response of either yes or no.

c) Reasoning Question: Realized by How- and Why- questions. This type of question requires thinking and perception of the interrelation of facts. The response elicited usually requires more sophisticated language structures.

d) Explanation Question: Realized by "What is the meaning of ___?" or "Can you explain____ ?" This type of question requires pupils to express their understanding of words and phrases, signs and symbols etc.

B. Genuine Questions: This category, as opposed to Display Questions is a type of question to which the teacher does not have an answer.

The term 'genuine' is used as opposed to 'pseudo-question' (Barnes 1969) to which the teacher already has an answer in mind. It can be a question about the pupils themselves or about their opinion.

a) Opining Question: Realized by expressions like "What do you think?" or "What is your opinion?" This type of question asks for pupils' opinion and is linguistically demanding because it requires expression of pupils' own feeling and opinion, and not mere parroting.

b) Information Question: The linguistic realizations of this category are varied. Some examples are, "Did you have breakfast this morning?" or "What did you do during the weekend?"

C. Restating Elicit: This category is realized by either repeating the preceding question or simplifying it. This act serves to ensure that pupils can follow both categories of 'Elicit' and is performed either on the teacher's own accord or when pupils fail to respond to the 'Elicit' e.g., The question, "What two forces are often balanced in a fairy story"; restated as "What are the two particular qualities of people?"

Category 2: ***'DIRECT'***

This category, as opposed to Category 1, elicits non-verbal responses. It can be realized by questions or imperatives. For example "Sit down" or "Turn to page xx".

Category 3: '***NOMINATE***'

Realized by pupils' names, or "yes?" or "you". It calls on or gives permission to pupils to give response.

Category 4: '***INFORM***'

Realized by statements. It serves to provide information or to impart knowledge.

Category 5: '***RECAPITULATE***'

Realized by statements, which repeat the information previously expressed. It is often marked by "So" or "Right" at the beginning of the statement. For example, "Right, the stream flowed right under their tent."

Category 6: '***FRAME***'

Realized by statements referring to some future acts, which will be performed in the course of the lesson. For example, "Today, we are going to learn Chapter 27 'A Wet Night'. Now I'll read the passage once and then ask you some questions." This act structures the lesson so that pupils know where they are going.

Category 7: '***STARTER***'

Usually realized by statements, though occasionally it is realized by questions. It usually occurs before an 'Elicit', and its purpose is either to provide information about or direct pupils' attention to the following 'Elicit'. For example, "We wouldn't say 'lo!' What would we say?"

Category 8: '***CHECK***'

Realized by a closed class of questions such as "O.K.?" , "Finished?" "Ready?" It helps the teacher to know the progress of the lesson and usually occurs when the teacher wants to move from one task or topic to another.

II. 'Teacher-Respond'

Category 9: '***EVALUATE***'

This act is vital in classroom interaction because pupils need to know whether they have performed adequately or not.

This act is classified into two types:

a) Encouraging/Positive Evaluation: realized by a closed class of words or phrases such as "good", "excellent" or "that is very interesting", "you're close to it". It is a positive response to contributions made by pupils.

b) Negative Evaluation: realized by words or phrases such as "no", "nonsense" or repetition of pupils' response with a rising intonation. For example, "It isn't? I think it's warm today." It rejects pupils' response.

Category 10: '***ACCEPT***'

Realized by "yes", "right" or repeating pupils' response with low fall intonation. This act serves to confirm that the teacher has heard the response and that it is an appropriate one. It may precede or replace and 'Evaluate' in the feedback from the teacher.

Category 11: '***COMMENT***'

Realized by statements and tag questions. The function of this act is to expand, develop or provide additional information to the response given by a pupil. It can also serve to express the teacher's personal opinion of the pupil's response.

This act often follows an 'Evaluate'. For example, "Yes, I think he was drowned because later the crocodile reappeared, didn't he"

Categories 12: '***CLUE***'

Realized by statements or questions or phrases. This act serves to help pupils to respond to elicitations or comply with directions. It can be performed by providing information or language structures, or allowing pupils to express themselves in L1. For example, "What equation do you think the king put to Uba-na-ner? *Isn't stated in the passage, you have to think out the question yourself."*

III. 'Pupil-Respond'

Category 13: '***REPLY***'

It provides a linguistic response to 'Elicit'. It is classified into: a) Restricted Reply; and b) Expanded Reply. The former is often realized by either one word or a short phrase. For example, T: "Where was she? Yes?" P: "*on the boat*". The latter expresses judgment, evaluation and the like. It is realized by statements. For example, T: "Is there a clue in the passage that tells you it is a bird?" P: "*The passage says that her skirt is made of the feather of cormorant*."

Category 14: '***APOLOGIZE***'

Realized by a closed class of statements or phrases such as "I'm sorry but _____" or "Sorry, I don't know the answer, fails to understand the question or to comply with the teacher's directions.

IV. 'Pupil-Initiate'

Category 15: '***REQUEST***'

Realized by the same class of items as category 2. Its function is to ask for permission to perform a non-verbal action. For example, "Sir, may I turn off the fan?"

Category 16: '***ELICIT***'

It has the same linguistic realization as category 1. As distinguished from category 16, which asks for permission, this act asks for verbal response from the teacher or fellow pupils. This is employed when pupils want to raise questions, clarify information or ask for explanation.

Category 17: '***INTERRUPT***'

Realized by phrases such as "Excuse me_____" or "Can I just interrupt?" This act is similar to category 17 in that it also serves to raise questions and ask for clarification except that it stops the on-going discourse.

Additional Categories added by Lo (2010)

Category 18: 'READ ALOUD'

Usually realised by statements. It refers to those teachers' utterances that read aloud the sentences on students' notes, worksheets, or teachers' PowerPoint slides. This act is different from the act 'INFORM' in the sense that the teacher does not aim at giving student information. He simply reads aloud something exactly as it is on the notes.

Category 19: **'TRANSLATE'**

Usually realised by statements. It refers to those teachers' utterances that translate the English utterances on the notes or worksheets which they have just read aloud to the students. Therefore, it usually comes immediately after 'READ ALOUD'. This act is different from 'INFORM' in the sense that the utterances are simply the translation of the previous English sentences, and the teachers do not provide any additional explanation or information.

Category 20: 'REPRIMAND/APPLAUD'

Realised by statements. They are teachers' utterances that comment on students' behaviours. It is different from the act 'COMMENT' in the sense that it is not the teachers' response to students' replies. Instead, it is usually initiated by the teachers to comment on students' behaviours.

Category 21: 'SELF UTTERANCE'

Realised by statements or rhetoric questions. It refers to those utterances that the teacher speaks to himself/herself. It does not aim at eliciting students' responses.

Category 22: 'ANSWERING QUESTIONS'

Realised by statements. It serves to answer students' questions. It is an act that teachers respond to students, which is different from the acts 'Evaluate', 'Accept', 'Comment', and 'Clue'.

Category 23: 'PARDON'

As the name suggests, this act refers to the utterances that the teachers want to show they cannot hear the speakers. It is realised by some limited expressions, such as 'Pardon?', 'What?', or 'Sorry'…etc. It is a rather unique type of act that cannot fit into any of the acts in the Seventeen-Category System.

Category 24: 'EXPRESS OPINIONS'

Realised by statements. It refers to those utterances produced by the students who would like to express their opinions or comment on what the teachers have said. These utterances are not 'Elicit', as the students do not want to elicit the teachers' response. They are not 'Interrupt', either, because they appear when the teachers finish their utterances and there are pauses.

Appendix P

Taxonomy of teacher's feedbacks to students' responses in science classroom

Here is the framework of different types of teacher's feedbacks to students based on Chin's work in junior science classrooms in Singapore Chin (Chin, 2006, p. 1337). The following section describes the meaning of each student's response and the corresponding feedbacks and their key utterance based on the IRF exchange model (see Table 12).

Table 12. Types of feedback to students' response in the 'F'move of the IRF exchange model in science classroom (Chin, 2006, p. 1326)

Nature of student's response	Type of feedback	Predominant nature of key utterances	Description
Correct	(a) Affirmation-Direct instruction	C-Q, C-S	Affirm and reinforce response followed by further exposition and direct instruction
Mixture of correct and incorrect	(b) Extension by responsive questioning: Focusing and Zooming	C-Q	Accept response followed by a series of related questions that build on previous ones to probe or extend conceptual thinking
Incorrect	(c) Explicit correction– Direct instruction	S-Q, S	Explicit correction followed by further expounding of the normative ideas Evaluative or neutral comment followed by

	(d) Constructive challenge	C-Q, Q	reformulation of the question or challenge via another question

Note: C, teacher comment; Q, teacher question; S, teacher statement.

