Project Title: L2 classroom talk and subject content learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms

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Final Report

by

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Transcription conventions used in the study

All dates, times, schools, teacher and student names have been removed for the purpose of anonymity.

Abbreviations and symbols

T	Teacher
S1	Identified student (S1, S2, etc.)
Ss	Multiple students
I	Interviewer
XXXX	Incomprehensible item or inaudible utterance

Other important terms related to the project and classroom discourse:

MOI: Medium of Instruction
CMI: Chinese Medium of Instruction
EMI: English Medium of Instruction
CLIL: Content and Language Integrated Learning
LAC: Language Across the Curriculum
ECA: Extracurricular Activity

IRF – I – Initiate
R – Respond
F – Feedback / follow-up (Sinclair & Coulthard, 1975)

E – Exchange
M – Move
P – Participant

Closed-ended / display questions: questions which can be answered by a simple "yes" or "no", and require no elaboration from the student.

Open-ended / referential questions: questions which require more than a simple one-word answer and allow students to offer longer responses.

Recasting / reformulation: where a teacher rephrases a student's response by changing one or more sentence components, but still addresses the central meaning.

Wait-time: the amount of time a teacher waits before eliciting an answer from a student or a class.

Nomination: when a teacher selects or nominates a particular student to answer a question or share a response with the class.

Student initiated questions/responses: when a student (or students) asks a question to the teacher / responds to a question without any prompting or instruction.

Peer-learning / peer discussion: when students learn with and from each other without the direct involvement of a teacher

Reference

Sinclair, J., & Coulthard, M. (1975). *Towards an analysis of discourse*. London: Oxford University Press.

Abstract

This study examined the role of English (as a second language, or L2) as the medium of instruction in the teaching and learning of Mathematics and Science classrooms in junior secondary schools of Hong Kong (F.1 and F.2 / Grades 7 and 8). It aimed at unpacking the complex question of how students develop cognitive understanding of content subjects through the use of English language. The study also sought insights on the role of language in science and mathematics learning through an investigation of classroom talk in these two subjects. While numerous professional development initiatives in local secondary schools have emphasized the integration of language and content in humanities, mathematics and science subjects, there is a paucity of systematic research in Hong Kong on the discourse of classroom teaching in content subjects. The study was underpinned by specific research questions which aimed at exploring classroom talk which facilitates successful learning in science and mathematics, teachers' pedagogical and linguistic strategies and students' learning experiences. To achieve these broad aims the study adopted a mixed-method approach including 283 lesson observations (of 7 mathematics and 8 science teachers across 8 local secondary schools), multiple semi-structured and focus-group interviews with teachers and students from each school and questionnaire data from 390 respondents. Findings are presented qualitatively and quantitatively and a range of detailed lesson extracts suggest that schools are implementing a bilingual model of teaching in different ways and with differing degrees of success. Implications are suggested for classroom practice and teachers' professional development.

Keywords

1. Conceptual and linguistic mediation
2. Co-construction of meaning
3. Student proficiency and competence to learn in EMI
4. Pedagogical strategies
5. Spoken and written discourse in subject classrooms
6. Subject teacher language awareness

Introduction

This study examines the role of English (as a second language, or L2) as the medium of instruction (MOI) in the teaching and learning of Mathematics and Science classrooms in junior secondary schools of Hong Kong (HK) (F.1 and F.2). It aims to explore how students develop cognitive understanding of content subjects through the use of English language (students' L2). The study also seeks insights into the role of language in science and mathematics learning through an investigation of classroom talk in these two subjects. An examination of language use in any classroom research is of paramount importance; as Christie suggested, "language" represents "the most fundamental resource with which participants negotiate and construct their meanings in classrooms" (2002: 10).

The backdrop to the study is important. It examines the role of language in the teaching and learning processes in English-medium mathematics and science classrooms in junior secondary classrooms of HK. The transition of using everyday language to academic language in subject content lessons creates many challenges to students and teachers. The particular nature of the academic languages can represent obstacles for students to comprehend and express knowledge and concepts in ways that are specific to a particular discipline. These difficulties are further heightened if the content has to be taught in a second language (L2), like English. Despite these difficulties, there has been very little research on the discourse of classroom teaching in content subjects in HK. By conducting an in-depth examination of the discourse or language in L2 mathematics and science classes across multiple classes in HK secondary schools, we maintain it is possible to achieve the following aims (corresponding to certain keywords):

1) To identify the distinctive features of the L2 classroom talk which promote successful learning in mathematics and science subjects (Keywords 1, 2).
2) To investigate the linguistic competency and knowledge required for students to

participate successfully in mathematics and science lessons (Keywords, 1, 2, 3).

3) To discuss teachers' pedagogical and linguistic strategies useful to facilitate the meaning making process and second language acquisition in class, and to inform teacher professional development (Keywords 2, 4, 5, 6).
4) To examine students' experience of learning mathematics and science in and out of the classroom for a better understanding of how content knowledge is constructed (Keywords 1, 2, 3).
5) To provide insights and directions for future MOI policy in HK.

The findings of this study provide evidence of how classroom talk can be effectively managed so as to enable students to develop cognitive and linguistic skills and carry local and international significance. When implementing a bilingual model of education, mathematics and science are usually the two subjects that are chosen for adopting English as the medium of instruction (EMI), yet little research exists in classroom discourse analysis and on the specific aspects described below:

- Challenges (and opportunities) faced by students when transitioning from L1/L2 primary to L1/L2 secondary to L2 tertiary subject content education in HK.
- Subject content teachers' sense of language awareness merits a closer examination; they often lack post-qualification language training and do not assume a role in teaching the L2 in their subjects (e.g. see Tang & Danielsson, 2018, on subject content teacher identity).
- The nature and types of professional development programmes and collaborative development programmes for subject content teachers (e.g. see Macaro, 2018).

This study is especially relevant to the local educational landscape as a result of the "fine-tuning" MOI policy where an increasing number of CMI schools are introducing EMI classes, particularly in science and mathematics (see Education Bureau HKSAR, 2010). This study also seeks to inform practices, teacher training and relevant educational policies.

Project focus at the outset

- To identify the linguistic competencies and knowledge required for students to participate successfully in mathematics and science discourses and practices;
- To identify the pedagogies useful in facilitating the meaning making process in mathematics and science classrooms in L2, both in and out of classrooms; and,
- To examine the role of L2 content teachers in supporting their students' content learning through L2 both in and out of classrooms.

The following research questions underpinned the study:

<u>Research Questions</u>

1) What linguistic competencies and knowledge are required for students to participate in mathematics and science discourses and practices? **(students' knowledge)**

2) What are the distinctive features of L2 mathematics and L2 science classroom discourse that are conducive to the co-construction of content knowledge, and the effective learning of mathematics and science? **(classroom discourse)**

3) What linguistic competence, linguistic strategies and pedagogical strategies do mathematics and science teachers need to enable students to participate in the co-construction of content knowledge? **(pedagogical strategies)**

4) How do L2 content teachers support students' content learning through L2 / L1? **(teachers' role and pedagogy)**

5) How do students experience the learning of mathematics and science in the construction of mathematical and scientific knowledge in L2 in the classroom? (And how do they experience the construction of such knowledge *outside* the classroom?) **(student voice)**

(a) Review of literature of the project

[See Appendix I *Detailed literature review*]

(b) Theoretical and/or conceptual framework of the project

This study adopted multiple frameworks for analysing diverse classroom discourse in different classrooms, considering different school contexts and the very distinctive nature of teaching and learning in Mathematics and Science classrooms. It was felt that one framework for both subjects across the different schools and subject levels was insufficient, so the project adopted a number of approaches to examining and analysing the classroom data and these are shown below, in Appendix XIII where we showcase a detailed sample case study of a Science class and in Appendix XIV where we illustrate our findings with extracts from lessons and interviews with teachers and students across the participating schools.

1. Social Constructivist Theories of Learning

This study draws on social constructivist theories of learning. According to Vygotsky, it is crucial to understand cognitive development from social and individual perspectives: "first, between people (inter-psychological) and then inside the child (intra-psychological)... All the higher mental functions originate as actual relations between people" (1978, p. 57). Vygotskian theory suggests that there is a strong relationship between social interaction via the use of semiotic tools and individual acquisition of knowledge, skills and values. Learning takes place in a social, dialogic environment of education where learners of different backgrounds engage in meaningful and collaborative activities. The interaction and mediation between more capable and less capable learners in the problem-solving tasks facilitates the co-construction of knowledge. For Vygotsky, the appropriate aid from others opens up the "zone of proximal development" (ZPD) for individual learners, which is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (1978, p. 86). The concept of ZPD is crucial to understand the role of teachers, scaffolding strategies and assessment of learning outcomes.

The importance of language in Vygotsky's theory of learning and development can be closely associated with Halliday's view of learning, which is a meaning-making process through the social use of language (Wells, 1999, p. xiii). In "Towards a language-based theory of learning", Halliday states: "The distinctive characteristic of human learning is that it is a process of making meaning—a semiotic process; and the prototypical form of human semiotic is language. Hence, the ontogenesis of language is at the same time the ontogenesis of learning" (93). Language is instrumental in the cognitive construction of knowledge and experience, not only because one disseminate knowledge to others by using a language, but also because language forms the way in which one construes an experience and internalizes it as knowledge. As Halliday argues, "language is the essential condition of knowing, the process by which experience becomes knowledge" (1993, p. 94). In this regard, both "learning language" and "learning through language" are important for the cognitive development of children (Halliday, 1993, p. 93). These two interrelated aspects address the objectives of the CLIL education in incorporating content subject learning and second language acquisition and highlight the crucial role of classroom talk—the focus of this study—in the co-construction of scientific and mathematical knowledge.

2. Classroom Talk

In *Talking Science* (1990), Lemke suggests that the teacher's task is to "see science teaching as a social process and … [lead] students, at least partially, into this community of people who *talk science*" (Lemke, 1990, p. x; emphasis in original). Drawing on both Vygotsky's and Halliday's theories, Wells (1999) highlights the importance of "dialogic inquiry" in creating a classroom community which enables students to participate collaboratively in the meaning making process. Dialogic models are vital to construct a socially learning community, because "dialogue is not fundamentally a specific communicative form of question and response, but at heart a kind of social relation that engages its participants" (Burbules, 1993, p.19-20). In this light, this study examines the dialogicality, and more broadly interactivity, of classroom talk in the process of achieving co-construction of knowledge. Here, classroom talk refers to the organized or spontaneous speech and discussion between teacher and student(s), and between student(s) and student(s) during the lessons.

2.1 Dialogic Patterns and Dialogic Teaching

This study adopts multi-layered coding for data analysis.

The exchange sequence of Initiation-Response-Feedback/Follow-up (IRF) put forward by Sinclair and Coulthard (1975) remains fundamental in classroom discourse analysis. Different *moves*, which comprise teacher initiation (I), pupil response (R), and teacher feedback or follow-up (F), form the most common interactive pattern in the classroom, which is called *exchange*; an array of exchanges that serve a relatively independent purpose, such as exposition of specific concepts or ideas, comprises a *sequence*; different sequences then form *transactions*, as a higher level of segmentation of a *lesson* (Sinclair & Coulthard, 1975; Tsui, 1994; Marton et al., 2004). The analysis of move, exchange and sequence in the classroom talk offer an emic, grounded perspective to identify the purposes, characteristics, and achievements of dialogues, which is of central importance for the effective co-construction of knowledge.

The traditional dialogic pattern of Initiate-Response-Feedback/Evaluate or IRF (Sinclair & Coulthard, 1975; Mehan, 1979), however, reinforces the teacher's central role in classroom talk, in which individual students communicate primarily with the teacher (Pimentel & McNeill, 2013). Facing the exam-driven syllabus and limited class hours in Hong Kong, triadic dialogue tends to be used for the purpose of knowledge checking, rather than knowledge exploration and co-construction (Lin & Lo, 2017; Mercer et al., 2009). Students benefit to a limited extent from teachers' elicitation of answers in a piecemeal fashion (Pimentel & McNeill, 2013; Edmin, 2011). Moreover, teachers' question-answer interaction with no further extension or elaboration, probing, or throwing back students' responses in fact recycles a continued and less productive discussion, in which the teacher brings forth the conceptual understanding through his/her monologue. Meaning making *for* students is different from meaning making *by* students. When the dominant speech act in class is the teacher's monologue, students can be discouraged to develop higher order thinking and reasoning abilities in meaning making process. As Pimentel & McNeill's study (2013) reflects on the dilemma of students, "if it is the norm for the teacher to transform short responses into more complicated and meaningful concepts, what motivation exists to risk elaborating on an answer themselves and being wrong?" (p. 388).

Reflecting on the significance of classroom talk, Lefstein & Snell (2011) stress that "[t]eachers need to understand the importance of talk in teaching and learning; be sensitive to the ways in which conventional discourse norms can be detrimental to pupil thinking and learning; and appreciate the promise—and complexity—of dialogic practice" (p. 16). Scholars identify various forms and effects of classroom interaction. In his critique of the conventional IRF structure of classroom interaction, Alexander (2005) examines the repertoires of teaching talk: rote, recitation, instruction/exposition, discussion, and dialogue (p. 34). He argues that the forms of talk do not guarantee the "*quality* of interaction" (p. 35). He therefore proposes that "dialogic teaching", which consists of five interrelated characteristics: collective, reciprocal, supportive, cumulative and purposeful, can "harnesses the power of talk to engage children, stimulate and extend their thinking, and advance their learning and understanding" (2005, p.34). Dialogic teaching, according to Alexander, suggests a productive and collaborative relationship between teachers and pupils, and that between pupils and their peers, and the way in which ideas and viewpoints can be exchanged and built up to achieve the educational goals.

To examine how the teacher develops ideas among students, Mortimer and Scott (2003) categorize the teacher's communicative approach into four dimensions: interactive and non-interactive, dialogic and authoritative. The distinction between dialogic and authoritative approaches is contingent upon whether more than one viewpoint is presented, probed or discussed with students (p. 33-4). This view distinguishes a teacher-centered talk from a student-oriented approach, for the latter not only gives students sufficient opportunities of speaking in class but also values their contribution of ideas and thoughts. According to Mortimer and Scott (2003), these dimensions form four classes of communicative approach: Interactive / dialogic, Non-interactive / dialogic, Interactive / authoritative, Non-interactive / authoritative. This is not to suggest that certain cases of a communicative approach work better than others, because the teacher's choice of different communicative approach is subject to the social context in which the content is taught. But these cases are useful in presenting different approaches whereby the teacher works with students to achieve co-construction of knowledge.

2.2 Scaffolding and Mediation

Teachers provide scaffolding to facilitate co-construction of knowledge. According to Holton and Clarke (2006), scaffolding in the learning process can be categorized into different agents: teachers (expert scaffolding), peers (reciprocal scaffolding) and learners (self-scaffolding). To promote a better construction of knowledge and independent learning for learners' long-term interest, it is necessary to realize "the progressive devolution of the role of scaffolding agent from teacher to learner" (Holton & Clarke, 2006, p.141). In terms of different domains, there are conceptual and heuristic scaffoldings (Holton & Clarke, 2006, p.134). An act of scaffolding often synthesizes both aspects to facilitate the problem-solving process.

One of the central tasks in CLIL education is to realise the translation from colloquial, everyday language to academic, technical language as required by the curriculum. The shift of different registers is a two-way process, requiring learners to practise "restating scientific expressions in their own colloquial words, and also … translating colloquial arguments into formal scientific language" (Lemke, 1990, p. 173). The heteroglossic, dynamic characteristic, as García and Lin (2016) point out, is not "two monolingualisms in one, but … one integrated linguistic system" (3). This view sheds light on the interrelatedness between different registers of colloquial and academic languages in knowledge expressions, as well as the necessity for teachers and students to master such practices of translation. Lin and Lo's study (2017) draws on Lemke's (1990) "thematic development strategies" and "social interactional strategies" together with Lin's framework of multiple bridging resources (2012), to examine the dialogic discourse in science CLIL classrooms. Lin's framework, also called the rainbow diagram (2012, p. 93), seeks to expand students' repertoire of both L1 and L2 communicative resources and to mediate the translation between L1 and L2, daily and academic languages, oral and written languages, by using visual and multi-modalities.

Gibbons (2003) draws on the sociocultural construct of mediation and the notion of mode continuum from systemic functional linguistics to examine the mode shifting from oral, everyday language to academic, specialist registers in content-based ESL classrooms. Mediation often takes place in a collaborative, interactional process. Related to the theoretical constructs such as zone of proximal development (ZPD), scaffolding, and contingency, the model of mediation is useful to analyse the dialogues between the teacher and students for the co-construction of subject knowledge and language. As suggested by Gibbons (2003), teacher's mediating role can be manifested through 1) recasting to shift modes, 2) enabling students to reformulate, 3) requesting clarification, and 4) evoking personal knowledge. Gibbons (2003) stresses that the teacher's mediation or scaffolding is contingent upon students' response to make meaning in science registers (p. 261). To understand the contingency in classroom interactions it is crucial for teachers to perform the mediating role and to discern the appropriate moment of handling classroom talk to students.

Considering the challenges facing CLIL classrooms in Hong Kong, Lin (2016) draws on Gibbons' model of designed and improvised scaffoldings to suggest an implementation of "systematic planning of embedded language support and spontaneous embedding of language support" during the teaching of content knowledge in CLIL contexts (p. 154; Gibbons, 2009). Given the effectiveness of implicit guidance varies in different classrooms to help students acquire language skills, the teacher's explicit language-oriented intervention remains important to facilitate students to process and negotiate meaning in academic contexts (Lin, 2016; Rose & Martin, 2012).

2.3 Discourse Patterns in Classrooms

Considering the distinctive nature of Mathematics and Science subjects, data analysis is supplemented by the following theoretical constructs, along with the aforementioned theories on the teacher's communicative approach and scaffolding strategies, to examine the discourse patterns in lessons observed.

Mathematics

According to Mok et al. (2015), there are some common types of interactive patterns in Chinese Mathematics classrooms (see p.714-8). First, the I-R-F pattern is a prevailing discourse pattern characterised by the teacher's elicitation of student's response, which is followed by the teacher's feedback. The talk-in-turn between the teacher and students is often confined to seeking the correct answer from students. This approach maintains the teacher's authority and provides little opportunity for students to raise questions or explore alternative ideas. Second, adopting the funnel pattern, the teacher narrows down an open-ended, exploratory question into several interrelated, closed-ended questions. Students are guided "to produce a predetermined answer or solution preferred by the teacher" (Mok et al., 2015, p.715; see also Wood, 1998). Third, the focusing pattern of interaction is also evident in Mathematics classrooms in which the teacher allows students to explore possible answers or alternative solutions (Mok et al., 2015; Wood, 1998). This type of interaction is often led by open-ended questions.

Written and spoken discourse of Mathematics

Pimm's work (1987) examined the written and spoken discourse of mathematics as a subject, pursing metaphors in mathematical language, the symbols and things symbolized in mathematics, and the Mathematics register (conventional metaphor, structural metaphor; linguistics aspects of mathematics), and meta-linguistics (symbols, signs, written maths, verbal or mixed mathematical texts. “Many of the algebraic algorithms are verbally coded in terms of concise precepts dealing with the surface form, that is, operating at the syntactic level of symbols only” (p. 20). O’Halloran (2015) discussed the multimodality of the Mathematics register.

Written and spoken discourse of Science

Sutton (1992) looked into the figurative use of language in presenting scientific ideas. “Figurative language is *not* a private possession of those with degrees in English Literature. It is a major mental tool for anyone thinking anew, and that includes scientists working on new topics and school pupils who are learning scientific ideas. It consists in using language to extend language, of drawing on what is familiar and using it to interpret something else” (p. 19). He also looked into collocation and encouraged awareness of language users on how words group themselves into families, e.g. connected by a particular image, and also grammatically linked families such as noun, verb and adjectival forms. This would represent a significant language learning process for English L2 learners in a more holistic and meaning associated manner.

Methodology

This naturalistic study adopted a non-intervention and grounded approach to examine classroom data. We made no assumptions on what would emerge from the data, nor were there any pre-determined categories to which the data was allocated. Both qualitative and quantitative methodologies were employed. The former included multiple lesson observations and audio and video recordings; semi-structured interviews with teachers, focus group and individual student interviews; and collection of student work artifacts to examine the discourse of Science and Mathematics classroom teaching; and the latter through a student questionnaire to gather a profile of learners’ views on their experiences of learning Science and/or

Mathematics in L2 and to understand their out-of-school support (if any)[1].

Participating schools and teachers were recruited through invitations by letter [see Appendix II *Invitation letter*]. We aimed to recruit 1 expert Science teacher, 1 novice Science teacher, 1 expert Mathematics teacher and 1 novice Mathematics teacher from each of the 4 secondary schools (i.e. 16 teachers from 4 schools) [see Appendix III *Project outline*, June 2016]. However, some schools responded that the long-term commitment to the study was challenging and/or clashed with their school plans. We fine-tuned the original school recruitment plan to allow for flexibility across a smaller number of teachers involved in each school [see Appendix IV *Revised project outline*, September 2016]; and subsequently, successfully recruited 7 Mathematics and 8 Science teachers[2] from 8 schools, who taught English-medium classes and agreed to participate. Of these participants one teacher taught both subjects in the same school.

All things considered, we found this fine-tuning to be a positive development; since i) more schools participated and there was a greater student intake in terms of diversity and banding, as well as a wider spread of gender and geographical locations; ii) more teachers were recruited and each brought different academic backgrounds and teaching experience to the project; and, iii) a wider range of units in both subjects were observed in order to fit the teaching schedules of participating teachers without too many time clashes.

Our project participants comprise expert and novice teachers as well as students of strong, medium and weak academic ability (nominated by the teachers in each school). A wide range

[1] Identity of schools, teachers and students have been anonymized to ensure confidentiality.
[2] One of the eight recruited Science teachers taught a CMI class where only the unit observed was taught in English to meet the school's objective to implement Language Across the Curriculum (LAC). For consistency in the comparison across this naturalistic study, the team later excluded the data collected from this CMI class for analysis.

of teaching expertise from schools provided rich samples of classroom discourse patterns and pedagogy [see Appendix V *General information of project schools, participating teachers and students, and topics observed*]. The study complied with the research ethics guidelines of the University of Hong Kong (HKU).

Data collection and analysis

Fieldwork data was collected from the classes of recruited teachers in 8 secondary schools between October 2016 and June 2017. The team first invited participating teachers to provide information about their major qualifications, professional training experience that they considered influential to their teaching of the subject; and their years of teaching experience [see Appendix VI *Proforma for completion by teachers*; see Appendix VII *Teacher qualifications and experiences*]. For each class case, the team conducted a pre-unit interview with the participating teacher and 10 focus group students representing a range of academic abilities (high to low) in their class. The actual data collection in each classroom includes an observation with video recording of a complete teaching unit of Mathematics/Science subject; in total 100 Mathematics lessons and 183 Science lessons across participating schools were video recorded [see Appendix VIII *Number of lessons observed in each class*].

Other data collected include observational field notes, pre-lesson interviews and post-lesson interviews with teachers (where appropriate and these were dependent on teachers' schedules), observation of school activities and for two of the Sciences classes, an observation of a mini-project, for further analysis. The 10 focus group students were invited again for a post-unit interview to elicit what they have learnt from the unit. Students of participating classes (not necessarily the focus group students) were invited to stimulated-recall interviews for their instantaneous reactions on certain lesson scenarios [see Appendix IX *Number and types of* *interviews conducted with teachers and students in each class/school*; see Appendix X *Sample interview protocols*]. To enable more detailed analysis of the data, cross-case studies and triangulation, selected interview data and classroom talk were transcribed.

Copies of students' work, including students' writing/notes in textbooks, worksheets, assessment papers, classwork books, notebooks etc. were collected and analysed [see Appendix XI *Types of student work collected from each class*].

A short questionnaire was conducted with students of participating classes on a voluntary basis. The survey aimed to solicit views on students' language use profile; the kind of classroom language exposure in relation to Mathematics and General Studies (GS) in their primary education; current experience of learning of the two subjects in English, and to survey whether they have any out-of-school support on their learning of these two subjects [see Appendix XII *Student questionnaire set for both subjects (Bilingual versions)*].

In addition, students' out-of-class learning experiences in relation to the subject content learning, e.g. Mathematics talk, school's learning celebration day, and Language across the Curriculum (LAC) Days were observed in some schools.

(c) Results and Discussion

Qualitative: One detailed case study of a science class and case extracts from Mathematics and Science classes [see Appendices XIII and XIV]

	TOPICS	ISSUES
RQ1) What linguistic competencies and knowledge are required for students to participate in mathematics and science discourses and practices? **(students' knowledge)**	• Students' lack of proficiency in English. • Teachers' need more support in how to deliver maths and science subjects through English. • There is a marked difference between the type of everyday English students use (and need) in school and life and the academic/scientific language they encounter in Maths and Science subjects. • Students face difficulties with specific subject content, concepts and vocabulary in English. • Students' prior learning experiences and their transition from primary to secondary school where the linguistic and cognitive demands increase.	• Students lack confidence in using English and don't seize the chance to participate in classroom discourse. • Teachers sometimes lack the practical knowledge and/or time to encourage extended classroom discourse through effective questioning strategies and classroom talk. • Students have difficulty adjusting to the demands of an EMI class when transitioning from Primary 6 to Secondary 1.

RQ2) What are the distinctive features of L2 mathematics and L2 science classroom discourse that are conducive to the co-construction of content knowledge, and the effective learning of mathematics and science? **(classroom discourse)**	• The difference between teachers' use of dialogicality and interaction in the classroom with many classes displaying a range of question types (open and closed), but relatively few dialogic episodes. • Some teachers demonstrated an ability to personalise their subjects and content through the use of visuals, building on students' prior experiences and their own personal anecdotes which was seen to have a positive effect on students' engagement.	• Teachers knowledge and experience of questioning techniques as well as related aspects such as appropriate wait-time, effective scaffolding, prompting and motivational strategies. • Teacher's willingness to give students time and space to consider questions and problems either individually or in pairs/groups and for students to 'talk' the language of Science and Mathematics in English during lessons.
RQ3) What linguistic competence, linguistic strategies and pedagogical strategies do mathematics and science teachers need to enable students to participate in the co-construction of	• Teachers using a range of pedagogical strategies in Science and Mathematics classes. • Teachers' receptivity to questions from learners and encourage student-initiated questions and prompts.	• Revisiting and revising students' prior knowledge and learning before starting a new unit of learning. • Encouraging students to be part of the co-construction of content knowledge and whether teachers provide

content knowledge? **(pedagogical strategies)**		opportunities for all students to participate in the classroom discourse.
RQ4) How do L2 content teachers support students' content learning through L2 / L1? **(teachers' role and pedagogy)**	• The use of L1 and L2 in class. • Scaffolding techniques. • Peer learning and group work. • Science appears more topic-based in terms of teaching while maths is more question and/or problem-based.	• How much L1 and L2 are used in class and what are the consequences for students' learning? • The use of peer learning and group work to provide students with opportunities to work on problems and negotiate meaning together.
RQ5) How do students experience the learning of mathematics and science in the construction of mathematical and scientific knowledge in L2 in the classroom? (And how do they experience the construction of such knowledge *outside* the classroom?) **(student voice)**	• The experience of students in terms of their prior learning (Primary school) and their classroom experience of learning Science and Mathematics through English. • The school's culture and infrastructure in terms of LAC policy, ECA provision in Mathematics and Science and the ways ECAs provide support to high performing *and* lower ability students.	• Providing better bridging courses for students coming from CMI contexts in primary schools to study in EMI classes. • More coherence between the formal and informal curriculum, especially in Science and Mathematics; students need more ECAs and opportunities to 'talk' the language of maths and science out of class. • Closer collaboration between teachers across departments and panels.

Quantitative: Questionnaire data

The questionnaire was conducted with agreeing participating students to solicit their language use background; Mathematics and Science classroom experience; and preference of the medium instruction of these subjects, if they have a choice. 390 valid questionnaires were returned (Mathematics n = 186; Science n = 204) [see Appendix XV *Record of completion of the student questionnaire by school and by class*].

In view of the diverse nature of Mathematics and Science subjects, two sets of questions were designed to obtain a clearer presentation of students' views on their learning experience of each subject. A summary of some *outstanding reading* of the questionnaire data with reference to the complete statistical data set distribution is available [see Appendix XVI *Student questionnaire statistical data by subject and MOI of schools with analyses*].

Overall Findings

As stated earlier, one of the most important aims of this study was to examine the role of English (as a second language, or L2) as the medium of instruction (MOI) in the teaching and learning of Mathematics and Science classrooms in junior secondary schools of Hong Kong (F. 1 and F. 2). The study sought to explore how students develop cognitive understanding of these content subjects through the use of English language (students' L2). We focus our findings on 5 research questions that were established to provide an overarching framework to our study. Appendices XIII and XIV contain a range of extracts from lessons and interviews with teachers and students which help to illustrate the research questions underpinning the study. These extracts are framed around a number of salient issues which were observed during the study of Mathematics and Science lessons taught through the medium of English.

Linguistic challenges to students and teachers

This research study wanted to examine the role of language in science and mathematics learning through an investigation of classroom talk in these two subjects. An examination of language use in any classroom research is crucial; with "language" representing "the most fundamental resource with which participants negotiate and construct their meanings in classrooms" (Christie, 2002: 10). There can be doubt that students' and teachers' language proficiency goes to the heart of our study. Data from student questionnaires (see Appendix XVI) reveals that more CMI school students than their EMI school counterparts expressed that they find the learning experience of studying Mathematics and Science in English difficult (8.5%) or difficult generally (24.4%) (the EMI school students' responses were 2.5% and 18.2% respectively for these items). In Science, referring to the kind of difficulties that students have in learning Science through English, a high percentage of respondents chose *"understanding scientific terms and/or concepts in English"* (63.5% for CMI school respondents; 72.2% for EMI school respondents). In Mathematics there was a similar finding with a high percentage of both EMI and CMI school respondents (68.5% and 56.4% respectively) selecting *"Understanding Mathematical terms and/or concepts in English."*

For the EMI school respondents, 43% of students expressed a preference to learn Science mainly in English with some Cantonese; while 36.4% prefer to learn mainly in Cantonese with some English. In comparison, only 11.6% of EMI school respondents prefer learning Science in Cantonese and 16.5% prefer to learn through English only. Whereas for the CMI school students, most respondents (39%) also prefer learning Science mainly in English along with some Cantonese; while 32.9% prefer having Cantonese as the main medium of instruction supported with some English. 11% of the respondents prefer to use only Cantonese in learning Science while 13.4% prefer English. In general, the preference of MOI in Science is consistent across respondents from Chinese or English medium schools. In the Mathematics subject students reported that if given a choice, 44.7%, (a majority) of the EMI school respondents would prefer to use mainly English with some Cantonese to learn Mathematics in secondary school. 48.3% of the CMI school respondents prefer to use mainly Cantonese with some English. For both cohorts, only a minority of respondents expressed a preference to have purely English-medium instruction in mathematics lessons (13.8% for English school respondents and 10% for CMI school respondents).

By asking students about their prior learning experiences of learning through English (in primary school and outside of school) we were able to shed some more light on these findings, perhaps. For example in Science the majority of respondents told us that they studied General Studies (GS) using Chinese textbooks and in Chinese as MOI in primary education. The proportion of students who studied GS in English is low—only 18.8% of students from one of the participating schools had this experience, for example. There was, however, an indication that some primary schools have prepared students to transition to EMI secondary education by using some English in upper primary GS lessons. It does suggest that the move from primary to secondary school for students who are going to be exposed to more lessons taught through their L2 is a crucial one. In Mathematics a similar finding emerged with the majority of CMI school respondents (96.6%) and their EMI school counterparts (85.7%) reporting that their Mathematics textbooks in primary education were in Chinese. Outside of school, a similar picture can be seen with almost half of the EMI school respondents (48%) reporting that they have Mathematics tutorial classes outside school; whereas a lower percentage of the CMI school respondents (32.8%) attended tutorial classes for Mathematics. Students reported that these tutorials are for the most part conducted in Cantonese (L1) although we also found that out-of-school academic support for Science was conducted in both English and Cantonese.

Returning to the classrooms we explored some of the challenges facing students (see Appendix XIV) when learning Science and Mathematics through English through individual and focus-group interviews. One question which focused on the students' difficulties faced when participating in the spoken discourse using English during lessons produced the following responses:

"English is not my mother tongue… Sometimes I can't follow quickly enough and don't get what the teacher is saying."

"During group discussions, you might unconsciously speak some English, just one or two sentences, then you'll shift back to Cantonese. Cantonese is my mother tongue so I can speak more fluently in it and express what I really want to say."

"I don't have the vocabulary that I need, grammar is not the main hindrance."

The issue of students' prior learning and exposure to teaching through EMI at primary school was also found in interview data as the following extracts show:

(After changing from a CMI Primary school to an EMI context) "It is more difficult and hard to get used to learning in English if only one subject is taught in English. However, if other subjects are also taught in English, we won't find it difficult because we are used to using English and learning the subjects in English."

The difficulties faced in spoken discourse and participating in class through English re-mirrored in students' written work as the following interview extracts show:

"If I want to revise (the handout) thoroughly, I need to look up all the words in the dictionary. However, I don't have enough time so I just remember the simple ones and skip the difficult ones."

"I know the chapter content well but didn't know what the exam questions are asking."