In Chin's study, the follow-up or feedback (F) given by the teachers in the IRF sequence can be in the form of a comment or statement followed by either another question, or further statements that expounded more scientific content.

In other words, in Chin's discussion (Chin, 2006, p. 1326), the teacher's feedbacks can be divided into three types: a "comment– question" (C–Q) or "statement–question" (S–Q) couplet where the question component of the couplet might be regarded as overlapping with the initiation or "I" move of the next IRF sequence. However, if no questions were asked, it took the form of a "comment–statement" (C–S) couplet. At times, feedback consisted of only comments (C) or statements (S).

The column titled "Move" indicates the form of the utterance (I, R, or F) while the column labeled "Purpose of utterance" represents the purpose or function in that discourse move (e.g., elicit, reply, probe, extend). Entries in the column titled "Type of utterance" indicate whether the utterance is in the form of a question, answer, statement, comment, or a combination of more than one type. Taken together, these three components (namely, move, purpose, and type of utterance) represent the "interactive" aspect of the discourse. The final column, entitled "cognitive process", indicates the thinking processes associated with students' utterances. Chin summarized the inter-relationship of different types of teacher's acts in the IRF sequence which stimulate more student's responses in facilitating science interactive learning (See Figure 3). Chin, in her analysis of junior science classrooms, suggested a number of conditions when science teachers consider applying different types of feedbacks in facilitating science

teaching. The decision of using different teacher's feedback depends on 1) nature of student's responses, nature or difficulty level of teaching topic, ability level of students, available time and teacher's skills and preferred teaching styles. Table 13 also summarizes the conditions when science teacher could use the teacher's feedbacks.

Table 1. Sample excerpt based on the "Questioning-based Discourse" framework

Speaker	Utterance	Move	Type of utterance	Purpose of utterance	Cognitive process
Teacher	What are the factors that affect the rate of dissolving? … What do you think? …	I	Q	Elicit	–
Student 1	Temperature of solvent.	R	A	Reply	Hypothesize/recall
Teacher	Temperature of solvent. What else?	F–I	C–Q	Accept, elicit	–
Student 2	The rate of stirring.	R	A	Reply	Hypothesize/recall
Teacher	The rate of stirring. How fast you stir it. And also? Yes?	F–I	C–Q	Accept, elicit	–
Student 3	The volume of the solvent.	R	A	Reply	Hypothesize/recall
Teacher	Yes. To be more specific, we are talking about size of solute … surface area … What do you observe in daily life that has a relation to the … size of solute?. … Let's say, in the morning when you make a cup of Milo or a cup of coffee … You want to make it sweet. What do you use?	F–I	S–Q	Focus, elicit	–
Students	Sugar.	R	A	Reply	Recall
Teacher	You think of sugar. And does … the size of sugar have an effect? …	F–I	C–Q	Probe	–
Student	Yes. (The student then shared his observation that sugar is sold in both fine and coarse grained forms).	R	A	Reply	Observe
Teacher	What type of sugar would you like to use?	I	Q	Probe	–
Students	Fine grain sugar.	R	A	Reply	Evaluate
Teacher	Fine grain sugar. Why would you like to use fine grain sugar? Yes, anyone wants to share?	F–I	C–Q	Probe	–
Student	Because size of solute affects the rate of dissolving.	R	A	Reply, justify	Explain
Teacher	So you find that, uh, does it dissolve faster or slower?	F–I	Q	Extend	–
Student	Faster.	R	A	Reply	Compare
Teacher	Faster. Okay, what is the theory behind here? Can anyone propose? …	F–I	C–Q	Accept, elicit	–
Student	Because the size of solute is smaller and covers more surface area …	R	A	Reply	Hypothesize
Teacher	Let's say, we have this cube A represents sugar. And we take this cube A and break it into many, many tiny cubes … There is a lot of it and all of them will have the same volume as this. So which has larger surface area? A or B?	F–I	S–Q	Focus, elicit	–

Figure 3. Chin's framework of the purpose of teachers' utterance during facilitative IRF iteration. (Chin, 2006, p. 1337)

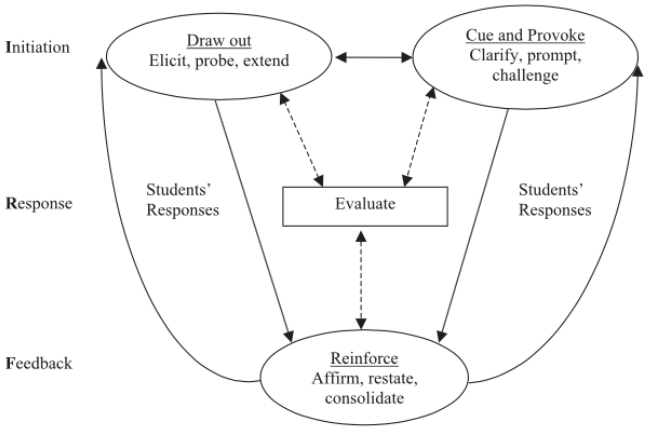


Figure 1. Purpose of teachers' utterances during facilitative IRF iterations

Table 13. Conditions under which types of teacher feedbacks science teacher could use in teaching science(Chin, 2006, p. 1339)

Table 7. Conditions under which each type of feedback may be used

Conditions under which feedback may be used	Type of feedback			
	Affirmation–Direct instruction	Focusing and Zooming	Explicit correction–Direct instruction	Reconstructive challenge
Nature of students' responses				
When students' answers are scientifically correct	✓			
When students' responses contain both correct and incorrect ideas		✓		
When students' answers are scientifically incorrect or insufficiently detailed			✓	✓
Nature or difficulty level of topic				
When new scientific vocabulary needs to be introduced	✓			
When concepts addressed are familiar to or within grasp of the students		✓		✓
When concepts addressed may be too difficult for students to handle on their own			✓	
Ability level of students				
When teacher believes students may not be capable of formulating or reasoning out the answers on their own	✓		✓	
When teacher believes students are capable of thinking at progressively higher levels (e.g. relational and extended abstract levels of the SOLO taxonomy)		✓		✓
Time available				
When there are constraints in curriculum time	✓		✓	
When time is available for extended classroom discourse		✓		✓
Teacher's epistemology, skills, and preferred teaching style				
When teacher views that dispensing information or teaching via exposition is appropriate	✓		✓	
When teacher subscribes to a constructivist epistemology		✓		✓

Appendix Q

The science pedagogy of the 8 biology lessons between early-full and partial-late EMI science classrooms

As presented in chapter 5 using Mortimer & Scott's framework (2003).

A. early-full EMI schools (School A and C)

School A, early-full EMI (Grade 11, biology) T1 Mr. Wong	
Topic: Antibodies	
Teaching purpose	Exploring on students' ideas about the antibodies. Working on the daily examples/ related science concepts of antibiotics (Bacteria, pathogens, Penicillin) in order to increase students' awareness of the proper use of antibiotics
Content	Establishing the empirical, descriptive generalisation to of the function of antibiotics, factors that related to the effectiveness of antibiotics (temperature, size, distance of diffusion, molecular size), and the biological mechanism of antibodies when inhibiting the cell growth (inhibit the growth of bacterial cell wall).
Approach	Interactive/authoritative
Patterns of interaction	I-R-F
Forms of interactions	Checking student understanding. Reviewing, selecting and sharing ideas with whole class.

School A, early-full EMI, (Grade 10, biology) T1 Mr. Wong	
Topic: photosynthesis	
Teaching purpose	Guiding students to apply their prerequisite knowledge in a lab experiment to predict factors that affect the process of photosynthesis and to explain the observable lab results.
Content	Teacher recalls students' learned concepts in photosynthesis (gas exchange, the role of chlorophyll) and develops their understanding of the process of photosynthesis. Establishing the empirical descriptions to make connection to the possible factors that lead to the limitations of the experiment design, control set-up and testing methods
Approach	Interactive/authoritative and interactive/dialogic
Patterns of interaction	I-R-F-R-F and I-R-F
Forms of interactions	Checking student understanding. Reviewing, selecting, marking and sharing ideas with whole class.

School C, early-full EMI (Grade 10, biology) T4 Mr. Wong	
Topic: Photosynthesis	
Teaching purpose	Exploring students' ideas about the biological functions of photosynthesis to plants and the possible factors that enhance or limit the process of photosynthesis through a lab experiment. Guiding students to use their understanding of photosynthesis to predict the experimental results, limitation of the experimental design and sources of errors.
Content	Establishing the empirical descriptions of the mechanism of photosynthesis and the reciprocal relationship of the respiration process in plants, in order to make connection to the possible factors that lead to the limitations of the experiment design, factors affect the rate of photosynthesis and limitations of the experiment design.
Approach	Interactive/authoritative and interactive/dialogic
Patterns of interaction	I-R-F-R-F and I-R-F
Forms of interactions	Checking student understanding. Selecting and sharing ideas with whole class. Reviewing and marking ideas with whole class.

B. late-partial EMI schools (School F and C)

School F, late-partial EMI (Grade 11, biology) T9 Mr. Law	
Topic: Immune system	
Teaching purpose	Exploring and working students' ideas about the related concepts of immune responses. Introducing and developing students' scientific understanding of the characteristics of immune system, the different types of cells in immune system (Helper T cells recognise antigen; B cell targets the pathogen.), and the mechanism of developing an immune response in human body (targeting specific pathogens). Guiding students to apply their understanding of immune system to make sense of common diseases in everyday life. For example, the HIV virus destroys the helper T cell, thus the specific immune response is inhabited.
Content	Establishing the empirical descriptions of the mechanism of immune responses in human body in order to help students to understand the importance of immune response to human, and the biological meaning behind vaccination, antibodies (artificial immunity), mother's breast feeding (passive immunity).
Approach	Interactive/authoritative
Patterns of interaction	I-R-F
Forms of interactions	Checking student understanding. Reviewing and sharing ideas with whole class.

School F, late-partial EMI (Grade 10, biology) T9 Mr. Law	
Topic: fertilization	
Teaching purpose	Exploring students' ideas about the mechanism of fertilization & ovulation, the biological meanings of different stages of menstrual cycle, the characteristics of male and female reproductive structures (ova and sperm), their structures and their roles in fertilization.
Content	Establishing the empirical descriptions of the mechanism of fertilization in order to help students to understand the biological meanings behind the differences in secondary sexual characteristics between boys and girls.
Approach	Interactive/authoritative
Patterns of interaction	I-R-F
Forms of interactions	Checking student understanding. Reviewing and sharing ideas with whole class.

School G, late-partial EMI (Grade 11, biology) T15 Mr. Ng	
Topic: *ecosystems (*Prey and predator)	
Teaching purpose	Exploring and working with students' ideas about the relationship between prey and predator, and their biological functions in ecosystem.
Content	Establishing the empirical descriptions of the reciprocal relationship between prey and predator in ecosystem in order to help students to understand the prey and predator are in competition of food, space and resources and the predator plays an important role in maintaining a balanced ecosystem.
Approach	Interactive/authoritative
Patterns of interaction	I-R-F
Forms of interactions	Checking student understanding. Reviewing marking and sharing ideas with whole class.

School G, late-partial EMI (Grade 11, biology) T10 Mr. Lee	
Topic: Capillaries	
Teaching purpose	Exploring students' ideas how materials are exchanged in human body through our blood vessels, and capillaries (smallest body's blood vessels), together with the blood flows from the heart through arteries.
Content	Establishing the empirical descriptions of the characteristics of capillaries, the structure (high surface area) in facilitating materials exchange (Glucose, oxygen, amino acid, carbon dioxide, waste, water, plasma) between body cells and blood cells, the important role of capillaries in facilitating the two parts of circulation of blood throughout the body (systematic circulation and pulmonary circulation).
Approach	Interactive/authoritative
Patterns of interaction	I-R-F and I-R-F-R-F
Forms of interactions	Checking student understanding. Reviewing and sharing ideas with whole class.

Appendix R

Summary of the science pedagogy in the all the observed EMI science lessons

Grade 10, early-full EMI schools (n=5)

School	Teacher	Subject	Science topics	Teaching purpose	Content	Approach	Patterns of interaction	Forms of interaction
A	T1	Biology	The process of photosynthesis [Teacher's Lab demonstration]	Guiding students to work with scientific ideas and supporting internalisation	Establishing the empirical descriptions	Interactive/ Authoritative	I-R-F-R-F and I-R-F	Checking student understanding; sharing ideas; Marking key ideas
C	T4	Biology	Photosynthesis [Lab experiment]	Exploring students' science ideas; Guiding students to use their understanding to interpret the science concept	Establishing the empirical descriptions	Interactive/ Authoritative	I-R-F-R-F and I-R-F	Checking student understanding. Selecting and sharing ideas with whole class.

								Reviewing and marking ideas with whole class.
D	T6	Biology	Genetic materials of plants; fertilization;	Opening up the problem; Introducing and developing the scientific story	Establishing the empirical generalisation	Non-Interactive/ Authoritative	I-R-F	Checking student understanding
D	T5	Chemistry	Petroleum, consequences of using excessive fossil fuels	Introducing and developing the scientific story	Establishing the empirical descriptions	Non-Interactive/ Authoritative	I-R-F (minimal)	Checking student understanding;
B	T2	Physics	Motions; the concepts of gravity, acceleration	Introducing and developing the scientific story; Guiding students to work with scientific ideas and supporting internalisation	Establishing the theoretical descriptions	Interactive/ Authoritative	I-R-F-R-F and I-R-F	Checking student understanding. Selecting and sharing ideas with whole class. Reviewing and marking ideas with whole class

Grade 11, early-full EMI schools (n=5)

School	Teacher	Subject	Science topics	Teaching purpose	Content	Approach	Patterns of interaction	Forms of interaction
A	T1	Biology	Antibiotics	Opening up the problem; Exploring and working on students' views	Establishing descriptive generalisations;	Interactive/ Authoritative	I-R-F	Checking student understanding. Selecting and sharing ideas with whole class. Reviewing and marking ideas with whole class
C	T4	Biology	Coronary heart disease	Guiding students to work with scientific ideas and supporting internalisation; Maintaining the development of the scientific story	Establishing empirical explanation;	Interactive/ Dialogic	I-R-F and I-R-F-R-F	Shaping, selecting, marking ideas; Checking student understanding; Reviewing
D	T6	Biology	Investigation of vitamin C in fruits (grape, kiwi fruit, lemon and orange).	Guiding students to work with scientific ideas and supporting internalisation;	Establishing empirical description	Non-interactive/ Authoritative	I-R-F	Checking student understanding;

D	T5	Chemistry	Reactions of Haloalkane	Introducing and developing the scientific story	Establishing the empirical descriptions	Non-interactive/ Authoritative	I-R-F (minimal)	Checking student understanding;
B	T3	Physics	Calculation of resistance in circuit; Ohm's law	Introducing and developing the scientific story	Establishing the empirical explanation	Interactive/ Authoritative	I-R-F	Checking student understanding. Reviewing and marking ideas with whole class

Grade 11, early-full EMI schools (n=5)

School	Teacher	Subject	Science topics	Teaching purpose	Content	Approach	Patterns of interaction	Forms of interaction
A	T1	Biology	Antibiotics	Opening up the problem; Exploring and working on students' views	Establishing descriptive generalisations;	Interactive/ Authoritative	I-R-F	Checking student understanding. Selecting and sharing ideas with whole class. Reviewing and marking ideas with whole class
C	T4	Biology	Coronary heart disease	Guiding students to work with scientific ideas and supporting internalisation; Maintaining the development of the scientific story	Establishing empirical explanation;	Interactive/ Dialogic	I-R-F and I-R-F-R-F	Shaping, selecting, marking ideas; Checking student understanding; Reviewing
D	T6	Biology	Investigation of vitamin C in fruits (grape, kiwi fruit, lemon and orange).	Guiding students to work with scientific ideas and supporting internalisation;	Establishing empirical description	Non-interactive/ Authoritative	I-R-F	Checking student understanding;

D	T5	Chemistry	Reactions of Haloalkane	Introducing and developing the scientific story	Establishing the empirical descriptions	Non-interactive/ Authoritative	I-R-F (minimal)	Checking student understanding;
B	T3	Physics	Calculation of resistance in circuit; Ohm's law	Introducing and developing the scientific story	Establishing the empirical explanation	Interactive/ Authoritative	I-R-F	Checking student understanding. Reviewing and marking ideas with whole class

Grade 10, late-partial EMI schools (n=6)

School	Teacher Code	Subject	Science topics	Teaching purpose	Content	Approach	Patterns of interaction	Forms of interaction
F	T9	Biology	Human Reproduction; fertilization and ovulation, menstrual cycle	Exploring and working on students' views; Guiding students to apply, and expand on the use of, the scientific view	Establishing the empirical explanation	Interactive/ Authoritative	I-R-F and I-R-F-R-F	Marking key ideas; Checking student understanding. Reviewing and marking ideas with whole class
G	T10	Biology	The mechanism of materials exchanges in human body through our blood vessels, and capillaries	Introducing and developing the scientific story;	Establishing the descriptive generalisation	Interactive/ Authoritative	I-R-F	Checking student understanding; Reviewing ideas
E	T7	Chemistry	Redox reactions (oxidation, reduction)	Guiding students to work with scientific ideas and supporting internalisation	Establishing the empirical explanation	Non-interactive/ authoritative	I-R-F	Checking student understanding; Reviewing ideas