Addressing these challenges in class

Teachers also reinforced these findings by stating that junior secondary students lacked vocabulary and confidence in expressing themselves in their L2. In the classroom we observed teachers and students taking a number of steps to address these linguistic challenges with their students. One effective approach was by encouraging student-initiated questions in class to stimulate curiosity, classroom discussion and meaning making (see <u>Appendix XIV</u>). In some Science classrooms, for example, students were seen to participate actively in classroom discourse and particularly through self-initiated questions to the teacher. In interviews with students on why they initiated particular questions in class, it was revealed that one of the ways they participated in classroom discourse was by bringing their prior knowledge or everyday observations into the classroom, and asking questions to the teacher about their everyday observations, speculations or hypotheses. Here students were seen to bridge their own prior knowledge with new materials introduced by the teacher or other students. The following interview extract (translated from Cantonese) shows one student's reasoning in this area:

I	Again, so why did you ask this question at that point?
S1	<If humans could> melt, <if human could become> gaseous state-- <if after human's death and human's> form <could be changed, it might be easier for storage. In the past, I had come across a book which mentioned some researches regarding putting certain substances in dead bodies and to> freeze <them. And maybe those dead bodies could have a chance for rebirth. But I don't have the exact idea. So I don't know why I would ask that question at that time. But then I saw a water bottle which was full of water, and I thought maybe we can put human beings inside a bottle?>
I	(*Laugh*) <Put people inside the bottle? You mean in> liquid form <or> gaseous form?
S1	<If a person is in> liquid form <and he/she can transform into> solid, <or even> gas, <suppose when the> locker <door is locked, I can become> gaseous form <to go inside the locker to unlock the door then come out again.>

Another example is presented in Appendix XIII where a detailed lesson transcription from a Science class shows a teacher introducing a topic by drawing on his own prior experiences and arousing students' curiosity and interest in the process. This lesson is also a good example of a dialogic co-construction of content knowledge in Science and demonstrates, too, how this research project employed different analytical frameworks to address RQ1 and RQ2 (see Alexander, 2005; Mortimer & Scott, 2003). In this episode, the teacher is recounting his own secondary school science competition story and explains how to conduct a proper scientific investigation from his own experience and engages the students in his personal sharing. The teacher instigates a discussion with the whole class on how to conduct an experiment to test which toothpaste is the most effective in preventing tooth decay. The students are curious about the experiment being described and participate freely in the classroom exchanges that are based around questions on how to construct a fair test using an experiment. In this example the teacher sometimes leads discussions or asks questions to draw effectively on students' prior knowledge, introduces new concepts to students, and checks answers for their workbook or test. Students could raise their ideas in L1 or L2, and effective communication is established through a clear rapport between teacher and students. The following extract from a student interview immediately after this lesson shows the learning that took place and provides evidence of the co-construction of knowledge:

I	What have you learnt from the Science lesson today?
S1	**Firstly, I've learnt how to distinguish between independent variables, control variables, dependent variables, etc. My experience is also broadened by seeing how my teacher claimed a first-runner up prize in a science competition with such an amazing experiment.**
I	Okay, do you think it is a good lesson today?
S1	Yes, definitely.
I	Why?
S1	The teacher's amazing experimental set up on his Form 4 Science competition really broadened my view. **It triggered a heated discussion between students, including me**. I listened to others' suggestions and although my guess was wrong, **I still have learned a lot.** **Remark: From this student perspective, it was a good lesson because it*

	involved dynamic learning with the whole class. The dialogue among students and between teacher and students is a significant learning process for him to build knowledge.
I	That's all?
S1	Yes, I also made a guess on how to manipulate the control variable, that is, the participants should have the same meal within one month. **It raised many discussions on how to make sure the test works.**

Based on extensive observations of Mathematics and Science classes we note that students should have access to the following linguistic competencies and knowledge:

- Encouragement to ask student-initiated questions in class to stimulate curiosity, classroom discussion and meaning making.
- Encouragement to use English in their answers and when self-correcting.
- Time to understand and make sense of teachers' questions.
- Encouragement and support in understanding concepts, ideas and vocabulary.
- Receive extra attention when making scientific descriptions, especially when using scientific vocabulary since many scientific words are compound nouns. For example, in one class, a student just used the term "the pressure" (missing the word "gas" or "atmospheric") and was required by the teacher to make clarifications.

Helping students to understand scientific ideas and vocabulary was cited by one teacher who identified what linguistic and conceptual knowledge students are required to participate in classroom talk in a unit called *"Matter as Particles"*. According to the teacher, there are two difficulties for students in science classes. First, the representational difficulty of describing and explaining scientific phenomena and causative relations by using accurate scientific terms and second, the linguistic difficulty of expressing scientific ideas in English due to their limited English vocabulary and knowledge of grammatical structures. This interview extract with the teacher elaborates on this finding:

"Students need more thinking in three learning areas [air pressure, thermal expansion, and density]. If using the particle model to explain… It is fine for them to use their own words to describe the conversion of the three states of matter. But they will have problems if they are required to employ scientific terms. They may not be able to describe the scientific phenomena correctly. Or when they try to describe it, they cannot correctly explain the causative relations of which they might skip some points. After stating the first point, they might skip, for example, when the temperature increases, they will immediately skip to the conclusion that the density decreases. However, in fact they miss some points in between, because they need to use the particle model to describe. The right way to describe [the whole process] is, first, when the temperature increases, particles move further apart. Based on the concept of density, as the number of particles remains unchanged, the mass also remains unchanged. Since particles have moved further apart, the volume [of the substance] increases. When the volume [of the substance] increases whereas mass remains unchanged, the density decreases. Students often fail to describe the whole mechanism this way and they should be able to state that when the temperature rises, the density drops. Some students are capable of doing it, but they need more guidance."

One finding from the observations of Science and Mathematics teachers was the difference between dialogic teaching and interactivity in lessons. For example while lessons contained many examples of questions it could also be seen that these rarely led to extended interactions. There could be a number of factors behind this finding. For one thing teachers might not always have expected students to respond in English (L2) and were perhaps less patient in directing questions to the class (as evidence by the very short wait-times given to students when asked to respond to questions, for example). As seen already, perhaps students' own lack of confidence about expressing themselves in English or responding to questions was a factor too. These might result in teachers asking many questions but yielding few responses. We sought to examine classrooms using Alexander's (2005) and Mortimer and Scott's (2003) frameworks and a detailed case study presented in Appendix XIII shows the complexity of classroom discourse. Mortimer and Scott (2003) categorize the teacher's communicative approach into four dimensions: interactive and non-interactive, dialogic and authoritative and in Appendix XIII we provide an example of what this looks like through the lens of a Science class. This episode exemplifies an interactive / authoritative discourse and concludes with a non-interactive / authoritative segment.

The issue of classroom discourse and how it is managed by teachers is a salient one with several examples of teachers missing opportunities to open up dialogue in class. Sometimes this happened when they missed a cue or a question by teachers or when they answered their own questions without letting students discuss or share their ideas first. Very often this was blamed on having to cover the curriculum or a lack of time, but it raises some important questions about the quality of interaction over the quantity of interaction in EMI classes. An example of a teacher employing effective pedagogical strategies to extend students' talk can be observed in Appendix XIV under RQ3. Here we see a teacher allowing extended student talk during student-initiated questions, scaffolding through clarification requests and confirmation checks and then providing counter-question turns using referential questions. An example of this use of referential questions to extend students' thinking (and discourse) now follows and here we can see how the teacher extends the students' participation by initiating questions and prompts (I) so that the sequence becomes more like I-R-F-I than a closed IRF pattern (Sinclair & Coulthard, 1975).

1	R	T	Why there is water vapour in the air. Because in the atmosphere there is some water vapour.
2	Re-I (S)	S1	Then, then if, then the temperature is not, does not make the water boil.
3	R	T	When the... temperature is...? (*to whole class*) Shh.
4	Re-I (S)	S1	Let's say in the air, there is water vapour.
5	R	T	Yes.
6	Re-I (S)	S1	Then how come it change to water vapour when it is, 20 something or 30 something, degree Celsius?
7	R	T	**You mean, you mean, why does evaporation happen?**
8	F	S1	Yea.
9	I (T)	T	**Okay. Eh, do you think that, eh why you think so, that will not happen?**
10	R	S1	Because, because I think that eh, water particle will stay (*pause*) stay as eh… stay as--
11	Re-I (T)	T	**Stay? As? Water? What will it stay as?**
12	R	S1	Yes because eh, it is, not the boiling point.
13	Re-I (T)	T	Okay so, you mean, do you mean that for the boiling it can get enough energy?

Another example was observed in a Mathematics class with the teacher employing a range of effective open questions in a lesson on Linear Equations in Two Unknowns.

Line	P	Discourse
1	T	For example I have an equation here. y equals to 2x plus 1 (y=2x+1). And here is our graph paper [T refers to the graph paper projected on the screen] Okay? And we draw the axis ourselves and put "y" and "x". Okay? And then we put the numbers. Okay? And after that we draw a box like this. [T refers to a table with two rows for the value of x and y in the PowerPoint] Draw a box like this. And we just put some values for "x". If it is equal to 0, what is the value of y?
2	S1	One.
3	S	One
4	T	One … We then calculate … calculate "y", it is 1. Okay? And, we put 1 for "x", what is the value of "y"?
5	Ss	Three. Three
6	T	Three …And actually we can put… any number as we like. [The PPT shows 100 for the value of x.]
7	S1	二佰零一 *<201>*
8	T	Will we put one hundred?
9	S1	No
10	Ss	No. No. [softly]
11	T	**Why?**
12	S1	Too big.
13	T	Yea. Too large. Okay? Too large. Eh… Too big. [T stretches his elbows] Okay?

Pedagogical strategies and school support systems for the teaching of Mathematics and Science through English

Other pedagogical approaches adopted by Mathematics and Science teachers included the following aspects and which are illustrated in Appendix XIII:

- Revising key words and concepts before starting a new unit.

- Using authentic materials and examples to contextualise and personalize subject content.

- Encouraging students to take notes in English during lessons and after board work

- Encouraging peer learning.

- Organizing learning through organized note-taking.

- Asking open-ended questions to stimulate students' thinking and prompting them to justify their reasoning.

- Helping students to use more English in class: the use of Cantonese in Science lessons to facilitate the acquisition of technical terminology in English.

- Being receptive to questions from learners: Allowing extended student talk during student-initiated questions.

- Building an infrastructure in school through LAC and ECAs.

The following interview extract shows how one Mathematics teacher acknowledges the importance of preparing students before a new teaching unit commences:

I	Do you think your students have any difficulties in learning Mathematics in English?
T	They may have some difficulties on handling Mathematics terms, for example, some students may not understand what solution is, they may not catch up with roots, this kind of words, substitute, this kind of words. So, before moving on we may have revision to talk about the Mathematics meaning of the words and what they need to do. It is better for the students if we can have a revision before opening a new chapter.

When peer learning was promoted by teachers it was seen to have positive impact on teaching and learning with the articulation of the ZPD (Vygotsky, 1978) deemed to be crucial in terms of scaffolding strategies and assessment of learning outcomes. One student observed in class working closely with his peers made the following comment on the importance of peer learning:

Just say, take an example of yesterday. In the Integrated Science lesson (IS) lesson, I got a question and asked my classmate. He also took the initiative to teach me. We would study the problem together.

The Maths examination is fast approaching. I don't want to fail in the exam. For the unit "Rate and Ratio", I took the initiative to seek help from my classmate who sits in front of me [referring to another student], hoping that … I seek his advice because he does better than me. I hope that in areas which I am not doing well, he can teach me.

Some teachers were able to bridge students' knowledge of their L1 and L2 in interesting ways. For example, in one Science lesson the teacher used English throughout except for an occasional translation of science-related, technical terms. One illustration related to equipment in the school laboratory and the teacher wanted his students to know the word “syringe” so as to discuss the issue of gas particles in a syringe. He may have expected students to answer in English, but his students answered “syringe” in Cantonese. The teacher accepted his students’ answer in L1, but then probed further to make students think about the word in English. One student gave an unexpected answer (i.e. “injection”) and the teacher then reformulated the question by stressing what he would like to ask is “針筒” in English. The teacher’s use of Cantonese here not only acknowledged students’ prior knowledge in their mother tongue, but was also likely to inspire students to voice what they knew in English. In doing so, the teacher used a small amount of Cantonese (L1) to facilitate his students’ mastery of technical terms in English.

The enabling curriculum provided by some schools represented an important finding, For example, a number of CMI and EMI schools which participated in this research project had clearly defined and articulated LAC structures which meant Science and Mathematics teachers had undergone professional development courses and/or were being supported by other teachers and departments in their schools. In two schools extra-curricular activities (ECAs) were set up to support classroom teaching in Science and Mathematics and these included talks, school projects and fairs. It was noted that these activities added a layer of coherence to the curriculum and formed a connection between classroom input and learning which took place outside of school. In one school, the alumni were utilized to provide ‘expert’ tutorials for their junior secondary Mathematics students. In the same school, high performing students were asked to stay after school to work with lower ability students. Such a buddy system fostered a sense of community in the school and ensured that students were performing the role of intellectual resources through peer mentoring. In an interview, a teacher from the Mathematics panel praised this school support system:

I: Do you think family members of the students are helpful in helping the students to understand the words?
T: I don't think their family members can help the students much as most of them are from average-income families.
I: In terms of English proficiency?
T: Yes, especially in terms of their English proficiency.
I: How about ability in Mathematics?
T: I think they might be able to help the lower form students.
I: Do the students go for tuition classes?
T: Probably half of the students will go for tuition classes. We will also have additional English classes in school. The teaching instructor will be the school's alumni or university students … We have both for Mathematics and English.
I: They will attend these classes after school dismisses?
T: Yes, after school dismisses.

Conclusions and Recommendations

This study has highlighted the many approaches to teaching Science and Mathematics being taken by teachers and schools in Hong Kong secondary schools. We acknowledge the challenges faced by teachers and students across EMI and CMI schools when asked to teach and learn Science and Mathematics in English and make the following recommendations:

- Schools and policy makers need to pay greater attention to the transition from senior primary classes to junior secondary classes where the MOI changes. Students find this transition a difficult one, and more needs to be done at both sectors to help students adjust to the linguistic demands of an EMI class, an English textbook and the linguistic competencies and knowledge required for them to participate in Mathematics and Science discourses and practices.
- Increase the number of programmes for teacher professional development with particular emphasis on the differences between L1 and L2 instruction. These could be aimed at upper primary teachers and junior secondary school teachers who are teaching their subjects through English. These PD sessions should focus on important classroom discourse skills like questioning, scaffolding and the voice of experienced teachers on how to employ English and Cantonese more effectively in class.
- The development of teaching packages and exemplars that demonstrate effective teaching

through L1/L2 with exemplars of good questioning skills/effective discussion prompting and facilitation, and general recommendations/guidelines for teachers who are new to using L2 when teaching their subjects.

- Equally, the development of case studies and exemplars showing clear examples of student learning in classrooms where the MOI is English.

- Strengthened collaboration between subject content teachers and the English teachers in and across school networks. Teachers need to learn from each other as well as from outside experts.

- Schools should try and offer students more out-of-class exposure to subject content learning through carefully structured ECAs that align with the curriculum and support and extend students' engagement and motivation in the subjects.

Implications for further research

There remains a lot work to do in this area. We argue that schools can also contribute to this through school-based and teacher-based action research projects. Although our study covered 8 schools and 15 teachers we believe that a longitudinal study of a few teachers and selected schools would also provide insights and knowledge on how students learn across one or two academic years and this would also shed light on the effectiveness of certain school policies and pedagogical strategies. This longitudinal approach could also be extended to the transition between students' final year in primary school (P.6) and the start of secondary school (F.1) where there is a paucity of research at the moment. A focused and in-depth analysis of one class across one to two academic years would allow for extended research of particular phenomena observed in this study (classroom strategies, paralinguistic features, gestural metaphors, the degree of code-switching/code-mixing practice of teachers and students in classroom talk and/or student work, student work documenting students' on-site learning processes, and further unpacking the difficulties and coping strategies they may have come across in mastering Mathematics and Science learning through English).

Deliverables

[Please see Appendix XVII for presentations on this research project at international conferences]

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References

Alexander, R. (2005). *Towards dialogic teaching: Rethinking classroom talk* (2nd ed.). York: Dialogos.

Burbules, N. C. (1993). *Dialogue in teaching: Theory and practice*. New York: Teachers College Press.

Cameron, L., & Low, G. (Eds.). (1999). *Researching and applying metaphor*. Cambridge: Cambridge University Press.

Cameron, L., & Maslen, R. (Eds.). (2010). *Metaphor analysis: Research practice in applied linguistics, social sciences and the humanities*. Oakville, CT: Equinox Pub.

Christie, F. (2002). *Classroom discourse analysis: A functional perspective*. London Continuum.

Cienki, A., & Muller, C. (2008). Metaphor, Gesture, and Thought. In R. W. J. Gibbs (Ed.), *The Cambridge handbook of metaphor and thought*. Cambridge; New York: Cambridge University Press.

Davison, C.M. (2017). Collaboration between English language and content teachers: Breaking the boundaries. In A. Tajino, T. Stewart and D. Dalsky (Eds.), *Team teaching and team learning in the language classroom*. London; New York: Routledge.

Davison, C. M., & Ollerhead, S. (2018). But I'm not an English teacher! Disciplinary literacy in Australian science classrooms. In K.S. Tang & K. Danielsson (Eds.), *Global developments in literacy research for science education*. Springer International Publishing.

Ding, M., Piccolo, D., Kulm, G., & Xiaobao, L. (2007). Teacher interventions in cooperative-learning mathematics classes. *Journal of Educational Research, 100*(3), 162-175.

Edmin, C. (2011). Dimensions of communication in urban science education: Interactions and transactions. *Science Education, 95*, 1-20.

Education Bureau, HKSAR. (April 2010). *Enriching our language environment realising our vision: Fine-tuning of medium of instruction for secondary schools*.

García, O. (2009). *Bilingual education in the 21st century: A global perspective*. Malden, MA; Oxford: Wiley-Blackwell Publishing.

García, O., & Lin, A. M. Y. (2016). "Translanguaging in bilingual education." In O. García, & A.M.Y. Lin (Eds.), *Bilingual and multilingual education (Encyclopedia of language and education, Vol. 5)*. Dordrecht: Springer.