G	T16	Chemistry	Common alkali in daily life (sodium hydroxide, potassium hydroxide, magnesium oxide, aluminium oxide),	Introducing and developing the scientific story	Establishing descriptive generalisations;	Interactive/ Authoritative	I-R-F	Checking student understanding;
G	T16	Chemistry	Alkali properties and hydroxide ions	Introducing and developing the scientific story	Establishing descriptive generalisations;	Interactive/ Authoritative	I-R-F	Checking student understanding;
G	T16	Chemistry	Acids and alkalis [Lab experiment]	Guiding students to apply, and expand on the use of, the scientific view, and handing over responsibility for its use	Establishing the empirical explanation	Interactive/ Authoritative	I-R-F/ I-R-F-R-F	Marking key ideas; Checking student understanding. Reviewing and marking ideas with whole class

Grade 11, late-partial EMI schools (n=6)

School	Teacher Code	Subject	Science topics	Teaching purpose	Content	Approach	Patterns of interaction	Forms of interaction
G	T11	Chemistry	Common acids in laboratory (HCl, H_2SO_4, HNO_3) and their reactions with metal, metal oxides, metal hydroxides	Introducing and developing the scientific story	Establishing descriptive generalisations;	Interactive/ Authoritative	I-R-F	Checking student understanding;
G	T11	Chemistry	Reactions with acid [Lab experiment]	Guiding students to apply, and expand on the use of, the scientific view, and handing over responsibility for its use	Establishing the empirical explanation	Interactive/ Authoritative	I-R-F	Marking key ideas; Checking student understanding. Reviewing and marking ideas with whole class
H	T18,	Chemistry	Calculation of the empirical formula CxHyOz of an unknown	Introducing and developing the scientific story	Establishing the empirical descriptions	Non-Interactive/ Authoritative	I-R-F (minimal)	Checking student understanding;

			hydrocarbon compound					
G	T14	Physics	Transverse stationary wave	*Opening up the problem; Exploring and working on students' views; Introducing and developing the scientific story*	Establishing the empirical explanation	Interactive/ Authoritative	I-R-F	Marking, selecting, shaping ideas; Reviewing and marking ideas with whole class
G	T14	Physics	Stationary wave	*Opening up the problem; Exploring and working on students' views; Introducing and developing the scientific story*	Establishing the empirical explanation	Interactive/ Authoritative	I-R-F	Marking, selecting, shaping ideas; Reviewing and marking ideas with whole class
H	T17	Physics	Force, Displacement, Distance	Introducing and developing the scientific story	Establishing the empirical descriptions	Non-Interactive/ Authoritative	I-R-F	Checking student understanding;

School	Teacher	Subject	Science topics	Teaching purpose	Content	Approach	Patterns of interaction	Forms of interaction
A	T1	Biology	The process of photosynthesis [Teacher's Lab demonstration]	Guiding students to work with scientific ideas and supporting internalisation	Establishing the empirical descriptions	Interactive/ Authoritative	I-R-F-R-F and I-R-F	Checking student understanding; sharing ideas; Marking key ideas
C	T4	Biology	Photosynthesis [Lab experiment]	Exploring students' science ideas; Guiding students to use their understanding to interpret the science concept	Establishing the empirical descriptions	Interactive/ Authoritative	I-R-F-R-F and I-R-F	Checking student understanding. Selecting and sharing ideas with whole class. Reviewing and marking ideas with whole class.
D	T6	Biology	Genetic materials of plants; fertilization;	Opening up the problem; Introducing and developing the scientific story	Establishing the empirical generalisation	Non-Interactive/ Authoritative	I-R-F	Checking student understanding
D	T5	Chemistry	Petroleum, consequences of using excessive fossil fuels	Introducing and developing the scientific story	Establishing the empirical descriptions	Non-Interactive/ Authoritative	I-R-F (minimal)	Checking student understanding;

B	T2	Physics	Motions; the concepts of gravity, acceleration	Introducing and developing the scientific story; Guiding students to work with scientific ideas and supporting internalisation	Establishing the theoretical descriptions	Interactive/ Authoritative	I-R-F-R-F and I-R-F	Checking student understanding. Selecting and sharing ideas with whole class. Reviewing and marking ideas with whole class

Appendix S
Academic CV

Jack Pun

CV: May, 17

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Address: University of Oxford, Department of Education, 15 Norham Gardens, Oxford, United Kingdom, OX2 6PY

Nationality: Hong Kong Chinese

Website: https://jackpunblog.wordpress.com

Language: Cantonese (native), Mandarin (fluent), English (fluent), Japanese (intermediate), Korean (intermediate)

Education

Oct 2013-Feb 2017 (expected)	DPhil (PhD Candidate) in Education (Applied Linguistics), University of Oxford
2013	Harvard Macy Scholar, Harvard Macy Institute at Harvard Medical School, Harvard University, USA
2010-2011	Master of Arts in English Language Studies (Distinction)
	The Hong Kong Polytechnic University
2006-2010	Bachelor of Science in Chemical Technology (Hons) and a Minor degree in English Language Studies for the Professions
	The Hong Kong Polytechnic University

Research Positions

July-August 2015	Visiting Scholar, LSA Summer Institute, University of Chicago, USA
2013-now	Research Fellow, The International Research Centre for Communication in Healthcare, The Hong Kong

	Polytechnic University & The University of Technology Sydney
September 2010-October 2013	Research Associate, Department of English, The Hong Kong Polytechnic University
February 2012	Visiting Scholar at Faculty of Arts and Social Sciences, University of Technology, Sydney, Australia
July—August 2011	Visiting Scholar, LSA Summer Institute, University of Colorado at Boulder, USA

Teaching Experiences

Teaching Experiences----University lecturer

- Taught undergraduate and master students; marked their essays, participated in evaluation of their oral presentations and co-supervised the undergraduate research projects for 2 students.
- Led a range of university lectures and seminars for both undergraduate and master students in the English department.

2016 Sep-Nov	Part-time lecturer for a Master course to two programmes: (English Language Education) and LAC (Language Across Curriculum) students, Methods of Research and enquiry (MEDD 6014), University of Hong Kong, Faculty of Education, English Language Division This course consists of 10-module of lectures and workshop, which examines different approaches to conducting research in English language education, including experimental, naturalistic, critical and action research. I am responsible for 3 lectures and nearly all the workshops to guide for the master students in English Language Studies to develop their research proposal for their Master dissertation, provide feedback to students on different stages of research process, including development of research questions and formulation of their research design, methods of data collection, data analysis and writing up. I was co-teaching with Prof. David Carless and Dr. Lo Yuen Yi from the ELE division.

University instructor

- Taught undergraduate and master students; marked their essays, participated in evaluation of their oral presentations and co-supervised the undergraduate research projects for 2 students.

- Led a range of university lectures and seminars for both undergraduate and master students in the English department.

2015 Instructor for Master course, Research Method and Design (ENGL518), The Hong Kong Polytechnic University, Department of English (Co-teaching, marking with Prof. Diana Slade for both lectures and seminars).

This course covers fundamental concepts in research design. I was responsible for teaching a number of research methods (quantitative, qualitative and multi-method approaches), helped student to identify, develop research questions, conduct literature review, define variables, sampling, and design research instruments. I also helped students to understand different research methods (case studies, experimental studies, action research, questionnaire design, interviews, observations) and data analysis (discourse analysis, content analysis, statistical analysis) in the field of educational and language research.

2011 Instructor for English Undergraduate course, English Discourse for the Profession (ENGL305),

Instructor for English Master course, Discourse Analysis (ENGL519),

The Hong Kong Polytechnic University, Department of English (Co-teaching with Prof. Diana Slade for both lectures and seminars)

Both ENGL 305 & 519 courses covers fundamental concepts in discourse analysis at undergraduate and master levels. I was responsible for teaching students the definition, different approaches to discourse analysis, the differences between written and spoken language; and genre analysis. I helped students to develop their ability to critically apply discourse analytical theories to the learning and teaching of a variety of authentic written and spoken discourse.

Research skills

- Knowledge of methodologies in educational and language research.

- Extensive experiences of conducting qualitative, quantitative mixed-method research,

- Solid statistical (t-test, ANOVA, MNOVA, Linear/multiple regression, factor analysis, Structural equation modeling) and computing skills (NVivo)

- Strong communication skills in both Chinese and English languages (writing and oral presentations)

- Strong presentation skills: presented data clearly and confidently in 30 international academic conferences around the world.

- Strong academic writing skills: summarizing, synthesizing, writing, academic articles: wrote scientific articles in international peer-reviewed journals; wrote funding application for Hong Kong (e.g. UGC) and Overseas research funding bodies (e.g. ARC for Australia)

- Managed several large-scale interdisciplinary projects and collaborations with schools, hospitals, in parallel, planned work to achieve goals, set realistic objectives.

Selected Publications

Leung, C.C.H, **Pun, J**., Lock, G., Slade, D., Comersall, C.D., Wong, W.T., Joynt, G.M., (submitted) Exploration of the Scope of Communication Needs of Mechanically Ventilated Patients. *Critical Care*.

Slade, D., Eggins, S., Murray K., Wong F., **Pun, J**. (submitted). Participants' evaluation of communication training for nurses on bedside handovers: a case study in an Australian hospital, *Journal of Patient and Education Counselling*

Pun J, Matthiessen C.M.I.M, Williams G, Slade D. (forthcoming in 2017 Jan). Using ethnographic discourse analysis to understand doctor-patient interactions in clinical settings. *SAGE Research Methods Case*.

Pun J, E.A. Chan, Matthiessen C.M.I.M., Slade D, Murray K. (2016). Clinicians' perceptions of communication challenges in a trilingual emergency department in Hong Kong. *Journal of Clinical Nursing*

Slade D, **Pun J**, Lock G, Eggins S. (2016). Potential risk points in doctor-patient communication: an analysis of Hong Kong emergency department medical consultations. In Helen de Silva Joyce (Eds). (2016). Language at Work: Analysing Language Use in Work, Education, Medical and Museum Contexts, Newcastle: Cambridge Scholars Publishing, p.146-165

Slade, D., Matthiessen, C.M.I.M., Lock, G., **Pun J**. & Lam, M. (2016). The interplay of interpersional and experiential meanings in doctor-patient communication and its impact on health outcomes in a Hong Kong Accident and Emergency Department. In Ortega, L., Tyler, A., & Park, H.-

I. (Eds.). (forthcoming in 2016). The usage-based study of language learning and multilingualism. Washington, DC: Georgetown University Press.

Pun J, Matthiessen C.M.I.M., Slade D, Murray K. (2015). Factors affecting communication in emergency departments: doctors and nurses' perceptions of communication in a trilingual ED in Hong Kong. International Journal of Emergency Medicine, 8:48, DOI: 10.1186/s12245-015-0095-y

Chandler E., Slade D., **Pun J.**, Espindola E., Lock G., Matthiessen C.M.I.M. & Ng C. (2015). Communication in Hong Kong Accident & Emergency Departments: The Clinicians' Perspective, *Global Qualitative Nursing Research*, 2, 1-11

Slade D, Chandler E., **Pun J**, Lam M, Matthiessen C,M.I.M., Williams G., Espindola E., Veloso F., Tsui K.L., Tang S. & Tang K.S. (2015). Effective Healthcare Worker-Patient Communication in Hong Kong Accident & Emergency Departments, *Hong Kong Journal of Emergency Medicine*, 22(2), 69-83

Rider EA, Kurtz S, Slade D, Longmaid E. III HE, Ho MJ, **Pun K.H.**, Eggins S & Branch WT. (2014) The International Charter for Human Values in Healthcare: An interprofessional global collaboration to enhance values and communication in healthcare. *Patient Education and Counselling*, *96(3)*, 273-280. http://dx.doi.org/10.1016/ j.pec.2014.06.017 (IMPACT Factor 3.1)

Submitted Manuscripts or in-preparation

Pun, J. & Macaro, E. (in preparation). The role of the L1 in second language (L2) learning in Hong Kong Secondary EMI Science classrooms. *Special issue on L1 use in Content-based/CLIL settings, International Journal of Bilingualism and Bilingual Education*.

Macaro, E., Seiter, S., **Pun, J**., An J. & Dearden, J. (submitted). A systematic review of English medium instruction in higher education, *Language Teaching.*

Pun J, Zayts, O.,Wang, Slade, D. (in preparation). How Asian view doctor-patient Communication in East Asia? A systematic review. *Journal of Patient and Education counselling*.

Selected Conference Presentations

(Poster) Jack Pun 'Classroom interactions in different English medium of instruction secondary science classrooms' presented at the Research Poster Conference, Department of Education, University of Oxford, United Kingdom, (12th Oct, 2015)

(Poster) Jack Pun 'Teaching and learning science through English: Classroom interactions, teachers' and students' perceptions and attitudes in Hong Kong' presented at 2015 LSA (Linguistic Association of America) Summer Institute, Department of Linguistics, University of Chicago, United States, (28th July, 2015)

(Refereed conference paper) Jack Pun & Diana Slade, 'Patient involvement in shared decision-making in a Hong Kong trilingual Emergency Department', oral paper presented at, Interdisciplinary Conference on Communication, Medicine and Ethics (COMET), University of Hong Kong, 25 & 26th June, 2015

(Colloquium) Jack Pun, Daniel McDonald, Christian M.I.M. Matthiessen, Diana Slade, Marvin Lam, Suzanne Eggins, 'Functional linguistic exploration of healthcare communication: theoretical and methodological issues' Work-in-progress roundtable and panel discussion presented at, Interdisciplinary Conference on Communication, Medicine and Ethics (COMET), University of Hong Kong, 25 & 26th June, 2015

(Poster) Jack Pun 'On-going study: Teaching and learning process in EMI science classrooms' presented at the 12th Annual Kaleidoscope Conference, Faculty of Education, University of Cambridge, United Kingdom, (28 & 29th May, 2015)

(Refereed conference paper) Diana Slade, Christian Matthiessen, Marvin Lam and Jack Pun, 'Patient involvement in shared decision-making in a Hong Kong trilingual Emergency Department', oral paper presented at 12th International Conference on Communication in Healthcare (ICCH), Amsterdam, the Netherlands, 1st October, 2014

(Refereed conference paper) Diana Slade and Jack Pun, 'Understanding the communication challenges in a bilingual emergency department: a linguistic perspective', 17th World Congress of Applied Linguistics, Brisbane, Australia, 15th August 2014

Jack Pun 'Classroom interactions in different English medium of instruction secondary science classrooms' presented at the Research Poster Conference, Department of Education, University of Oxford, United Kingdom, (12th Oct, 2015)

(Poster) Jack Pun 'Teaching and learning science through English: Classroom interactions, teachers' and students' perceptions and attitudes in Hong Kong' presented at 2015 LSA (Linguistic Association of America) Summer Institute, Department of Linguistics, University of Chicago, United States, (28th July, 2015)

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(Colloquium) Jack Pun, Daniel McDonald, Christian M.I.M. Matthiessen, Diana Slade, Marvin Lam, Suzanne Eggins, 'Functional linguistic exploration of healthcare communication: theoretical and methodological issues' Work-in-progress roundtable and panel discussion presented at, Interdisciplinary Conference on Communication, Medicine and Ethics (COMET), University of Hong Kong, 25 & 26th June, 2015

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(Refereed conference paper) Diana Slade, Christian Matthiessen, Marvin Lam and **Jack Pun**, 'Patient involvement in shared decision-making in a Hong Kong trilingual Emergency Department', oral paper presented at 12th International Conference on Communication in Healthcare (ICCH), Amsterdam, the Netherlands, 1st October, 2014

(Refereed conference paper) Diana Slade and **Jack Pun**, 'Understanding the communication challenges in a bilingual emergency department: a linguistic perspective', 17th World Congress of Applied Linguistics, Brisbane, Australia, 15th August 2014

(Refereed conference paper) Diana Slade, Marvin Lam, Christian M.I.M. Matthiessen and **Jack Pun**, Kazuhiro Teruya, 'Exploring doctor-patient communication in high stress contexts: Patient involvement in shared decision-making in a Hong Kong trilingual emergency department' Interdisciplinary Conference on Communication, Medicine and Ethics (COMET), Università della Svizzera italiana, Lugano, Switzerland, 26th June, 2014

Research Experiences

From September 2011 to October 2013

Project manager and Research Associate

A research group in the Hong Kong Polytechnic University focusing on personalized healthcare, with specific focus on the investigation of communication between patients and healthcare professions in Accident & Emergency Department.

From June to September 2011

Research Assistant

Department of English, The Hong Kong Polytechnic University, I was a project manager of the four research projects

(Total amount: HKD 630,711 =USD $ 81,381)

1. Effective Clinical Handover Communication: Improving Patient Safety, Experiences and Outcomes (HKD 320,711)

2. Emergency Communication: Analysing the Significance of Interpersonal Meanings during Clinician-patient Interaction (HKD$ 80,000)

3. Emergency Communication: Improving the Quality and Safety of Patient Care through Effective Communication (HKD $150,000)

4. Emergency Communication: an Ethnographic and Statistical Analysis of Clinicians and Patent's Perception of Communication Effectiveness in Accident and Emergency Department (HKD $80,000)

My roles and responsibilities:

- To prepare large grant applications to Hong Kong government (University Grants Committee (UGC) e.g. General Research Fund (GRF) and Collaborative Research Fund (CRF) applications)
- To prepare ethics applications and co-ordinate the briefing and meetings with the hospital
- To conduct interviews with 30 key clinicians, doctors, nurses working in one of the busiest emergency department in Hong Kong and recorded 10 patient journeys from triage to deposition
- To observe and audio-record 80-hour journeys of 10 patients from triage to deposition from emergency department
- To transcribe, translate and analyze approximately 60 hours of interviews and clinical communication between patients and healthcare professionals.
- To conduct analysis of the questionnaires and interviews with 58 medical doctors and nurses about their perceptions towards clinical communication at high-risk setting like emergency department
- To perform statistical analysis of the questionnaire data in order to explore any group differences of clinician's attitudes and their communication challenges in emergency communication.