Gibbons, P. (2003). Mediating language learning: Teacher interactions with ESL students in a content-based classroom. *TESOL Quarterly, 37*(2), 247-273.

Halliday, M. A. K. (1993). Towards a language-based theory of learning. *Linguistics and Education, 5,* 93-116.

Holton, D., & Clarke, D. (2006). Scaffolding and metacognition. *International Journal of Mathematical Education in Science and Technology, 37*(2), 127-143.

Lefstein, A., & Snell, J. (2011). Classroom discourse: The promise and complexity of dialogic practice. In S. Ellis, E. McCartney, & J. Bourne (Eds.), *Applied linguistics and primary school teaching: Developing a language curriculum.* (pp. 165-185). Cambridge University Press.

Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Norwood, N.J: Ablex Pub. Corp.

Lin, A.M.Y. (2012). Multilingual and multimodal resources in L2 English content classrooms. In C. Leung & B. Street (Eds.), *English – A changing medium for education*. (pp. 79-103). Bristol, U.K.: Multilingual Matters.

Lin, A.M.Y. (2016) *Language across the curriculum & CLIL in English as an additional language (EAL) contexts*. Singapore: Springer.

Lin, A. M. Y., & Lo, Y. Y. (2017). Trans/languaging and the triadic dialogue in content and language integrated learning (CLIL) classrooms. *Language and Education, 31*(1), 26–45.

Macaro, E. (2018). *English Medium Instruction*. Oxford: Oxford University Press.

Marton, F., Runesson, U., & Tsui, A. B. M. (2004). The space of learning. In F. Marton et al., *Classroom discourse and the space of learning* (pp. 3-42). Mahwah, N.J: L. Erlbaum Associates.

Mehan, H. (1979). *Learning lessons: Social organization in the classroom*. Cambridge, MA: Harvard University Press.

Mercer, N., Dawes, L., & Staarman, J. K. (2009). Dialogic teaching in the primary science classroom. *Language and Education, 23*(4), 353-369.

Mok, I. A. C., Yang, X., & Zhu, Y. (2015). Mathematical discourse in Chinese classrooms: An insider's perspective. In B. Sriraman et al. (Eds.), *The first sourcebook on Asian research in mathematics education: China, Korea, Singapore, Japan, Malaysia, and India.* (pp. 705-731). Charlotte, North Carolina: Information Age Publishing.

Mortimer, E. F., & Scott, P. (2003). *Meaning making in secondary science classrooms*. Buckingham: Open University Press.

O'Halloran, K. L. (2015). The language of learning mathematics: A multimodal perspective. *The Journal of Mathematical Behavior, 40, Part A*, 63-74.

Pimentel, D. S., & McNeill, K. L. (2013). Conducting talk in secondary science classrooms: Investigating instructional moves and teachers' beliefs. *Science Education, 97*(3), 367-394.

Pimm, D. (1987). *Speaking mathematically: Communication in the mathematics classroom*. London: Routledge & Kegan Paul.

Rose, D., & Martin, J. R. (2012). *Learning to write, reading to learn: Genre, knowledge and pedagogy in the Sydney school*. Sheffield (UK) and Bristol (USA): Equinox.

Sinclair, J., & Coulthard, M. (1975). *Towards an analysis of discourse: The English used by teachers and pupils*. London: Oxford University Press.

Sutton, C. R. (1992). *Words, science, and learning*. Buckingham: Open University Press.

Tang, K. S., & Danielsson, K. (Eds.). (2018). *Global development in literacy research for science education*. Cham, Switzerland: Springer.

Tsui, A. B. M. (1994). *Introducing classroom interaction.* London: Penguin.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological functions*. Cambridge, MA: Harvard University Press.

Wells, G. (1999). *Dialogic inquiry: Towards a socio-cultural practice and theory of education*. Cambridge, MA: Harvard University Press.

Wood, T. (1998). Alternative patterns of communication in mathematics classes: Funneling or focusing? In H. Steinbring, M.G. Bartolini Bussi, & A. Sierpinska, (Eds.). *Language and communication in the mathematics classroom* (pp. 167-178). Reston, VA.: The National Council of Teachers of Mathematics, Inc.

<u>APPENDIX I</u> ***Detailed literature review***

LITERATURE REVIEW

1. Introduction

Content and Language Integrated Learning (CLIL) has a worldwide application, which aims to achieve the learning of both content knowledge and a second language (e.g. Argentina as in Pistorio, 2009; Austria, Finland and Spain as in Llinares & Dalton-Puffer, 2015; Tanzania as in Kasmer, 2013). CLIL in secondary schools constitutes a considerable challenge for teachers and students, notably in the subjects of science and mathematics (Fung & Yip, 2014; Yip et al., 2007; Yip & Tsang, 2007; Day & Shapson, 1996). There is a rich literature on classroom talk to facilitate knowledge construction in first language (L1) classrooms (Lemke, 1990; Mortimer & Scott, 2003) and the acquisition of English as a foreign language (L2), while there remains a paucity of research on how classroom talk is conducive to content learning and language acquisition in the CLIL contexts. This literature review will situate the CLIL education in Hong Kong, trace the development of local language policy, and identify the incurring challenges for teachers and students.

2. Medium of Instruction (MOI) Policy in Hong Kong

In Hong Kong, the English language has long been adopted as a medium of instruction (MOI), with the purpose of enhancing local students' English language skills and better preparing them for further study and work in the future (Education Bureau, 2009, p. 2). In September 1997, the Medium of Instruction Guidance for Secondary Schools stipulated that the medium of instruction (MOI) for the junior years of secondary schools was determined by their student intakes' English language proficiency. According to this Guidance, 112 public-sector secondary schools keep using English for instruction, hence commonly referred to as English-as-the-medium-of-instruction (EMI) schools. Around 300 secondary schools are designated as

Chinese-as-the-medium-of-instruction (CMI) schools, where Chinese, the mother tongue for most students, becomes the MOI for the junior forms.

English, as a lingua franca both internationally and locally in the multicultural society of Hong Kong, has high socio-economic value. Due to the pressure from parents whose children in CMI schools were believed to be disadvantaged, since 2010/11 academic year the fine-tuned MOI policy has been implemented: on top of the EMI schools where non-language academic subjects are essentially taught in English (Education Commission, 2005, p. 37), local secondary schools can have the autonomy to make professional decisions regarding the use of EMI in classrooms of up to two non-language subjects, subject to the school's fulfillment of the three criteria prescribed in the Report on Review of Medium of Instruction for Secondary Schools and Secondary School Places Allocation published in 2005. Under the new MOI arrangements, a diversity of teaching modes have emerged in non-language classrooms among local secondary schools in Hong Kong, i.e. the same subject can be conducted primarily in Chinese and sometimes English for certain units of subject content and teaching activities in some schools, whereas in some other schools the subject can be taught entirely in Chinese or in English.

The fine-tuned MOI policy has exerted an enormous impact on local teachers and students (Fung & Yip, 2014). Reviewing and assessing the efficacy of the current MOI policy, the policy makers face question of how to balance the complementary, instead of competing, roles of English and Chinese as MOIs in order to facilitate students' content subject learning and language development (see Kirkpatrick, 2012). So far it lacks sufficient empirical research to address the difficulties and pedagogical strategies of how to enhance teacher professional development regarding the language use in classroom talk and how to improve students' content knowledge and English language acquisition in local CLIL classrooms.

3. Immersion Program and CLIL Education in Hong Kong

Despite the public understanding of EMI learning environments in Hong Kong as a form of "immersion", supported by its frequent use in government documents issued to the public (e.g. Education Commission, 2005; Education Bureau, 2009), it is important to distinguish the form of "immersion" understood by the public from that defined by education scholars. According to Lasagabaster and Sierra, immersion programs "are carried out in languages present in the students' context (be it home, society at large, or both home and society)" (2016, p. 370). However, in Hong Kong, English is primarily used in formal education and work contexts whereas Cantonese is the spoken language used in less formal occasions. The so-called "immersion" understood by the public and stated in the aforementioned official documents is, in fact, more in line with the model of CLIL. The EMI environments established in Hong Kong secondary schools is essentially a form of CLIL, which It is evident from the expectations of schools adopting the EMI to raise students' English proficiency and students' academic performance through "direct access to, and comprehension of, information and the latest knowledge worldwide" (Education Commission, 2005, p. 73). Coyle, Hood and Marsh (2010) characterize CLIL as "a dual-focused educational approach in which an additional language is used for the learning and teaching of both content *and* language" (p.1). Various other terms (with slightly different meanings and emphases in the enactment), such as Content-Based Instruction (CBI) and Language Across the Curriculum (LAC), also denote the growing interest in the contextualized language learning. This study hence adopts the overarching term CLIL to investigate the challenges and strategies of integrating the learning of content subjects and English language in a range of Hong Kong secondary classrooms.

4. Challenges in CLIL classrooms

CLIL has long been orchestrated in a variety of educational settings where both knowledge of content subject and L2 language pose challenges for both teachers and students.

One of the challenges for students is the shifts between academic and everyday English lexicon, which can be difficult for first language classrooms, let alone in the CLIL contexts. For instance, many scholars (Shuard & Rothery, 1984; Raiker, 2002; Molina, 2012, p.22; Barrow, 2014) have argued that English can be a barrier for native speakers to understand mathematical knowledge. Shuard and Rothery (1984) attempt to classify the vocabulary of mathematics into three categories: 1) words that share the same meaning in both ordinary and mathematical contexts; 2) words that only have a mathematical meaning; 3) words that have different meanings in the above two contexts (p. 24). Each of lexical categories poses distinctive problems for learners, and yet the third situation is most likely confusing. Raiker (2002) points out a similar difficulty for students to grasp mathematical vocabulary in the situation of which the words have "precise meanings in mathematics … [yet] their meanings in non-mathematical language may not be so precise" (p. 45).

The challenges for students in content subject classrooms, as Seah, Clarke, and Hart (2015) point out, are not only the conceptual understanding of subject contents, but also the representational demand for using language to articulate specific ideas. Besides, the linguistic demand in CLIL classrooms is of considerable concerns, for students' self-concept can be significantly affected by the L2 instruction. Self-concept refers to one's perception or evaluation of his/her own life experiences. Yip & Tsang's study (2007) shows that the EMI students have greater interest in learning science but lower self-concept than their peers in CMI contexts. According to this study, low self-concept in EMI students can be attributed to the language of instruction in EMI science classrooms which requires a good command of English so as to understand, analyze, and express scientific concepts in an L2 environment.

Assessing students' language ability in class, Skehan (1998) identifies three aspects of language learner performance, namely fluency, accuracy and complexity. Though these aspects are interrelated, Skehan argues that it is not likely for students to accomplish all of them in a single task. As students concentrate on the complexity of ideas (i.e. the content knowledge required in the curriculum), the accuracy of grammar, pronunciation and vocabulary is bound to drop. Skehan's propositions call for thorough lesson planning, designing, combination and sequencing of tasks, so as to facilitate students to deal with their linguistic challenges in CLIL classrooms.

In terms of CLIL teachers in Hong Kong, most of them are non-native English speakers and hence do not necessarily command high proficiency in English (Lasagabaster & Sierra, 2016, p. 370). The polysemic nature of mathematical and scientific vocabulary in English could possibly be as confusing to the teachers as to the learners (August et al., 2005, p. 51). This inevitably casts doubts as to how capable CLIL mathematics and science teachers are, in particular those who used to teach the subjects in Chinese but are now required to shift to English after the implementation of fine-tuned MOI arrangement (Raiker, 2002, p. 45).

Studies show that many teachers have weak awareness of the significance of language in the co-construction of subject knowledge, which may adversely affect students' learning outcomes (Hoare 2003; Mercer et al., 2009, p. 363). García suggested that bilingual education must have the support of, and commitment from, subject teachers who "lend" their discipline for language goals, and hence language and subject must take advantage of each other for more general educational progress (2009, p. 211). In other words, content subject teachers are expected to have higher pedagogical and language awareness in teaching subjects in a second language. As Pistorio stresses, when scaffolding "learners on their way towards becoming competent in both linguistic areas and in non-linguistic content subjects" (2009, p. 39), CLIL teachers need to emphasize in lesson plans the mastery of both target language and knowledge of content subject.

By investigating the complexity and difficulties in local CLIL education and exploring teachers' strategies and students' voices in the process of co-construction of knowledge, this study informs teacher professional development and future MOI policy.

THEORETICAL FRAMEWORK

1. Social Constructivist Theories of Learning

This study draws on social constructivist theories of learning. According to Vygotsky, it is crucial to understand cognitive development from social and individual perspectives: "first, between people (inter-psychological) and then inside the child (intra-psychological)... All the higher mental functions originate as actual relations between people" (1978, p. 57). Vygotskian theory suggests that there is a strong relationship between social interaction via the use of semiotic tools and individual acquisition of knowledge, skills and values. Learning takes place in a social, dialogic environment of education where learners of different backgrounds engage in meaningful and collaborative activities. The interaction and mediation between more capable and less capable learners in the problem-solving tasks facilitates the co-construction of knowledge. For Vygotsky, the appropriate aid from others opens up the "zone of proximal development" (ZPD) for individual learners, which is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (1978, p. 86). The concept of ZPD is crucial to understand the role of teachers, scaffolding strategies and assessment of learning outcomes.

The importance of language in Vygotsky's theory of learning and development can be closely associated with Halliday's view of learning, which is a meaning-making process through the social use of language (Wells, 1999, p. xiii). In "Towards a language-based theory of learning", Halliday states: "The distinctive characteristic of human learning is that it is a process of making meaning—a semiotic process; and the prototypical form of human semiotic is language. Hence the ontogenesis of language is at the same time the ontogenesis of learning" (93). Language is instrumental in the cognitive construction of knowledge and experience, not only because one disseminate knowledge to others by using a language, but also because language forms the way in which one construes an experience and internalizes it as knowledge. As Halliday argues, "language is the essential condition of knowing, the process by which experience becomes knowledge" (1993, p. 94). In this regard, both "learning language" and "learning through language" are important for the cognitive development of children (Halliday, 1993, p. 93). These two interrelated aspects address the objectives of the CLIL education in incorporating content subject learning and second language acquisition and highlight the crucial role of classroom talk—the focus of this study—in the co-construction of scientific and mathematical knowledge.

2. Classroom Talk

In *Talking Science* (1990), Lemke suggests that the teacher's task is to "see science teaching as a social process and … [lead] students, at least partially, into this community of people who *talk science*" (Lemke, 1990, p. x; emphasis in original). Drawing on both Vygotsky's and Halliday's theories, Wells (1999) highlights the importance of "dialogic inquiry" in creating a classroom community which enables students to participate collaboratively in the meaning making process. Dialogic models are vital to construct a socially learning community, because "dialogue is not fundamentally a specific communicative form of question and response, but at heart a kind of social relation that engages its participants" (Burbules, 1993, p.19-20). In this light, this study examines the dialogicality, and more broadly interactivity, of classroom talk in the process of achieving co-construction of knowledge. Here, classroom talk refers to the organized or spontaneous speech and discussion between teacher and student(s), and between student(s) and student(s) during the lessons.

2.1 Dialogic Patterns and Dialogic Teaching

This study adopts multi-layered coding for data analysis.

The exchange sequence of Initiation-Response-Feedback/Follow-up (IRF) put forward by Sinclair and Coulthard (1975) remains fundamental in classroom discourse analysis. Different *moves*, which comprise teacher initiation, pupil response, and teacher feedback or follow-up, form the most common interactive pattern in the classroom, which is called *exchange*; an array of exchanges that serve a relatively independent purpose, such as exposition of specific concepts or ideas, comprises a *sequence*; different sequences then form *transactions*, as a higher level of segmentation of a *lesson* (Sinclair & Coulthard, 1975; Tsui, 1994; Marton et al., 2004). The analysis of move, exchange and sequence in the classroom talk offer an emic, grounded perspective to identify the purposes, characteristics, and achievements of dialogues, which is of central importance for the effective co-construction of knowledge.

The traditional dialogic pattern of Initiate-Response-Feedback/Evaluate (Sinclair & Coulthard, 1975; Mehan, 1979), however, maintains the teacher's central role in classroom talk, in which individual students communicate primarily with the teacher (Pimentel & McNeill, 2013).

Facing the exam-driven syllabus and limited class hours, triadic dialogue tends to be used for the purpose of knowledge checking, rather than knowledge exploration and co-construction (Lin & Lo, 2017; Mercer et al., 2009). Students benefit to a limited extent from teachers' elicitation of answers in a piecemeal fashion (Pimentel & McNeill, 2013; Edmin, 2011). Moreover, teachers' question-answer interaction with no further expansion, probing, or tossing back students' responses in fact recycles a continued and less productive discussion, in which the teacher would bring forth the conceptual understanding through his/her monologue. Meaning making *for* students is different from that *by* students. When the dominant speech in class is teacher's monologue, students can be discouraged to develop higher order thinking and reasoning abilities in meaning making process. As Pimentel & McNeill's study (2013) reflects on the dilemma of students, "if it is the norm for the teacher to transform short responses into more complicated and meaningful concepts, what motivation exists to risk elaborating on an answer themselves and being wrong?" (p. 388).

Reflecting on the significance of classroom talk, Lefstein & Snell (2011) stress that "[t]eachers need to understand the importance of talk in teaching and learning; be sensitive to the ways in which conventional discourse norms can be detrimental to pupil thinking and learning; and appreciate the promise—and complexity—of dialogic practice" (p. 16). Scholars identify various forms and effects of classroom interaction. In his critique of the conventional IRF structure of classroom interaction, Alexander (2005) examines the repertoires of teaching talk: rote, recitation, instruction/exposition, discussion, and dialogue (p. 34). He argues that the forms of talk do not guarantee the "*quality* of interaction" (p. 35). He therefore proposes that "dialogic teaching", which consists of five interrelated characteristics: collective, reciprocal, supportive, cumulative and purposeful, can "harnesses the power of talk to engage children, stimulate and extend their thinking, and advance their learning and understanding" (2005, p.34).

Dialogic teaching, according to Alexander, suggests a productive and collaborative relationship between teachers and pupils, and that between pupils and their peers, and the way in which ideas and viewpoints can be exchanged and built up to achieve the educational goals.

To examine how the teacher develops ideas among students, Mortimer and Scott (2003) categorize the teacher's communicative approach into four dimensions: interactive and non-interactive, dialogic and authoritative. The distinction between dialogic and authoritative approaches is contingent upon whether more than one viewpoint is presented, probed or discussed with students (p. 33-4). This view distinguishes a teacher-centered talk from a student-oriented approach, for the latter not only gives students sufficient opportunities of speaking in class but also values their contribution of ideas and thoughts. According to Mortimer and Scott, these dimensions form four classes of communicative approach: Interactive / dialogic, Non-interactive / dialogic, Interactive / authoritative, Non-interactive / authoritative. This is not to suggest that certain class of communicative approach works better than the other, because the teacher's choice of different communicative approach is subject to the social context in which the content is taught. But these classes are useful to present different approaches through which the teacher works with the students to achieve co-construction of knowledge.

2.2 Scaffolding and Mediation

Teachers provide scaffolding to facilitate co-construction of knowledge. According to Holton and Clarke (2006), scaffolding in the learning process can be categorized into different agents: teachers (expert scaffolding), peers (reciprocal scaffolding) and learners (self-scaffolding). To promote a better construction of knowledge and independent learning for learners' long-term interest, it is necessary to realize "the progressive devolution of the role of scaffolding agent from teacher to learner" (Holton & Clarke, 2006, p.141). In terms of different domains, there are conceptual and heuristic scaffoldings (Holton & Clarke, 2006, p.134). An act of scaffolding often synthesizes both aspects to facilitate the problem-solving process.

One of the central tasks in CLIL education is to realise the translation from colloquial, everyday language to academic, technical language as required by the curriculum. The shift of different registers is a two-way process, requiring learners to practice "restating scientific expressions in their own colloquial words, and also … translating colloquial arguments into formal scientific language" (Lemke, 1990, p. 173). The heteroglossic, dynamic characteristic, as García and Lin (2016) point out, is not "two monolingualisms in one, but … one integrated linguistic system" (3). This view sheds light on the interrelatedness between different registers of colloquial and academic languages in knowledge expressions, as well as the necessity for teachers and students to master such practices of translation. Lin and Lo's (2017) study draws on Lemke's (1990) "thematic development strategies" and "social interactional strategies" (for more, see *Science Talk in CLIL Contexts*), together with Lin's framework of multiple bridging resources (2012), to examine the dialogic discourse in science CLIL classrooms. Lin's framework, also called rainbow diagram (2012, p. 93), seeks to expand students' repertoire of both L1 and L2 communitive resources and to mediate the translation between L1 and L2, daily and academic languages, oral and written languages, by using visual and multi-modalities.

Gibbons (2003) draws on the sociocultural construct of mediation and the notion of mode continuum from systemic functional linguistics to examine the process of mode-shifting from oral, everyday language to academic, specialist registers in content-based ESL classrooms. Mediation often takes place in a collaborative, interactional process. Related to the theoretical constructs such as zone of proximal development (ZPD), scaffolding, and contingency, the model of mediation is useful to analyse the dialogues between the teacher and students for the co-construction of subject knowledge and language. As suggested by Gibbons (2003), teacher's mediating role can be manifested through 1) recasting to shift modes, 2) enabling students to reformulate, 3) requesting clarification, and 4) evoking personal knowledge. Gibbons (2003) stresses that the teacher's mediation or scaffolding is contingent upon students' response to make meaning in science registers (p. 261). To understand the contingency in classroom interactions is crucial for teachers to perform the mediating role and to discern the appropriate moment of handling classroom talk to students.

Considering the challenges facing the CLIL classrooms in Hong Kong, Lin (2016) draws on Gibbons' model of designed and improvised scaffoldings to suggest an implementation of "systematic planning of embedded language support and spontaneous embedding of language support" during the teaching of content knowledge in CLIL contexts (p. 154; Gibbons, 2009). Given the effectiveness of implicit guidance varies in different classrooms to help students acquire language skills, the teacher's explicit language-oriented intervention remains important to facilitate students to process and negotiate meaning in academic contexts (Lin, 2016; Rose & Martin, 2012).

2.3 Discourse Patterns in Mathematics Classrooms

Considering the distinctive nature of content subjects, the data analysis is supplemented by the following theoretical constructs, along with the aforementioned theories on the teacher's communicative approach and scaffolding strategies, to examine the discourse patterns in Mathematical lessons.

According to Mok et al. (2015), there are some common types of interactive patterns in Chinese

Mathematics classrooms (see p.714-8). First, the I-R-F pattern is a prevailing discourse pattern characterised by the teacher's elicitation of student's response, which is followed by the teacher's feedback. The talk-in-turn between the teacher and students is often confined to seeking the correct answer from students. This approach maintains the teacher's authority and provides little opportunity for students to raise questions or explore alternative ideas. Second, for the funnel pattern, the teacher narrows down an open-ended, exploratory question into several interrelated, closed-ended questions. Students are guided "to produce a predetermined answer or solution preferred by the teacher" (Mok et al., 2015, p.715; see also Wood, 1998). Third, the focusing pattern of interaction is also evident in Mathematics classrooms in which the teacher allows students to explore possible answers or alternative solutions (Mok et al., 2015; Wood, 1998). This type of interaction is often led by open-ended questions.

References

Alexander, Robin. (2005). *Towards dialogic teaching: Rethinking classroom talk* (2nd ed.). York: Dialogos.

August, D., Carlo, M., Dressler, C., & Snow, C. (2005). The Critical Role of Vocabulary Development for English Language Learners. *Learning Disabilities Research & Practice, 20*(1), 50-57.

Barrow, M. A. (2014). Even math requires learning academic language. *The Phi Delta Kappan, 95*(6), 35-38.

Burbules, N. C. (1993). *Dialogue in teaching: Theory and practice*. New York: Teachers College Press.

Coyle, D., Hood, P., & Marsh, D. (2010). *CLIL: Content and language integrated learning*. Cambridge, UK: Cambridge University Press.

Day, E. M., & Shapson, S. (1996). *Studies in immersion education*. Clevedon: Multilingual Matters.

Edmin, C. (2011). Dimensions of communication in urban science education: Interactions and transactions. *Science Education, 95*, 1-20.

Education Bureau. (2009) *Fine-tuning the Medium of Instruction for Secondary Schools*. Hong Kong SAR: Education Bureau.

Education Commission. (2005). *Report on Review of Medium of Instruction for Secondary Schools and Secondary School Places Allocation*. HKSAR: Government Logistics Department.

Fung, D., & Yip, V. (2014). The effects of the medium of instruction in certificate-level physics on achievement and motivation to learn. *Journal of Research in Science Teaching, 51*(10), 1219-45.

García, O. (2009). *Bilingual education in the 21st century: A global perspective*. Malden, MA;

Oxford: Wiley-Blackwell Publishing.

García, O., & Lin, A.M.Y. 2016. "Translanguaging in bilingual education." In O. García, & A.M.Y. Lin (Eds.), *Bilingual and Multilingual Education (Encyclopedia of Language and Education, Vol. 5)*. Dordrecht: Springer.

Gibbons, P. (2003). Mediating language learning: Teacher interactions with ESL students in a content-based classroom. *TESOL Quarterly, 37*(2), 247-273.

Halliday, M.A.K. (1993). Towards a language-based theory of learning. *Linguistics and Education, 5,* 93-116.

Hoare, P. (2003). *Effective teaching of science through English in Hong Kong secondary schools.* Unpublished doctoral dissertation, The University of Hong Kong, Hong Kong.

Holton, D., & Clarke, D. (2006). Scaffolding and metacognition. *International Journal of Mathematical Education in Science and Technology, 37*(2), 127-143.

Kasmer, L. (2013). Pre-service teachers' experiences teaching secondary mathematics in English-medium schools in Tanzania. *Mathematics Education Research Journal, 25*, 399-413.

Kirkpatrick, A. (2012). English as an Asian Lingua Franca: The 'Lingua Franca Approach' and implications for language education policy. *Journal of English as a Lingua Franca, 1*(1), 121-139.

Lasagabaster, D., & Sierra, J. M. (2016). Immersion and CLIL in English: more differences than similarities. *ELT Journal, 64*(4), 367-375.

Lefstein, A., & Snell, J. (2011). Classroom discourse: The promise and complexity of dialogic practice. In S. Ellis, E. McCartney, & J. Bourne (Eds.), *Applied Linguistics and Primary School Teaching: Developing a Language Curriculum.* (pp. 165-185). Cambridge University Press.

Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Norwood, N.J: Ablex

Pub. Corp.

Lin, A.M.Y. (2012). “Multilingual and Multimodal Resources in L2 English Content Classrooms.” In C. Leung & B. Street (Eds.), *English—A Changing Medium for* Education. (pp. 79-103). Bristol, U.K.: Multilingual Matters.

Lin, A.M.Y. (2016) *Language Across the Curriculum & CLIL in English as an Additional Language (EAL) Contexts*. Singapore: Springer.

Lin, A. M. Y., & Lo, Y. Y. (2017). Trans/languaging and the triadic dialogue in content and language integrated learning (CLIL) classrooms. *Language and Education, 31*(1), 26–45.

Llinares, A., & Dalton-Puffer, C. (2015). The role of different tasks in CLIL students’ use of evaluative language. *System, 54*, 69-79.

Marton, F., Runesson, U., & Tsui, A. B. M. (2004). The Space of Learning. In F. Marton et al., *Classroom discourse and the space of learning* (pp. 3-42). Mahwah, N.J: L. Erlbaum Associates.

Mehan, H. (1979). *Learning lessons: Social organization in the classroom*. Cambridge, MA: Harvard University Press.

Mercer, N., Dawes, L., & Staarman, J. K. (2009). Dialogic teaching in the primary science classroom. *Language and Education, 23*(4), 353-369.

Mok, I.A.C., Yang, X., & Zhu, Y. (2015). “Mathematical discourse in Chinese classrooms: An insider’s perspective.” In B. Sriraman et al. (Eds.), *The first sourcebook on Asian research in mathematics education: China, Korea, Singapore, Japan, Malaysia, and India.* (pp. 705-731). Charlotte, North Carolina: Information Age Publishing.

Molina, C. (2012). *The problem with math is English: a language-focused approach to helping all students develop a deeper understanding of Mathematics.* San Francisco, USA: Jossey-Bass.

Mortimer, E. F., & Scott, P. (2003). *Meaning making in secondary science classrooms*. Buckingham: Open University Press.

Pimentel, D. S., & McNeill, K. L. (2013). Conducting talk in secondary science classrooms: Investigating instructional moves and teachers' beliefs. *Science Education, 97*(3), 367-394.

Pistorio, M. I. (2009). Teacher training and competences for effective CLIL teaching in Argentina. *Latin American Journal of Content & Language Integrated Learning, 2*(2), 37-43.

Raiker, A. (2002). Spoken Language and Mathematics. *Cambridge Journal of Education, 32*(1), 45-60.

Rose, D., & Martin, J. R. (2012). *Learning to write, reading to learn: Genre, knowledge and pedagogy in the Sydney school*. Sheffield (UK) and Bristol (USA): Equinox.

Seah, L. H., Clarke, D., & Hart, C. (2015). Understanding middle school students' difficulties in explaining density differences from a language perspective. *International Journal of Science Education, 37*(14), 2386-240.

Shuard, H., & Rothery, A. (1984). *Children reading mathematics*. London: J. Murray.

Sinclair, J., & Coulthard, M. (1975). *Towards an analysis of discourse: The English used by teachers and pupils*. London: Oxford University Press.

Skehan, P. (1998). *A cognitive approach to language learning.* Oxford: Oxford University Press.

Tsui, A.B.M. (1994) *Introducing Classroom Interaction.* London: Penguin.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological functions*. Cambridge, MA: Harvard University Press.

Wells, G. (1999). *Dialogic Inquiry: Towards a socio-cultural practice and theory of education*. Cambridge, MA: Harvard University Press.

Wood, T. (1998). "Alternative patterns of communication in mathematics classes: Funneling or focusing?" In H. Steinbring, M.G. Bartolini Bussi, & A. Sierpinska, (Eds.). *Language and communication in the mathematics classroom* (pp. 167-178). Reston, VA.: The National Council of Teachers of Mathematics, Inc.

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.

Yip, D. Y., Coyle, D., & Tsang, W. K. (2007). 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.

APPENDIX II ***Invitation letter***

THE UNIVERSITY OF HONG KONG

POKFULAM ROAD
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香港 大學

FACULTY OF EDUCATION
教育學院

4 July 2016

Mr /Ms / Dr XXXX

Principal

XXXXXXXXXXXX

Dear Mr/ Ms/ Dr XXX,

SCOLAR Project

L2 Classroom Talk and Subject Content Learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms

I am Dr Gary Harfitt, Associate Professor in English Language Education at the University of Hong Kong. My Research Team and I are conducting a research project funded by the Standing Committee on Language Education and Research (SCOLAR) and we seek your kind support and help in achieving the goals of the study. This project aims to examine the role of English as a medium of instruction in junior secondary Mathematics and Science classrooms in Hong Kong, as well as to understand how classroom talk can be effectively conducted to help students master both the subject knowledge and the English language. Through collaboration with your school, we hope to further develop the effectiveness of teachers' pedagogy in the teaching of mathematics and science as well as the English language. We believe these are the long-term benefits of the study as we seek to understand more about how language is used across the curriculum.

For our study we would like to invite two Mathematics and / or two Science teachers, one expert teacher and one novice / relatively new teacher for each subject, in consideration of their professional qualifications and years of experience in teaching their subject using English. With your permission, our team would like to carry out the following research activities at your school:

- observe, video-record and audio-record a unit of Mathematics and/ or Science lessons on a particular topic (about 40 minutes/lesson, around 20 lessons/teacher; see Appendix I for the topic list). Each subject will be taught by two teachers at the same grade level. We would also like to collect lesson artifacts such as teaching materials and student work samples in order to triangulate our findings.
- conduct interviews with each teacher, including a baseline interview pre-lesson and post-lesson interviews and a post-unit interview We understand how busy teachers are and these interviews would be arranged with each teacher to ensure no inconvenience is caused to them or your students.
- conduct some student focus group interviews.
- conduct follow-up interviews with individual students if necessary.
- observe and audio-record/video-record any out-of-class activities concerning the Mathematics/Science lessons if this is acceptable to you.

How we hope your School will benefit from joining our research project

- At the end of the project, we will gladly give feedback to individual teachers and the panel chair(s) on the teaching units we observe and an overall report of our project findings will be given to your school. This can be done to the whole school or to you and the management committee (or both).
- We are happy to organize a teacher training workshop on Language Across the Curriculum. All Science / Mathematics teachers of the School will be invited to attend the event and have access to the training materials.
- As a token of appreciation, a certificate of participation will be presented to your school and teachers.
- Please feel free to suggest other ways in which we can help promote teaching and learning in your school.

We would be very happy to discuss the aims of our project with you and how we can benefit your school. If you wish to know more about the project, please feel free to contact either Miss Scarlet Poon, Project Research Manager, at scarletws@hku.hk / 3917 7602 or contact me directly at gharfitt@hku.hk / 3917 5729.

Your support is greatly appreciated and we sincerely hope you might consider working with us on this valuable project. We await your reply.

Yours sincerely,

Gary Harfitt (Dr)
Principal Investigator
Assistant Dean and Associate Professor
Faculty of Education

In terms of the subject topics, for Science, we have selected *Matter as particles* (F.1) and *Living Things* and *Air* (F.2); for Mathematics, *Number and Algebra* (F.1 and F.2) is selected.