Computer Skills

SPSS (t-test, ANOVA, MNOVA, Linear/multiple regression, factor analysis, Structural equation modeling), NVivo, Corpora utilization, UAM CorpusTool, Wordsmith Tools, Praat, ELAN, FLEX, Audio editing, MS Office, Mac operation system

Appendix T

Conference posters

1. (presented at OUED)

2. (presented at University of Cambridge, Faculty of Education)

3. (presented at OUED, stories conference)

Classroom Interaction in Hong Kong EMI Secondary Science Classrooms



Jack Pun, DPhil Student *kwok.pun@education.ox.ac.uk*

Department of Education, University of Oxford

Summary

My doctoral research involves comparing classroom interactions in different types of EMI secondary science classrooms in Hong Kong and exploring teachers' and students' perceptions on EMI experiences, particularly, their language challenges and coping strategies for teaching and learning science through English.

1. Introduction

•Teaching science through a second language (L2 instruction) is a growing phenomenon around the world; English is often the medium of instruction (EMI).

•Research into the effectiveness of EMI on science learning only compared students' science achievements under L1 and L2 (EMI) instruction; and concluded that EMI led to substantial disadvantages in teaching science. In particular, poor classroom interactions, poor understanding of science concepts,(Yip *et al*, 2003).

•Studies explored the quality of science learning in EMI classrooms have no consensus about the common language challenges and the most effective teaching and learning strategies (Othman & Saat, 2009).

•In Hong Kong, under the fine-tuning language policy in 2010, more teachers and students in Chinese-medium schools at senior levels (Grade 10-12) started to switched into English-medium. These teachers and students have no clue on how to adapt their teaching and learning from L1 to L2 instruction (Chan, 2014).

•Very limited research have yet explored the nature of classroom interactions in different types of EMI schools (100% EMI, partial EMI, MOI-switching schools) and the role of L1 in EMI classrooms (e.g. code-switching), as it has been constantly reported as one of the effective strategies in EMI classrooms.



2. Aims

- To explore the nature of classroom interactions in different types of EMI science classrooms between late EMI schools and very late EMI schools in Hong Kong (Grade 10 vs 11).
- To investigates these teachers' and students' perceptions of teaching and learning in EMI classrooms.

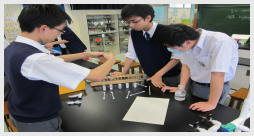
3. Research Questions

1.In the late and very late EMI classrooms, what are the differences and similarities in classroom interaction?

2.What are the differences and similarities in classroom interaction between Grades 10 and 11 in both types of schools?

3.What are teacher perceptions of learning science through EMI?

4.What are student perceptions of learning science through EMI?

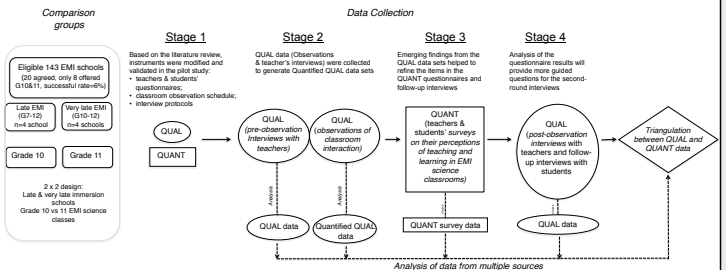






4. Research Design

Concurrent, multiphase, Mixed methods approach:
Comparison groups: 1) late EMI vs very late EMI 2) Grade 10 vs Grade 11 in each school type



5. Analysis of the Video-recorded observations

(n= 34 lessons, Late EMI schools=13 vs Very late EMI schools=21, Physics=8,Chemistry=10,Biology=16, Grade 10=15, Grade 11=19, with 796 students in 25 classes)

Quantifying the classroom interactions using *NVivo*, based on the integrated coding frameworks:

- no./types of teacher-student interactions, I-R-F sequences (Sinclair & Coulthard, 1975);
- teacher's pedagogical moves in L2 classrooms (Tsui, 1985);
- science teachers' questioning (Yip, 2004);
- science teachers' feedbacks (Chin, 2006)
- Frequency of L1/L2 instructional language(s) (Timed & Turn Analysis: Macaro, 2001; Macaro & Mutton, 2002) & code-mixing patterns, pedagogical uses of L1 (Lo & Macaro, 2012);

Qualitative analysis of different types of science classrooms, based on their communicative purposes (Mortimer & Scott, 2003), this includes: teaching purposes, content, communicative approach, pattern of interactions (IRF/IRFRF), teaching interventions.

Reliability of the coding (inter-rater reliability): around 10% of each type of data (observations, interviews) will be coded by two-raters independently.





6. Preliminary findings:

1) % of interaction time:

Late EMI schools (69%) and very late EMI (73%) had similar interaction time. The two groups had a drop in the interaction time from Grade 10 to 11. In the late EMI schools, the interaction time from Grade 10 to Grade 11 decreased from 73% to 64%. In very late EMI schools, it decreased from 77% to 68%.

2) % of teacher and student talk:

A similar distribution of talks between teachers and their students were observed in the two types of EMI schools. For late EMI schools, teachers contributed 89% and students contributed 11%. For very late EMI schools, teacher talk was 94% and student talk was 6%. From Grade 10 to 11, teacher talk increased in the late EMI schools (83%→96%) but student talk decreased (17%→4%); there is no significant changes in both teacher and student talk observed in the very late EMI schools (teacher:94%->93%; student: 6%->7%) .

3) Proportion of teacher and student turns

- Teachers and students in the very late EMI schools had relatively less number of turns than those in the late EMI schools. However, in the very late EMI schools, the averages of length of teacher turns and student turns were slightly shorter. The range of student turns in very late EMI schools was four times shorter.
- From Grade 10 to 11, In very late EMI schools, the average length of teacher turns slightly increased but the student turns decreased.
- In late EMI schools, the average length of teacher and student turns significantly decreased
- In addition, the range of student turns from Grade 10 to 11 was largely reduced in both types of schools.

4) L1 and L2 use

- A high percentage of L2 use was observed in late EMI schools, a more balanced percentages of L1 and L2 use was observed in the very late EMI schools.
- From Grade 10 to 11, a slightly increase of L1 use and a relative drop of L2 use in both type of schools were observed.

5) Most frequent pedagogical functions

- Similar ranking of frequent occurring pedagogical functions of teacher and student talk in both types of schools was observed: Inform> self-utterance> direct> reply; but more 'check' was observed in the late EMI schools; and 'express opinion' was observed in the very late EMI schools.
- From Grade 10 to 11, a similar pattern was observed. In the late EMI schools, 'self-utterance' was more frequent than 'check' at Grade 10 but such pattern was reversed in Grade 11. In the very late EMI schools, 'direct' was more frequent than 'self-utterance' but the result was reversed in Grade 11.

6) Initiations and responses

- In the late EMI schools, more teacher's initiations and responses were observed but student's initiations and responses were relatively less than those in the very late EMI schools
- From Grade 10 to 11, a similar proportion of initiations and responses between teachers and their students were observed in the two types of schools.

7) Teacher's feedbacks

- A similar distribution of teacher's feedbacks were observed in both types of schools and their frequency order was: Affirmation-direct instruction (71%; 74%)> extension by responsive questioning: focusing & zooming (11%; 9%)> explicit correction-direct instruction (13%; 10%) > constructive challenge (4%; 7%)
- From Grade 10 to 11, more Affirmation-direct instruction was observed in the late EMI schools but such pattern was reversed in the very late EMI schools.

8) Science teacher's questions

- More recalling questions were observed in the late EMI schools than those in the very late EMI schools.
- More higher order questions (analysis, evaluation) were observed in the very late EMI schools.
- More motivations were observed in the late EMI schools.
- From Grade 10 to 11, there was an increase in lower order questions in the late EMI schools. Similarly, there was an increase in higher order questions in the very late EMI schools.

7. Preliminary Conclusions

The late and very EMI science classrooms have similar interaction patterns (% of interaction time; no. of turn, teacher and student talk; frequent pedagogical functions) but the quality of interactions is different (more higher order questions, students' initiations and response, less direct feedbacks are observed in very late EMI schools).

From Grade 10 to 11, with the advanced level and more abstract concepts in science, teachers and students in both type of schools became less interactive, perhaps resulted in a slightly decrease in average length of turns, no. of turn.

8.References

Chan, J. Y. H. (2014). Fine-tuning language policy in Hong Kong education: stakeholders' perceptions, practices and challenges. *Language and Education, 28*(5), 459–476. doi:10.1080/09500782.2014.904872

Chin, C. (2006). Classroom Interaction in Science: Teacher questioning and feedback to students' responses. *International Journal of Science Education, 28*(11), 1315–1346. doi:10.1080/09500690600621100

Corbin, J., & Strauss, A. (2008). Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory (3rd ed.). Thousand Oaks, CA: Sage.

Hoare, P. (2002). *Effective teaching of science through English in Hong Kong secondary schools.* (Unpublished PhD thesis). University of Hong Kong. Retrieved from http://hdl.handle.net/10722/39139

Lo, Y. Y., & Macaro, E. (2012). The Medium of Instruction Effect on Vocabulary Learning: Some Evidence from Immersion Education and Bilingualism. *Applied Linguistics, 33*(3), 345–369. doi:10.1093/applin/ams016

Macaro, E. (2001). Analysing student teachers' codeswitching in foreign language classrooms: theories and decision making. *The Modern Language Journal, 85*(4), 531–548. doi:10.1111/0026-7902.00124

Macaro, E., & Mutton, T. (2002). Developing language teachers through a co-researcher model. *The Language Learning Journal, 25*(1), 27–39. doi:10.1080/09571730285200071

Mortimer, E., & Scott, P. (2003). *Meaning Making in Secondary Science Classrooms.* Berkshire: England: Open University Press.

Othman, J., & Mohd. Saat, R. (2009). Challenges of Using English as a Medium of Instruction: Pre-service Science Teachers' Perspective. *The Asia-Pacific Education Researcher, 18*(2), 307–316.

Sinclair, J. and Coulthard, M. (1975). *Towards an Analysis of Discourse.* Oxford: Oxford University Press.

Tsui, A. B. M. (1985). Analysing input and interaction in second language classrooms. *RELC Journal, 1*, 8–32.

Yip, D. Y., Tsang, W. K., & Cheung, S. P. (2003). Evaluation of the Effects of Medium of Instruction on the Science Learning of Hong Kong Secondary Students: Performance on the Science Achievement Test. *Bilingual Research Journal, 27*(2), 295–331. doi:10.1080/15235882.2003.10162808

Yip, D. Y. (2004). Questioning skills for conceptual change in science instruction. *Journal of Biological Education, 38*(2), 76–83. doi:10.1080/00219266.2004.9655905

An exploratory study of teaching and learning secondary science through English: classroom interactions, perceptions of teachers and students

Jack Pun , DPhil PRS student
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Introduction

- Teaching science through a second language (L2) is a growing phenomenon around the world. English is often the medium of instruction (EMI).
- Research investigated the quality of science learning in L2 show that teachers and students in EMI science classrooms encounter many language challenges with teaching and learning processes.
- For examples, science teachers have limited English communication skills, lack of EMI training, confused role of teaching both content and language of science, negative belief towards EMI teaching, different levels of students' English abilities, low teachers' language awareness.
- This in turn has resulted in limited opportunities for students' L2 (second language) learning, limited teaching practices and reduced interactions in the classroom
- like Hong Kong (HK), under the new fine-tuning policy (from 2010-11), more teachers and students who were legitimate to L1 instruction but now have switched into EMI. These have no clue on how to improve their learning experiences in L2 science classroom.

Aims

The project will explore the similarities and differences in classroom interactions of two groups (late & very late EMI immersion) during the first year of the senior science curriculum and between grades 10 and 11 in both groups. It will investigate teacher and student perceptions of EMI teaching and learning processes in terms of participants' classroom language choices and their beliefs about teaching and learning in the EMI environment. It will also explore other learning outcomes, such as student achievements in English and science, as well as students' self-concepts in science—students' beliefs about their ability to do well in science.

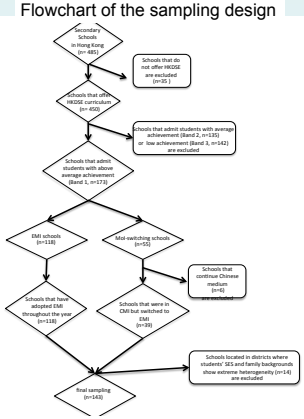
Research Questions

1. In late (where EMI starts at Grade 7) and very late (where EMI starts at Grade 10) immersion classrooms, what are the differences and similarities in classroom interaction?
2. What are the differences and similarities in classroom interaction between grades 10 and 11 in both late and very late immersion classrooms?
3. What are teacher perceptions of learning science through EMI?
4. What are student perceptions of learning science through EMI?
5. To what extent is self-reported achievement in English related to grade 11 student self-reported achievement in science?

Participant Groups

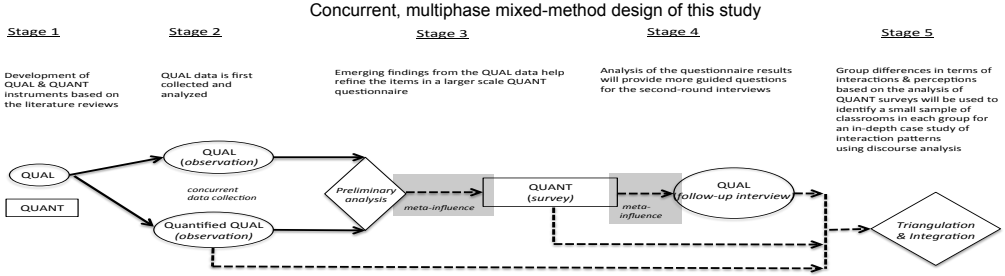
Groups (Schools)	A		B	
	late EMI immersion		*very late EMI immersion*	
Type of school	Traditional EMI secondary schools		MOI-switching secondary schools	
When did EMI start?	EMI started in the first year of secondary school, grade 7		Students were taught in Chinese medium until they switched to EMI in grade 10	
Groups (Students)	A1	A2	B1	B2
	grade 10	grade 11	grade 10	grade 11
Medium/s of instruction	EMI: Grades 7–10/11		CMI: Grades 7–9 EMI: since Grade 10	
Years of experiences in EMI instruction	4	5	0	1
Science curriculum	Grades 7 to 9: junior curriculum: 1 subject (integrated science) Grade 10 onwards: senior curriculum, 3 subjects (physics, chemistry, biology)			

Flowchart of the sampling design



Research Design

Concurrent, multiphase mixed-method design of this study



Sampling: 4 late and 4 very late EMI schools, grade 10-11 science (Chem, Bio) teachers (n=40), students (n=400)

Mixed methods approach: (A) Classroom observation, (B) semi-structured Interviews, (C) Questionnaire

A. Observations

Unstructured and non-participant

Notes will include information about lesson structure, the teacher's pedagogical moves, the flow of interactions, the classroom climate and other non-verbal behaviour.

Further detailed discourse analysis after transcribing all the audio/video recorded observations (quantifiable items: no./types of teacher-student interactions (Initial-Response-Feedback sequences, communicative approaches in science classroom (Mortimer & Scott, 2003); frequency/ duration of code-mixing, science teachers' questioning technique (Yip, 2004))

B. Interviews

Questions adopted from (Hoare, 2003; Wong, 2012) with aims to:

-examine the teacher's and student's views on the classroom interactions in EMI environment

-seek clarifications and reasons of each teaching pedagogy (eg questioning techniques, code-switching,) in the observed lessons

-examine teacher and student views on teaching practices, language challenges and the strategies used when resolving any language challenges encountered by students in understanding and communicating scientific ideas in English.

C. Questionnaires (5-point Likert scale)

Survey items adapted from validated instruments in previous studies after an intensive literature review. They include classroom language use (Evans, 2000), teacher beliefs and teaching practices about L2 teaching in science (Hoare, 2003); student self-concepts and belief in science (Yip et al., 2007) and language challenges and strategies in EMI classroom (Tatzl, 2011).

Methods of analysis

Qualitative data (interviews, transcript of observations)

a two-step coding process using *Nvivo* 9 software designed for in-depth qualitative analysis (Strauss & Corbin, 2008).

1st: develop open coding for each pattern or recurrent themes concerning the main interests of the study (ie. views on EMI, challenges, strategies).

2nd: specific parts of the texts in these open-coded segments will be coded (anixal coding) again to represent sub-themes to which the statements belonged.