A summary of the key subject content and discourse features

Subject	Key Content	Examples of Discourse Features
Mathematics	Number and Algebra Dimension (F.1 and F.2) For example, ◦ Directed numbers & number line ◦ Numerical estimation ◦ Approximation & errors ◦ Percentages, rate & ratio ◦ Algebra ◦ Manipulations & factorization of polynomials ◦ Identities ◦ Formulae ◦ Linear equations in two unknowns **The chapter/unit to be observed will be confirmed upon teacher's recommendation.**	These include discussion of: ◦ rate and ratio that involve daily life examples and comparison of quantities in formal and abstract terms ◦ simultaneous equations that involve multiple representations and formulation of problems, including word problems
Science	Matter as Particles (F.1) ◦ Particle theory ◦ Three states of matter ◦ Gas pressure ◦ Density ◦ Thermal expansion & contraction	These include discussion of: ◦ accounting for the states of matter/gas pressure with the use of particle theory ◦ describing the particle arrangement as shown in diagrams (e.g. in thermal expansion) ◦ arguing why some diagrams are more accurate for the particle arrangement ◦ calculating the density of solids and liquids ◦ describing and explaining results observed in practical lessons
	Living Things and Air (F.2) ◦ Composition of air ◦ Burning ◦ How human and plants obtain energy ◦ Gas exchange in animals & plants ◦ Air pollution and smoking	These include discussion of: ◦ explaining why a fire can be put out by various methods and the importance of maintaining the gas balance in the globe ◦ describing the equations of photosynthesis and respiration ◦ comparing the events of breathing in and out

		◦ drawing concept maps to link up the key content ◦ describing and explaining results observed in practical lessons

Reply Slip

SCOLAR Project

L2 Classroom Talk and Subject Content Learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms

To: Dr Gary Harfitt
Faculty of Education
The University of Hong Kong
Pokfulam Road, Hong Kong
Email: gharfitt@hku.hk

Our School **is / is not** (delete as appropriate) interested in participating in the aforementioned research project and **would / would not** like to be contacted by the Research Team.

School's name	:	________________
Principal's name	:	________________
Principal's signature	:	________________
Principal's contact number	:	________________

<u>APPENDIX III</u> ***Project outline, June 2016***

SCOLAR Research and Development Project
Faculty of Education, University of Hong Kong

L2 Classroom Talk and Subject Content Learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms
(Current to 31 March 2018)

Objectives

This study examines the role of English (L2) as the medium of instruction in Mathematics and Science classrooms in junior secondary schools of Hong Kong. It aims to understand how students develop cognitive learning of content subjects through the use of English language. Specifically, the Project Team aims

1) To identify the distinctive features of the L2 classroom talk that promote successful learning in mathematics and science.
2) To investigate the linguistic competency and knowledge required for students to participate successfully in mathematics and science classrooms.
3) To discuss teachers' pedagogical and linguistic strategies useful to facilitate the meaning making process and second language acquisition in class, and to inform teacher professional development.
4) To examine students' experience of learning mathematics and science in and out of the classroom for a better understanding of how content knowledge is constructed.

Participation of project schools

Four schools will take part in the study. We will invite two mathematics and two science teachers from each school. A total of four EMI classrooms (two Mathematics and two Science classes at the same grade level) will be selected in each school. In terms of the subject topics, for Science, we have selected *Matter as particles* (F.1) and *Living Things* and *Air* (F.2); for Mathematics, *Number and Algebra* (F.1 and F.2) is selected.

A summary of the key subject content and discourse features is provided as follows:

Subject	Key Content	Examples of Discourse Features
Mathematics	Algebra (F.1 and F.2) ◦ Directed numbers & number line ◦ Numerical estimation ◦ Approximation & errors ◦ Percentages, rate & ratio	These include discussion of: ◦ rate and ratio that involve daily life examples and comparison of quantities in formal and abstract terms ◦ simultaneous equations that involve multiple representations and formulation of problems, including word problems
Science	Matter as Particles (F.1) ◦ Particle theory ◦ Three states of matter ◦ Gas pressure ◦ Density	These include discussion of: ◦ accounting for the states of matter/gas pressure with the use of particle theory ◦ describing the particle

	◦ Thermal expansion & contraction	arrangement as shown in diagrams (e.g. in thermal expansion) ◦ arguing why some diagrams are more accurate for the particle arrangement ◦ calculating the density of solids and liquids ◦ describing and explaining results observed in practical lessons
	Living Things and Air (F.2) ◦ Composition of air ◦ Burning ◦ How human and plants obtain energy ◦ Gas exchange in animals & plants ◦ Air pollution and smoking	These include discussion of: ◦ explaining why a fire can be put out by various methods and the importance of maintaining the gas balance in the globe ◦ describing the equations of photosynthesis and respiration ◦ comparing the events of breathing in and out ◦ drawing concept maps to link up the key content ◦ describing and explaining results observed in practical lessons

Classroom observations

Classroom observations will be conducted between October 2016 and April 2017. A unit of Mathematics/Science lessons on a particular topic (about 40 min/lesson; around 20 lessons/teacher) will be observed. Each classroom observation will be audio and video-recorded and transcribed. A sample of 5 high and 5 low academic ability students in each class will be identified by their teachers at the beginning of the study. Students' participation in the classroom and their performance in school-based assessments in the content subjects studied and English will be tracked and triangulated. Sample of student work such as assessment and assignments will be collected for analysis. We would be keen to observe and audio/video-record any out-of-class activities related to the Mathematics and Science lessons if this is agreeable.

Interviews with teachers

Each participating teacher will be invited for a baseline interview (30-60 min), pre-lesson and post-lesson interviews (5-10 min each) and a post-unit interview (30-60 min). Interview foci will include lesson planning, material design, reference to particular classroom episodes, teachers' opinions on teaching content subjects through L2, teachers' pedagogical decisions particularly in the area of classroom language and the organization of classroom learning. Interviews will fit into the teachers' schedules during our visits to the schools. Each interview will be audio-recorded and transcribed.

Interviews with students
Two focus group interviews will be conducted with the sampled students, which include a pre-unit interview and a post-unit interview (30-40 min each). Interview foci will include students' experiences of learning subject contents through L2, their response to teachers' pedagogical strategies, views on knowledge and concept building in respective subjects, their participation in class and experience of learning of mathematics and science out of the classroom. Follow-up semi-structured interviews will also be conducted with individual students (30 min each) to elicit their feedback on particular learning experience. Interviews will be audio-recorded and transcribed.

Research ethics

All data collection and analysis will strictly follow the ethics regulations set out by HKU. Prior consent will be sought from all the stakeholders before the project starts.

Potential contribution to the project schools, teachers, students and the education sector

The findings of this study will provide evidence of how classroom talk can be effectively conducted to develop students' cognitive and linguistic skills in the subjects of Mathematics and Science. It will inform pedagogical practices, teacher professional development, and future education policies. Support from the project schools would be valuable to the study.

Research Team

Principal Investigator
Dr Gary Harfitt

Co-Investigators
Dr Valerie Yip
Dr Ida Mok
Dr Alice Wong
Dr Dennis Fung
Dr Cheri Chan
Dr Arthur Lee
Dr Kennedy Chan
Professor Amy Tsui

Project Research Manager
Ms Scarlet Poon

Senior Research Assistant
Ms Xu Daozhi

Research Assistants
Ms Jennifer Wong
Ms Elaine Chin

If you are interested to know more about our project and collaborate with us, please contact Dr Gary Harfitt, Faculty of Education, HKU at 3917 5729 / Email: gharfitt@hku.hk

Enquiries can also be directed to the Research Support Team at 3917 7602.

We look forward to your participation!

June 2016

<u>APPENDIX IV</u> ***Revised project outline, September 2016***

SCOLAR Research and Development Project
Faculty of Education, University of Hong Kong

L2 Classroom Talk and Subject Content Learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms (Current to 31 March 2018)

<u>Objectives</u>

This study examines the role of English (L2) as the medium of instruction in Mathematics and Science classrooms in junior secondary schools of Hong Kong. It aims to understand how students develop cognitive learning of content subjects through the use of English language. Specifically, the Project Team aims

5) To identify the distinctive features of the L2 classroom talk that promote successful learning in mathematics and science.
6) To investigate the linguistic competency and knowledge required for students to participate successfully in mathematics and science classrooms.
7) To discuss teachers' pedagogical and linguistic strategies useful to facilitate the meaning making process and second language acquisition in class, and to inform teacher professional development.
8) To examine students' experience of learning mathematics and science in and out of the classroom for a better understanding of how content knowledge is constructed.

<u>Participation of project schools</u>

We invite two mathematics or two science teachers from each school. For each subject, participating teachers should teach in the same grade level. In terms of the subject topics, for Science, we have selected *Matter as particles* (F.1) and *Living Things* and *Air* (F.2); for Mathematics, *Number and Algebra* (F.1 and F.2) is selected.

A summary of the key subject content and discourse features is provided as follows:

Subject	**Key Content**	**Examples of Discourse Features**
Mathematics	Number and Algebra Dimension (F.1 and F.2) For example, ◦ Directed numbers & number line ◦ Numerical estimation ◦ Approximation & errors ◦ Percentages, rate & ratio The chapter/unit to be observed will be confirmed upon teacher's recommendation.	These include discussion of: ◦ rate and ratio that involve daily life examples and comparison of quantities in formal and abstract terms ◦ simultaneous equations that involve multiple representations and formulation of problems, including word problems

Science	Matter as Particles (F.1) ◦ Particle theory ◦ Three states of matter ◦ Gas pressure ◦ Density ◦ Thermal expansion & contraction	These include discussion of: ◦ accounting for the states of matter/gas pressure with the use of particle theory ◦ describing the particle arrangement as shown in diagrams (e.g. in thermal expansion) ◦ arguing why some diagrams are more accurate for the particle arrangement ◦ calculating the density of solids and liquids ◦ describing and explaining results observed in practical lessons
	Living Things and Air (F.2) ◦ Composition of air ◦ Burning ◦ How human and plants obtain energy ◦ Gas exchange in animals and plants ◦ Air pollution and smoking	These include discussion of: ◦ explaining why a fire can be put out by various methods and the importance of maintaining the gas balance in the globe ◦ describing the equations of photosynthesis and respiration ◦ comparing the events of breathing in and out ◦ drawing concept maps to link up the key content ◦ describing and explaining results observed in practical lessons

Classroom observations

Classroom observations will be conducted between October 2016 and April 2017. A unit of Mathematics/Science lessons on a particular topic (about 40 min/lesson; around 20 lessons/teacher) will be observed. Each classroom observation will be audio and video-recorded and transcribed. A sample of 5 high and 5 low academic ability students in each class will be identified by their teachers at the beginning of the study. Students' participation in the classroom and their performance in school-based assessments in the content subjects studied and English will be tracked and triangulated. Sample of student work such as assessment and assignments will be collected for analysis. We would be keen to observe and audio/video-record any out-of-class activities related to the Mathematics and Science lessons if this is agreeable.

Interviews with teachers

Each participating teacher will be invited for a baseline interview (30-60 min), pre-lesson and post-lesson interviews (5-10 min each) and a post-unit interview (30-60 min). Interview foci will include lesson planning, material design, reference to particular classroom episodes, teachers' opinions on teaching content subjects through L2, teachers' pedagogical decisions particularly in the area of classroom language and the organization of classroom learning. Interviews will fit into the teachers' schedules during our visits to the schools. Each interview will be audio-recorded and transcribed.

Interviews with students
Two focus group interviews will be conducted with the sampled students, which include a pre-unit interview and a post-unit interview (30-40 min each). Interview foci will include students' experiences of learning subject contents through L2, their response to teachers' pedagogical strategies, views on knowledge and concept building in respective subjects, their participation in class and experience of learning of mathematics and science out of the classroom. Follow-up semi-structured interviews will also be conducted with individual students (30 min each) to elicit their feedback on particular learning experience. Interviews will be audio-recorded and transcribed.

Research ethics

All data collection and analysis will strictly follow the ethics regulations set out by HKU. Prior consent will be sought from all the stakeholders before the project starts.

Potential contribution to the project schools, teachers, students and the education sector

The findings of this study will provide evidence of how classroom talk can be effectively conducted to develop students' cognitive and linguistic skills in the subjects of Mathematics and Science. It will inform pedagogical practices, teacher professional development, and future education policies. Support from the project schools would be valuable to the study.

Research Team

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If you are interested to know more about our project and collaborate with us, please contact Dr Harfitt at gharfitt@hku.hk / 3917 5729. Enquiries can also be directed to Ms Poon at scarletws@hku.hk and the Research Support Team at 3917 7602.

We look forward to your participation!

September 2016

APPENDIX V ***General information on project schools, participating teachers and students and topics observed***

School Code	District	School MOI (General)	No. of Participating Classes	Subject	No. of Students	No. of students who agree to participate	Topic of observation
1	Central and Western	EMI	T1A	Maths	33	33	Introduction to Algebra
			T1B	Maths	33	33	Introduction to Algebra
			T1B	Science			Matter as Particles
2	Southern	EMI	T2	Maths	28	26	Linear Equations in Two Unknowns
3	Kowloon City	EMI	T3A	Maths	22	22	Linear Equations in Two Unknowns
			T3A	Maths	23	23	Linear Equations in Two Unknowns
4	Sai Kung	CMI	T4A	Science	32	32	Matter as Particles
			T4B	Science	31	29	Matter as Particles
5	Tuen Mun	CMI	T5	Science	32	30	Alkaline and Acid
			T5B*	Science	29	27	Alkaline and Acid
7	Kwai Tsing	EMI	T7	Science	31	28	Matter as Particles
8	Tsuen Wan	EMI	T8A	Science	31	31	Matter as Particles
			T8B	Science	32	32	Matter as Particles
9	Wong Tai Sin	CMI	T9A	Maths	31	27	Rate and Ratio
			T9B	Maths	35	35	Linear Equations in Two Unknowns

Remark:

* Data was collected from T5B's class in School 5 but considering it was a CMI Science by nature, the team has decided to withdraw its data from the main analysis to keep consistent comparison across this naturalistic study.

- School 6 has decided not to participate before the project started.

<u>APPENDIX VI</u> ***Proforma for completion by teachers***

Faculty of Education, University of Hong Kong
SCOLAR Project
L2 Classroom Talk and Subject Content Learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms

Please complete a separate page of information for each participating teacher.

School: ____

Name of Participating Teacher: ___________________________

(Science / Maths teacher of Class ______________)

Number of years of teaching experience in the above subject: _______________

Number of years of experience in teaching the above subject in English: __________

Major educational and professional qualifications that *<u>you consider influential to your teaching of your Science/Maths class</u>* (e.g. undergraduate/ postgraduate studies offered by local/ overseas universities, teacher training/ workshops relevant to mathematics/ science teaching organized by EDB/ book publishers, etc.)

Name of the institution/ organizer	**Title of the qualification/ course/ workshop, etc.**	**Duration of the programme/ course/ workshop, etc.**

Teaching Duties in 2016-2017

Subject(s)	**Class level (e.g. F. 1B)**	**Medium of instruction (‘C’ for CMI; ‘E’ for EMI)**

Please provide details for lesson observation arrangement

Title of textbook: ____

Publisher: ____

Edition: ____

Subject and Key Content	**When the unit will be taught in 2016-17 (e.g. 3rd – 20th Oct 2016 / 15th Feb – 8th Mar 2017)**
MATHEMATICS Number and Algebra Dimension (F. 1) Chapter / Unit recommended for observation ____	
MATHEMATICS Number and Algebra Dimension (F. 2) Chapter / Unit recommended for observation ____	
SCIENCE Matter as Particles (F. 1 Second Term) Particle theory Three states of matter Gas pressure Density Thermal expansion & contraction	
SCIENCE Living Things and Air (F. 2 First Term) Composition of air Burning How human and plants obtain energy Gas exchange in animals & plants Air pollution and smoking	

APPENDIX VII ***Teacher qualifications and experiences***

Maths teachers

School Code	General MOI of the school	Teacher Code /Form Level of Maths class	Major qualifications and professional training that teachers consider influential to their teaching of the Maths class	Years of experience in teaching Maths	Years of experience in teaching Maths in English	Other teaching duties in 2016-17 / Level(s) / MOI
1	EMI	T1A (F.1)	- MPhil (Maths) - PGDE	12	12	I.S. / F.1 (EMI); Maths / F.5 (EMI)
		T1B (F.1)	- BSc (Chemistry) - PGDE (Chemistry)	1	1	Maths / another F.1 class (E); Integrated Science / F.2 (EMI)
2	EMI	T2 (F.2)	- PGDE - MSc (Statistics)	10	10	Maths / F.3, F.4 & F.5 (EMI)
3	EMI	T3A (F.2)	- BEng (Information Engineering) - PCEd (Maths and Statistics)	20	20	Maths / F.6 (EMI)
		T3B (F.2)	- BSc (Maths and Physics) - PGDE (Physics and Maths) - MEd (Educational Psychology) - 6-week Professional development course for secondary schoolteacher (Maths training) - 8-week Professional development programme for teachers using EMI in secondary school - 45-hour Advanced and intermediate courses in gifted education	11	11	Maths / another F.2 class (EMI); Maths / F.4 (EMI)
9	CMI	T9A (F.1)	- BSc in Mathematics (Mathematics and IT Education)	9	9	Maths / F.4 & F.6 (EMI); Maths (M2) / F.4 (EMI)
		T9B (F.2)	- BEng (Information Engineering) - PGDE (Mathematics)	7	5	Maths / F.1 & F.3 (CMI); Computer Studies / F.3 (EMI); Information and Communication Technology / F.4 (EMI)

Science teachers

School Code	General MOI of the school	Teacher Code /Form Level of Science class	Major qualifications and professional training that teachers consider influential to their teaching of the Science class	Years of experience in teaching Science	Years of experience in teaching Science in English	Other teaching duties in 2016-17 / Level(s) / MOI
1	EMI	T1B (F.1)	- BSc(Chemistry) - PGDE (Chemistry)	1	1	Maths / F.1 (EMI); Integrated Science / F.2 (EMI)
4	CMI	T4A (F.1)	- BSc (Biology) - MSc (Biotechnology) - PGCE (Biology)	~10	~10	Science / F.2 (CMI); Biology / three F.3 classes (EMI) and one F.3 class (CMI) / E) and F.5 (CMI)
		T4B (F.1)	- BEng in Computer Science (Information Engineering) - MSc (ITM) - PGDE (Maths & IT)	1	1	Physics / F.3 (EMI & CMI); Information and Communication Technology / F.1 (EMI & CMI) and F. 3 (EMI)
5	CMI	T5 (F.2)	- BSc (Biology) - PGDE (Biology and Integrated Science)	8	4	Liberal Studies / F.6 (CMI); Biology / .3 and F.6 (CMI)
7	EMI	T7 (F.1)	- BSc (Chemistry) - PGDE (Liberal Studies) - MEd (Psychological Studies)	2	2	Science / other F.1 classes (EMI); Physics / F.3 (EMI)
8	EMI	T8A (F.1)	- BSc (Chemistry) - PGDE (Chemistry and Integrated Science)	10	10	Science / F.2 (EMI); Chemistry / F.3 and F.5 (EMI)
		T8B (F.1)	- BSc (Animal and Plant Biotechnology)	8	8	Science / F.2 (EMI); Biology / F.3 and F.6 (EMI)

APPENDIX VIII ***Number of lessons observed in each class***

*The number of lessons observed in T5B's class has also been counted for record

MOI of school	Teacher	Level	Subject	Topic	No. of lessons observed
EMI	T1A	F1	Math	Algebra	8
EMI	T1B	F1	Math	Algebra	10
EMI	T1B	F1	Sci	Matter	22
EMI	T2	F2	Math	Linear Equations in Two Unknowns	28
EMI	T3A	F2	Math	Linear Equations in Two Unknowns	16
EMI	T3B	F2	Math	Linear Equations in Two Unknowns	17
CMI	T4A	F1	Sci	Matter	26
CMI	T4B	F1	Sci	Matter	18
CMI	T5A	F2	Sci	Acid and Alkaline	20
CMI	T5B*	F2	Sci	Acid and Alkaline	14
EMI	T7	F1	Sci	Matter	26
EMI	T8A	F1	Sci	Matter	26
EMI	T8B	F1	Sci	Matter	31
CMI	T9A	F1	Math	Rate and Ratio	9
CMI	T9B	F2	Math	Linear Equations in 2 Unknowns	12
					Total: 283 (Maths: 100) (Science: 183)

<u>APPENDIX IX</u> ***Types and number of interviews conducted with teachers and students in each class/ school***

Types and number of interviews conducted with Mathematics classes

Interview type/Class of Teacher	**Sch1 T1A**	**Sch1 T1B**	**Sch2 T2**	**Sch3 T3A**	**Sch3 T3B**	**Sch9 T9A**	**Sch9 T9B**
Pre-unit Teacher Interview	1	1	1	1	1	1	1
Pre-unit Student Interview	2	2	2	2	2	2	3
Pre-lesson Teacher Interview	1	0	1	1	0	1	2
Post-lesson Teacher Interview	3	7	16	1	2	1	6
Post-lesson Student Interview	0	3	18	10	10	0	3
Post-unit Teacher Interview	1	1	1	1	1	1	1
Post-unit Student Interview	2	3	3	0	5	6	8
Miscellaneous	n/a	n/a	n/a	n/a	n/a	n/a	2 student interviews on Learning Celebration Day)
Total number of interviews in each school	10	17	42	16	21	12	26

Grand total number of interviews concerning Mathematics lessons: 144

Types and number of interviews conducted with Science classes

Interview type/Class of Teacher	Sch1 T1B	Sch4 T4A	Sch4 T4B	Sch5 T5A	Sch 5 T5B^	Sch7 T7	Sch8 T8A	Sch 8 T8B
Pre-unit Teacher Interview	1	1	1	1	1	1	1	1
Pre-unit Student Interview	2	2	2	2	3	2	2	2
Pre-lesson Teacher Interview	5	1	1	6	3	0	0	0
Post-lesson Teacher Interview	8	5	4	10	7	1	1	1
Post-lesson Student Interview	12	3	6	15	1	15	10	7
Post-unit Teacher Interview	1	1	1	1	1	0	1	1
Post-unit Student Interview	3	3	2	2	2	0	2	2
Miscellaneous	n/a	n/a	n/a	n/a	n/a	n/a	2 teacher interviews concerning Mini Project (Pre-project and post-lesson)	2 teacher interviews concerning Mini Project (Pre-project and post-lesson) and 2 post-project interviews with students
Total number of interviews in each school	32	16	17	37	18	19	19	18

Grand total number of interviews concerning Science lessons: 176

^ Sch 5 T5B's class is a CMI class. Data was eventually not included in the data pool for analysis.

APPENDIX X ***Sample interview protocols***

Interview Questions for Teachers

BASELINE INTERVIEW

A. Teacher's background information

1. How many years have you been…
   - in the teaching profession?
   - teaching Mathematics/Science in English, and/or in Chinese? And what levels are the Mathematics/Science lessons that you've taught?

2. Have you taught any other subjects previously, at this school or in other schools? In what language(s)?

B. Teaching Objectives of the Coming Unit

1. What do you want your junior form students to learn or achieve in the unit about ______________?
2. What are the key concepts in this unit? In what ways are they key concepts? (Can you elaborate with some examples?)
3. What are the difficult concepts? In what ways are they difficult concepts? (Can you elaborate with some examples?)
4. How are you going to help students with these concepts?

C. Teachers' practices of classroom talk

1. Do you think your students have any difficulties in understanding/following Mathematics/Science lessons in English? What are some of the difficulties in your opinion? (wait for answers then suggest these three possibilities for comment)
   - listening to teachers' explanation and instructions
   - asking questions and responding to teachers' questions
   - participating in group discussions in English

2. When you plan your lesson, do you take into consideration these difficulties? Take for example this unit on ______________, how would you address these difficulties?

3. Do you think using students' mother tongue in Mathematics/Science classrooms would help them to understand the concepts better? In this unit, are there any concepts or points that may be easier for students to understand if you were to teach them in Chinese, and why?

Possible follow-up question:

4. Do you think students face any difficulties when they take part in classroom discussions in English? If so,
   a. Is the difficulty related to specific knowledge points?
   b. Does the difficulty come from the ways in which students describe, analyze, and communicate ideas?
   c. Does the difficulty come from using English as a second language?
   d. Is the difficulty related to aspects other than those above?

D. Teacher's views on the medium of instruction (MOI) policy and others

1. Could you tell us the school policy relating to MOI in the classroom – how much Cantonese can be used in classroom teaching and group discussions? Are there any rules set by the school about this?

   (For CMI schools: Could you tell us the school policy in EMI lessons relating to MOI in the classroom – how much Cantonese can be used in classroom teaching and group discussions?)

2. Do you think using English as the MOI has a positive or negative impact on students' (1) academic achievement; (2) motivation to learn Mathematics/Science and the English language? Why?

3. Is there any cross-curricular collaboration between English and Mathematics/Science panels in your school? If yes, can you give us some examples?

> *Possible follow-up question:*
> 4. Can you give us some other examples of school support that help students to improve English language proficiency in Mathematics/Science classrooms? If not, do you have any suggestions? (e.g. Language Across Curriculum, LAC)

E. Out-of-class Mathematics/ Science learning activities

1. Will there be any out-of-class Mathematics/ Science learning activities during our coming visits?

2. Are there any out-of-class Mathematics/Science learning activities for students organized by your school? If yes, what are they? What language(s) is/are used in the learning activities that you mentioned? Why? (If applicable, we'll ask Q3)

3. If no, are there any reasons for not having any out-of-class learning activities?

4. Can you tell us how these activities are designed so that students can use English to communicate mathematical/scientific ideas in out-of-class settings? How about extra lessons and how are they organized and who teaches them? (for the weaker students and possibly the more gifted ones)

Interview Questions for Teachers

PRE-LESSON INTERVIEW

1. What will you do with your students today?

2. What do you want your students to achieve in today's activities? Or = what type of learning outcome do you hope to see today?

3. What difficulties do you anticipate your students might have in today's lesson? Why?

POST-LESSON INTERVIEW

1. Have you come across any moments in this lesson that are out of your expectations? If yes, would you like to share with us?

2. If you were to teach the same lesson again this afternoon or tomorrow, would you make any changes? If yes, could you tell us what changes you would make and why?

3. Based on your observations in the lesson, are there any difficulties students were facing when they participated in ___________________ (e.g. whole-class/group discussions, pair work, presentations) in English?

4. In this lesson why did you choose to use Chinese (only ask this when a teacher does use Chinese)

    - When you asked questions for the whole class?
    - When you communicated with your students during group work in class?
    - When you communicated with students individually during class?
    - When you communicated with students individually after class?

5. Would you plan your lessons differently if they are conducted in Chinese? If so, how?

Interview Questions for Teachers

POST-UNIT INTERVIEW

1. Do you think your students have mastered the key concepts _________? How do you know?

2. Have they come across any difficulties with the key concepts? Were those difficulties conceptual or linguistic, or intertwined?

3. During the pre-unit interview, you have mentioned that there were some difficult concepts or concepts that could be difficult for students now based on students' performance of this unit. Do you think they found them as difficult as you thought? Apart from the questions that you have identified, do you think there are any other difficulties that students have encountered in this unit?

4. Do you feel that you have been successful in helping students learn this key concept/ this unit?

5. What kind of skills do you think students need in order to participate more effectively in the Mathematics/Science classroom discussions? How could you/your school help students develop those skills?

6. How do you feel about the teaching materials used in this unit in helping students understand the key concepts? (In what ways… could you provide some example)

7. In what ways do students with higher, medium and lower academic abilities perform differently in your class? What do you do to address different needs of these groups of students?

8. If you could teach the same unit again, what changes would you make and why? Would you make any changes? If yes, could you tell us reasons for those changes? This question is in III (2) – suggest delete from here.

9. How do you value the learning of Mathematics/Science in out-of-class settings (e.g. science clubs, science museums, science fairs, university-based laboratories, or fieldwork experiences)? Could this question be moved up to the section on linguistic / subject infrastructure? Section E?

<u>Possible follow-up question on coursework and assessments:</u>

10. (After we collect the sample coursework/ assessments) How typical are these coursework/ assessments for your class? What kinds of English language skills do students need to complete these assignments? Do students in general possess the skills you mentioned?

11. Can you tell us the weighting for English language usage in the assessment of students' coursework/presentations/tests/exams?

Interview Questions for Students

PRE-UNIT FOCUS GROUP INTERVIEW

1. Is English your mother tongue?
   你的母語是英語嗎？
2. Did you learn Mathematics/ Science in English in your primary school?
   在小學時,你有用英語上數學/科學科嗎？
3. Do you like learning Mathematics/ Science? Why/Why not?
   你喜歡數學/科學科嗎？ 為什麼？
4. What do you like about learning Mathematics/ Science in English? What do you dislike?
   你喜歡用英文學習數學/科學科嗎? 有什麼喜歡/不喜歡的地方？
5. Do you think learning Mathematics/ Science in English helps you learn the subject(s) better? Why/Why not?
   你覺得用英文學數學/科學, 會不會幫助到你學習數學/科學？為什麼？
6. Do you think learning Mathematics/ Science in English helps you learn English better? Why/Why not?
   你覺得用英文上數學/科學堂,能不能夠幫助你學習英語？為什麼？
7. Do you think learning your other subjects through English helps you learn Mathematics/ Science in English? Why/Why not?
   你覺得用英文學習其他的科目,能不能夠幫助你用英文學數學/科學?
8. If you have a choice, what language would you like your teacher to use in your Mathematics/ Science lessons? Why?
   如果你可以選擇，你想老師用什麼語言教你數學/科學課？為什麼？

Possible follow-up questions:
Do you like taking part in classroom talk in English during Mathematics/Science lessons? Why or why not? (Explain if needed: "classroom talk" includes asking and answering teachers' questions, doing presentations, talking with classmates during the group/pair work, etc.)

在數學堂/科學堂時，你喜歡參與以英文進行的課堂對話嗎? 為什麼喜歡?為什麼不喜歡? (課堂對話包括向老師發問，答老師問題，做課堂簡報，小組討論等等。)

Interview Questions for Students

SEMI-STRUCTURED INDIVIDUAL INTERVIEW (STIMULATED RECALL)

1. (If we show them a certain episode in the lesson) Do you think this part of the lesson is useful to your understanding of _______________? Do you understand your Mathematics/ Science teacher's instructions or explanations here? If not, what do you not understand?
   （如果我們向學生展示了課堂的片段）你覺得這部份課堂對你明白___________有幫助嗎？你明不明白數學/科學老師的指令或解釋嗎？如果你不明白, 你能否解釋不明白的地方嗎？

2. (If we show them a certain episode in the lesson) Do you like this activity? What do you like/not like? Is there anything interesting that you want to share with us about this activity?
   （如果我們向學生展示了課堂的片段）你喜歡這活動嗎?你喜歡什麼地方/不喜歡什麼地方？在這活動中, 有什麼有趣的地方可以與我們分享？

3. Can you tell us what you have done in this task? Do you think this activity/task is easy/difficult for you? What did you learn in this task/activity? Have you received any written/spoken feedback from your teacher? Are you happy with your own performance in this task? Do you understand your teacher's marking/feedback? Do you think you will be able to do better next time? Do you often have these activities/ instructions in class (without our presence to videotape your lessons)?
   告訴我們, 你在這個活動中做了什麼？你覺得這個活動/任務是很容易/為難你？你在這個活動中學到了什麼？你有沒有收到老師的任何書面/口頭的回應？你滿不滿意你自己的表現？你明不明白老師給你的回應？你認為你下一次能否做得更好嗎？你是否經常有這些活動（當我們沒有錄像帶您的課程時)？

Interview Questions for Students

POST-UNIT FOCUS GROUP INTERVIEW (STIMULATED RECALL)

1. What have you learnt in the unit about __________? Which part of this unit do you find difficult? Why?
   你在這單元______中學了什麼？此單元的那一部分，你覺得困難呢？為什麼？

2. Can you use what you have learnt in this unit to explain what you see and experience in everyday life? Can you give us some examples?
   你可以使用你在這單元的知識來解釋你在日常生活中的事情嗎？你能否給我們一些例子嗎？

3. What has your Mathematics/Science teacher done to help you learn the subject in English? What else do you think your teacher can do?
   你的數學/科學老師有沒有幫助你學習英語？

4. Have you taken part in any out-of-class Mathematics/Science activities (e.g. activities organized by the Mathematics/Science Society, visits to science museums or laboratories, competitions)? If yes, can you share your experience with us? What language(s) are used for these activities? Do you find that experience helpful for you to learn Mathematics/Science (or specifically, the unit about ____________) in English at school?

Possible follow-up questions: Can you share with us a class activity which you feel is enjoyable in the unit of ___________ in Mathematics/Science, and tell us more?