Reliability of the coding (inter-rater reliability): around 10% of each type of data (observations, interviews) will be coded by two-raters independently

Quantitative data (questionnaire surveys)

1) teachers & students' views on particular issues (teaching beliefs, students' self-concepts)

-summary measure such as mean and standard deviations of their responses in each item.

mean score of students in different school types (late vs very late immersion); different grades (10 vs 11) doing different science subjects (ie. Chemistry, Biology) obtained from the students' survey can be treated with ANOVA to identify the effect of English on students' self-concept and teaching beliefs in different science subjects and types of schools.

2) underlying factors determining teacher and students' overt responses to individual language challenges and strategies.

-employ exploratory factor analysis to calculate each factor loading in each item (ie. challenges and strategies) and then later to decide the number of factors

A Review of Language Challenges & Strategies Teaching & Learning Secondary Science through English

Jack Pun , DPhil PRS student
Department of Education, University of Oxford *Email: kwok.pun@education.ox.ac.uk*

Introduction

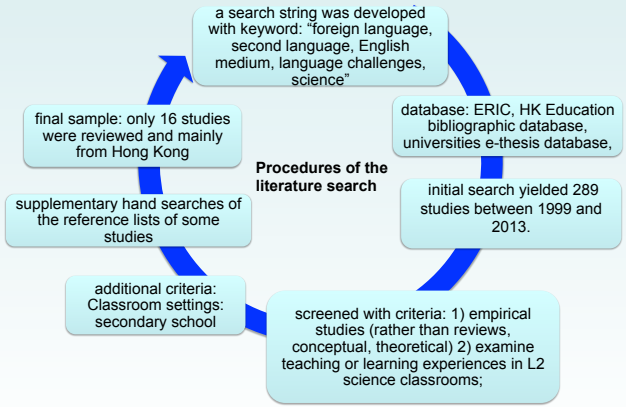


- Teaching science through a second language (L2) is a growing phenomenon around the world; English is often the medium of instruction (EMI). Research investigated the quality of science learning in L2 and the effectiveness of EMI on science achievements have no consensus about the nature of the language challenges and the most effective teaching strategies.
- like Hong Kong (HK), under the new fine-tuning policy, more teachers and students who were legitimate to L1 instruction but now have switched into EMI. These have no clue on how to improve their learning experiences in L2 science classroom.
- This poster will explore these issues in EMI secondary science classrooms in HK.

Objectives/ Research Questions

- To explore the language challenges and strategies in L2 science classrooms reported in the previous studies through a literature search across disciplines: applied linguistics, language policy, science education

Methodology



Research Evidences from previous studies

1.Research in science education (pedagogies, questioning techniques, PCK)

- Science Teachers:
  - respond incorrectly to students and questioning fails to promote understanding of science concepts. (Yip,1999)
  - use lower cognitive demand questions (eg. recall-type) (Yip, 2004)
  - when conceptual questions identify students' misconceptions, they fail to resolve these, build upon existing ideas and promote cognitive thinking (Yip, 2004)
  - HK teachers do not have adequate subject knowledge or PCK; they also fail to identify and address misconceptions and have limited questioning techniques (Mak, Yip & Chung, 1999)

2. Research on Medium of instruction (MOI) and students' science achievements

- HK EMI junior secondary students:
  - had lower science scores and lower self-concept in contrast to students in L1 (Yip & Tsang, 2007).
  - had more difficulty in understanding abstract concepts, distinguishing scientific terms and applying concepts through L2 (Yip, Tsang, & Cheung, 2003).
- EMI created negative effects on the quality of science learning at junior level due to students' limited English proficiency and the inadequate repertoire of instructional strategies used by teachers (Yip, Coyle & Tsang, 2007).
- At senior level, when students are more proficient in English and teachers use English in their instructional strategies fully, the disadvantages of learning science in L2 can be offset at senior level (Marsh, Hau & Kong, 2000)

3. Research in applied linguistics (classroom interactions patterns)

- Science lessons in MOI-switching schools in HK (Grade 9) are teacher-centred, teacher-student interactions involve reduced I-R-F sequences and there is a lower proportion of student' talk with short turns (Lo & Macaro, 2012).
- The distinctive register of science and the extensive use of other semiotic resources for explaining science reduce the L2 opportunities for students to engage with discussions and to interact with their teachers (Lo, 2014).
- There are some bilingual pedagogies that can help students develop English proficiency and access the English scientific discourse (Lin, 2006)
- English enrichment courses for Grade 10 students switching from L1 to L2 were found to have no direct causal effect on students' English proficiency in science (Walker, 2010).

Challenges

Perceptions on teaching and learning science in L2

- **Mixed responsibilities:** Teachers experience a tension between teaching science content or teaching the language of science
- Teachers **have negative perceptions and beliefs about EMI**. Students have **lower self-concepts** and highly related to their achievement in science .

→Both reduce the quality of teaching practices and learning in L2 science classrooms.

English proficiency of science students

- Teachers **use lower-cognitive demand tasks, recall-type questions.**
- **Teacher-student talks are short and disconnected**; Interactions are minimal and mainly on checking students' understanding of factual information.
- Poor English stops students to express and discuss science ideas; **limit their interactions and reduce their L2 learning opportunities.**

→impact on the quality of classroom climate.

Pedagogy

- Problems of teachers' **questioning technique**
- Teacher's **inadequate subject matter knowledge**/PCK for teaching

→lead to students' misconception, confusion, frustration

Strategies

1. Use of **available linguistics resources**: Code-switching, Bilingual pedagogies (Lin, 2006)
2. Developing students **specific language skills in science** (Cognitive Academic Language Proficiency, moving from context-embedded to context-reduced language; discourse competence in L2, registers in science, school science genres, lexciogrammatical features, eg grammatical metaphors)
3. Use of **pedagogy for promoting meaningful science learning** (conceptual change question, skillful questioning technique)
4. **Correcting misconceptions**: Bridging the gap by evaluating student understanding through prompt questions and identifying their inconsistent concepts
5. **Providing L2 support for articulation**: Bridging the gap between what these students can understand in English and what they can articulate in English.
6. **Others:** Collaborative teaching between English language teachers and science teachers (Poon, 2013); supportive climate, teamwork within a school to introduce new teaching interventions

Conclusion

- The challenge of teaching or learning science through English is not simply a language problem. **It is a mixture of language, subject and pedagogy.**
- For meaningful and effective learning to occur in L2 science classrooms, teachers should consider: **1) their teaching role and responsibilities; 2) the quality of the pedagogy used to teach science 3) developing L2 language awareness.**

References

*Lin, A. (2006). Beyond linguistic purism in language-in-education policy and practice: exploring bilingual pedagogies in a hong kong science classroom, *Language and Education*, 20:4, 287-305
*Lo, Y.Y. & Macaro, E. (2012). The Medium of instruction and classroom interaction: evidence from Hong Kong secondary schools. *International Journal of Bilingual Education and Bilingualism*,15, 29-52.
Lo, Y.Y. & Lo, E.S.C. (2014) A meta-analysis of the effectiveness of English-medium education in Hong Kong, Review of Education Research,
*Lo, Y.Y. (2014). L2 learning opportunities in different academic subjects in content-based instruction – evidence in favour of 'conventional wisdom, *Language and Education*, 28:2, 141-160
*Mak, S.Y., Yip, D.Y. & Chung, C.M. (1999). Alternative conceptions in biology-related topics of integrated science teachers and implications for teacher education. *Journal of Science Education and Technology*, 8(2), 161-170.
*Marsh, H. W., Hau, K.T., & Kong, C.K., (2000). Late Immersion and Language of Instruction (English vs. Chinese) in Hong Kong High Schools: Achievement Growth in Language and Nonlanguage Subjects. *Harvard Educational Review* 70, 302-346.
*Walker, E. (2010). Evaluation of a support intervention for senior secondary school English immersion. *System* 38, 50-62
*Yip, D.Y. (1999). Implications of students' question for science teaching. *School Science Review*, 81(294), 49-54
*Yip, D.Y. (2004). Questioning skills for conceptual change in science instruction. *Journal of Biological Education*, 38(2), 76-83
*Yip, D. Y., Coyle, D., & Tsang, W. K. (2007). Evaluation of the effects of medium of instruction on the science learning of Hong Kong secondary students: Instructional activities in science lessons. *Educational Journal*, 35, 77–107.
*Yip, D. Y., Tsang, W. K., & Cheung, S. P. (2003). Evaluation of the effects of medium of instruction on the Science learning of Hong Kong secondary students: Performance on the science achievement test. *Bilingual Research Journal*, 27, 295–331.
*Yip, D. Y., & Tsang, W. K. (2007). Evaluation of the effects of the medium of instruction on science learning of Hong Kong secondary students: Students' self-concept in science. *International Journal of Science and Mathematics Education*, 5, 393– 413.