<u>Appendix XI</u> ***Types of student work collected from each class***

<u>Mathematics</u>

Class of teacher	Topic	Artefacts							Copies of students' textbook pages
T1A	*Introduction to Algebra*	Notebooks	Worksheet	Homework book	Test papers	Quiz papers	Uniform test papers		N/A
T1B	*Introduction to Algebra*	Notebooks	Homework book	Uniform test papers					N/A
T2	*Linear Equations in Two Unknowns*	Lesson Worksheets	Unit Quiz						N/A
T3A	*Linear Equations in Two Unknowns*	Daily Work Book	Notebook	Textbook	Homework book	Quiz paper & corrections	Worksheet	Textbook	√
T3B	*Linear Equations in Two Unknowns*	Chapter Quiz	Core Assignment Workbook 1	Lesson Worksheet 1	Core Assignment Workbook 2	Lesson Worksheet 2			N/A
T9A	*Rate and Ratio*	Pre-unit exercise	Classwork book pages	Homework book pages	Quiz paper				√
T9B	*Linear Equations in Two Unknowns*	Classwork book pages	Graph book pages						√

Science

Class of teacher	Topic	Artefacts								Copies of students' textbook pages
T1B	*Matter as Particles*	Assignment Books	Quiz Books	Tests						N/A
T4A	*Matter as Particles*	Notebooks	Tests	Brown Gas worksheet	Lab report	Second Term Uniform Test	Scientific Investigation Worksheet 2	Final Exam	Workbook	N/A
T4B	*Matter as Particles*	Tests	Brown Gas worksheet	Lesson Worksheet	Density Worksheet	Workbook				N/A
T5	*Common Acids and Alkalis*	LAC Folder	Workbook	Uniform test	Dictation					N/A
T7	*Matter as Particles*	Unit worksheet	Unit Quiz 1	Unit Quiz 2	Uniform Test					√
T8A	*Matter as Particles*	Handout	Dictation book	Unit test paper	Textbook					√
T8B	*Matter as Particles*	Handout	Worksheets	Unit test paper	Textbook	Revision Exercise				√

Appendix XII ***Student questionnaire set for both subjects (bilingual versions)***

香港大學教育學院

語言教育及研究常務委員會 (簡稱語常會) 研究項目

「以第二語言在課堂交流及學習學科知識:

調查學習英語和學習數學及科學學科內容之間的關係」

學生問卷

學校名稱：___________________________ 班別：_________________

姓名：___________________ 學號：_________________

請用中文或英文回答下列問題，及在適當的空格內填上剔號“✓”。

1. 你的母語是
   - ☐ 廣東話
   - ☐ 普通話
   - ☐ 英語
   - ☐ 其他 （請註明）: __________________

2. 你在家裡用什麼語言？（可選多過一項）
   - ☐ 廣東話
   - ☐ 普通話
   - ☐ 英語
   - ☐ 其他 （請註明）: __________________

3. 在家你會用英語和誰溝通？（可選多過一項）
   - ☐ 父母 / 監護人
   - ☐ 兄弟姊妹
   - ☐ 外傭
   - ☐ 其他人（請註明）: __________________

4. 你曾經就讀於哪間小學 ？(倘若多過一間，請註明) ________________________________

5. 你曾就讀的小學的數學課使用哪種語言？（可選多過一項）
   - ☐ 廣東話
   - ☐ 英語
   - ☐ 廣東話為主，英語為輔
   - ☐ 英語為主，廣東話為輔
   - ☐ 普通話
   - ☐ 其他 （請註明）_________________

6. 小學數學課的課本使用哪種語言？
   - ☐ 中文
   - ☐ 英文
   - ☐ 其他 （請註明）_________________

請繼續回答第二頁的問題

7. 現階段你用英語學習數學有沒有困難？
   ☐ 非常有困難（請回答第 8 題）
   ☐ 大致上有困難（請回答第 8 題）
   ☐ 大致上沒有困難（請回答第 8 題）
   ☐ 完全沒有困難 （請直接回答第 9 題）

8. 你覺得困難在於（可選多過一項）
   ☐ 明白數學老師在課堂上的英語講解
   ☐ 明白數學科的英文辭彙，或 / 及以英文表達的概念
   ☐ 明白英文數學課本內的習題
   ☐ 在數學課堂時用英文回答問題
   ☐ 用英語向數學老師提問
   ☐ 用英語與同學討論數學問題
   ☐ 其他 （請註明）_________________

9. 你有參加課外數學補習班嗎 (包括私人補習、小組補習班)？
   ☐ 有 （請回答第 10 題）☐ 沒有（請直接回答第 11 題）

10. 數學補習老師 (私人補習老師 / 小組補習班老師) 授課時使用哪種語言？（可選多過一項）
   ☐ 廣東話
   ☐ 英語
   ☐ 廣東話為主，英語為輔
   ☐ 英語為主，廣東話為輔
   ☐ 普通話
   ☐ 其他 （請列明）_________________

11. 如果可以選擇，你希望在中學階段使用哪種語言學習數學？
   ☐ 廣東話
   ☐ 英語
   ☐ 廣東話為主，英語為輔
   ☐ 英語為主，廣東話為輔
   ☐ 普通話
   ☐ 其他 （請列明）_________________

謝謝您的參與

如您對是項研究有任何查詢，請與首席研究員 Dr Gary Harfitt (電話: 3917 5729 / 電郵: gharfitt@hku.hk) 或研究團隊 (電話: 3917 7602) 聯絡。

(香港大學研究操守委員會參照號碼： EA1607014)

THE UNIVERSITY OF HONG KONG
FACULTY OF EDUCATION

SCOLAR Project "L2 Classroom Talk and Subject Content Learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms"

QUESTIONNAIRE FOR STUDENTS

School name:______________________________ Class: _________________

Name:___________________________________ Class number:__________

Please answer the following questions in *either English or Chinese* and tick '✓' the appropriate boxes where necessary.

1. **What is your mother tongue?**

☐ Cantonese
☐ Putonghua
☐ English
☐ Others (please specify): ____________ __________

2. **What language(s) do you use at home? (You may select more than one)**
☐ Cantonese
☐ Putonghua
☐ English
☐ Others (please specify): ___________

3. **Whom do you use English at home with? (You may select more than one)**
☐ Parents/Guardians
☐ Siblings
☐ Domestic helper(s)
☐ Others (please specify): ___________

4. **Which primary school(s) did you attend?** ____________________________________

5. **Could you tell us the language(s) used in your Mathematics lessons in your primary school? (You may select more than one)**
☐ Cantonese
☐ English
☐ Mainly Cantonese with some English
☐ Mainly English with some Cantonese
☐ Putonghua
☐ Others (please specify): __________

6. **Could you tell us the language of your Mathematics textbooks in your primary school?**
☐ Chinese
☐ English
☐ Others (please specify): __________

7. **At this stage, do you have any difficulty learning Mathematics in English?**
☐ I find it very difficult. (Please go to Q. 8)
☐ I find it difficult generally. (Please go to Q. 8)
☐ I don't have many difficulties generally. (Please go to Q. 8)
☐ I have no difficulties at all. (Please go to Q. 9 directly)

Please also answer the questions on P.2

8. What difficulties do you have when learning Mathematics in English? (You may select more than one)

☐ Understanding Mathematics teachers' instructions in English in class
☐ Understanding Mathematical terms and/or concepts in English
☐ Understanding Mathematics questions in the textbook in English
☐ Answering questions in Mathematics lessons in English
☐ Asking Mathematics teachers questions in English
☐ Discussing Mathematics questions with classmates in English
☐ Others (please specify): ____

9. Do you have Mathematics tutorial classes outside school (including private tutorial sessions and small tutorial groups)?

☐ Yes (Please go to Q. 10) ☐ No (Please go to Q. 11 directly)

10. What language(s) does your Mathematics tutor (private tutor or in tutorial centres) use? (You may select more than one)

☐ Cantonese
☐ English
☐ Mainly Cantonese with some English
☐ Mainly English with some Cantonese
☐ Putonghua
☐ Others (please specify): _____________

11. If you have a choice, which language do you prefer to use when learning Mathematics in secondary school?

☐ Cantonese
☐ English
☐ Mainly Cantonese with some English
☐ Mainly English with some Cantonese
☐ Putonghua
☐ Others (please specify): __________

Thank you very much for your participation.

If you have any enquiries, please contact Dr Gary Harfitt, Principal Investigator, by telephone at 3917 5729 / email: gharfitt@hku.hk, or the Research Team by telephone at 3917 7602.

(HREC Reference Number: EA1607014)

香港大學教育學院

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調查學習英語和學習數學及科學學科內容之間的關係」

學生問卷

學校名稱：____________________________ 班別：__________________

姓名：____________________ 學號：__________________

請用中文或英文回答下列問題，或在適當的空格內填上剔號“✓”。

12. 你的母語是
    - ☐ 廣東話
    - ☐ 普通話
    - ☐ 英語
    - ☐ 其他 （請註明）: ____________________

13. 你在家裡用什麼語言？（可選多過一項）
    - ☐ 廣東話
    - ☐ 普通話
    - ☐ 英語
    - ☐ 其他 （請註明）: ___________________

14. 在家你會用英語和誰溝通？（可選多過一項）
    - ☐ 父母 / 監護人
    - ☐ 兄弟姊妹
    - ☐ 外傭
    - ☐ 其他人（請註明）: ___________________

15. 你曾經就讀於哪間小學 ？(倘若多過一間，請註明)

    ____

16. 你曾就讀的小學的常識課使用哪種語言？（可選多過一項）
    - ☐ 廣東話
    - ☐ 英語
    - ☐ 廣東話為主，英語為輔
    - ☐ 英語為主，廣東話為輔
    - ☐ 普通話
    - ☐ 其他 （請註明）__________________

17. 小學常識課的課本使用哪種語言？
    - ☐ 中文
    - ☐ 英文
    - ☐ 其他 （請註明）__________________

請繼續回答第二頁的問題

18. 現階段你用英語學習科學有沒有困難？
   ☐ 非常有困難（請回答第 8 題）
   ☐ 大致上有困難（請回答第 8 題）
   ☐ 大致上沒有困難（請回答第 8 題）
   ☐ 完全沒有困難 （請直接回答第 9 題）

19. 你覺得困難在於（可選多過一項）
   ☐ 明白科學老師在課堂上的英語講解
   ☐ 明白科學科的英文辭彙，或 / 及以英文表達的概念
   ☐ 明白英文科學課本內的指引或習題
   ☐ 明白英文科學課本內的實驗指引或習題
   ☐ 在科學課堂時用英語回答問題
   ☐ 用英語向科學老師提問
   ☐ 用英語與同學討論科學問題
   ☐ 用英文完成科學實驗報告
   ☐ 其他 （請註明）________________

20. 你有參加課外科學補習班嗎 (包括私人補習、小組補習班)？
   ☐ 有 （請回答第 10 題）☐ 沒有（請直接回答第 11 題）

21. 科學補習老師 (私人補習老師 / 小組補習班老師) 授課時使用哪種語言？（可選多過一項）
   ☐ 廣東話
   ☐ 英語
   ☐ 廣東話為主，英語為輔
   ☐ 英語為主，廣東話為輔
   ☐ 普通話
   ☐ 其他 （請列明）________________

11. 如果可以選擇，你希望在中學階段使用哪種語言學習科學？
   ☐ 廣東話
   ☐ 英語
   ☐ 廣東話為主，英語為輔
   ☐ 英語為主，廣東話為輔
   ☐ 普通話
   ☐ 其他 （請註明）________________

謝謝您的參與

如您對是項研究有任何查詢，請與首席研究員 Dr Gary Harfitt (電話: 3917 5729 / 電郵: gharfitt@hku.hk) 或研究團隊 (電話: 3917 7602) 聯絡。

(香港大學研究操守委員會參照號碼： EA1607014)

THE UNIVERSITY OF HONG KONG
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SCOLAR Project "L2 Classroom Talk and Subject Content Learning: Investigating the relationship between L2 learning and content learning in EMI mathematics and science classrooms"

QUESTIONNAIRE FOR STUDENTS

School name:_______________________________ Class: _____________________

Name: ____________________________________ Class number: ______________

Please answer the following questions in *either English or Chinese* and tick '✓' the appropriate boxes where necessary.

1. **What is your mother tongue?**

☐ Cantonese
☐ Putonghua
☐ English
☐ Others (please specify): __________

2. **What language(s) do you use at home? (You may select more than one)**
☐ Cantonese
☐ Putonghua
☐ English
☐ Others (please specify): ____________

3. **Whom do you use English at home with? (You may select more than one)**
☐ Parents/Guardians
☐ Siblings
☐ Domestic helper(s)
☐ Others (please specify): ______________

12. **Which primary school(s) did you attend?** ____

13. **Could you tell us the language(s) used in your General Studies lessons in your primary school? (You may select more than one)**
☐ Cantonese
☐ English
☐ Mainly English with some Cantonese
☐ Mainly Cantonese with some English
☐ Putonghua
☐ Others (please specify): ____________

14. **Could you tell us the language of your General Studies textbooks in your primary school?**
☐ Chinese
☐ English
☐ Others (please specify): ______________

15. **At this stage, do you have any difficulty learning science in English?**
☐ I find it very difficult. (Please go to Q. 8)
☐ I find it difficult generally. (Please go to Q. 8)
☐ I don't have much difficulties generally. (Please go to Q. 8)
☐ I have no difficulties at all. (Please go to Q. 9 directly)

Please also answer the questions on P.2

16. **What difficulties do you have when learning Science in English? (You may select more than one)**
☐ Understanding Science teachers' instructions in English in class
☐ Understanding scientific terms and/or concepts in English
☐ Understanding instructions/questions in the Science textbook in English
☐ Understanding instructions/questions of experiments in the textbook in English
☐ Answering questions in Science lessons in English
☐ Asking Science teachers questions in English
☐ Discussing questions about science with classmates in English
☐ Completing lab reports in English
☐ Others (please specify): ______________

17. **Do you have Science tutorial classes outside school (including private tutorial sessions and small tutorial groups)?**
☐ Yes (Please go to Q. 10) ☐ No (Please go to Q. 11 directly)

18. **What language(s) does your tutor (private tutor or in tutorial centres) use? (You may select more than one)**
☐ Cantonese
☐ English
☐ Mainly English with some Cantonese
☐ Mainly Cantonese with some English
☐ Putonghua
☐ Others (please specify): ______________

19. **If you have a choice, which language do you prefer to use when learning Science in secondary school?**
☐ Cantonese
☐ English
☐ Mainly English with some Cantonese
☐ Mainly Cantonese with some English
☐ Putonghua
☐ Others (please specify): ______________

Thank you very much for your participation.

If you have any enquiries, please contact Dr Gary Harfitt, Principal Investigator, by telephone at 3917 5729 / email: gharfitt@hku.hk, or the Research Team by telephone at 3917 7602.

(HREC Reference Number: EA160701)

APPENDIX XIII ***Detailed Case Study***

Co-construction of content knowledge and the effective learning of science: a case study of how a lesson in Science was examined using different analytical frameworks (also addresses RQ2)

In this episode, the teacher is going through a worksheet and talking about saliva that led to his recounting of his secondary school science competition story. He explains how to conduct a proper scientific investigation from his own secondary school experience and engages the students in his personal sharing. The students are curious about the experiment being described and participate freely in the classroom exchanges that are based around questions on how to construct a fair test using an experiment (see *Annex A* for lesson transcript excerpts).

Teacher's feature highlighted:
Feature 1 - Dialogic (Teacher initiated)
The teacher sometimes leads discussions or asks questions in revising prior knowledge, introducing new concepts to students, and checking answers for their workbook or test.

Pedagogy:
The teacher instigates a discussion with the whole class on his competition. It is an experiment to test which toothpaste is the most effective in preventing tooth decay. He first gives opportunities for students to make guesses and when the students come to some ideas and build some variables, he starts to review what a fair test is. Then, he guides the students to construct an experiment step by step based on their answers. Students could raise their ideas in L1 or L2, and the teacher and students have a strong rapport, so an effective communication is established.

Teacher and students role:
During the construction of ideas on the experiment, the teacher acts as a facilitator to help students explore the issues in the topic. He gives relevant feedback for students to think more, and learn from the strength and weakness of their points. They also throw out problems, work together to solve the problems and re-organize their knowledge with the help of the teacher.

In this episode, the teacher firstly opens up the problem and introduces his Science competition in secondary school. He tries to arouse students' interests to conduct the experiment. It is an experiment to test which toothpaste is the most effective in preventing tooth decay. He keeps talking on the topic of the competition and ignores the students. After he introduces the problem, he asks students to give out ideas on how to conduct the experiment. And he stops and tells the student that he should tell how to conduct the experiment but not give out arbitrary guesses. It is an authoritative non-interaction move.

Then the teacher explores and works on his students' views. He probes students' views and understandings of specific ideas and phenomena. He listens to the students' suggestion and writes it on the blackboard. He acknowledges the student's view and it is clear that he is focusing on the student's idea through a dialogic interaction. Then the teacher wants other students to comment on thr student's idea. Although he listens to another pupil's view, when he does not give out the required answer, his suggestion is put to one side. When the student, tries to say something, he does not finish what he wants to explain and the teacher just stops him again. This is an authoritative interaction. After this, another student shares her point of view. Even though the student does not answer what the teacher wants, he explains the weakness of the suggestion. This small episode is dialogic and interactive.

Thirdly, the teacher guides students to work with scientific meanings, and supports internalization. He gets students back to the right track and he questions whether the suggested experiment is good enough for testing the effectiveness of the toothpaste. The students then realize that it does not work. The students continue to share alternative viewpoints. However, when the student does not give the required answer, the teacher ignores it. It is clear that the teacher has an answer in mind and pay little attention to the student's idea. The conversation is authoritative and interactive. Then, it comes to dialogic interaction again. The teacher listens to several students' viewpoints, tries to elicit students' views and guides them to build up an experiment step by step.

When students have thought about some possible ideas, the teacher guides students to apply and expand on the use or the scientific view, and hands over responsibility for its use. He supports students to apply a fair test in the toothpaste experiment. This small episode is authoritative and interactive. The teacher questions how to apply a fair test in the toothpaste experiment, and at the same time he ignores students' ideas when those ideas are not required. He ignores some questions but pays attention on what some students say because one says something that is what he wants them to think about. Then, the teacher makes an authoritative and non-interactive summary on what they just reviewed on applying the fair test to the toothpaste experiment.

After the students understand how to construct a fair test, teacher maintains the development of the scientific story. He provides comments on the unfolding experiment and helps students to follow its development and to solve the existing problems. He listens to students' viewpoints, tries to elicit their views and guides them to think in a logical way to reach a completed toothpaste experiment. The teacher establishes a dialogic interaction here. Then, the shape of the experiment is mostly constructed and when the teacher explains his approach students still raise questions. The teacher tries to control the pace of the class and finish what he wants to say. The teacher creates an authoritative interaction. After he explains how to construct the toothpaste experiment. He teaches students how to obtain the experiment's result from a graph and he has a dialogic and interactive communication with students. The teacher listens to his student's question and asks students which one is the better toothpaste shown on the graph.

<u>Teacher Interview:</u>

I	Have you shared your competition to your Science class every year?
T	Yes, because nowadays, Education Bureau takes account of STEM, that is Science, etc. And also I expect the students to **not only memorize** what acid is, what alkalis are when they are learning Science. They should have the **scientific mind**, I want them to **seek the truth or learn how to solve problem with their prior knowledge.**
I	I notice that when you were talking about the experiment you had done in your Science competition, you guided them step by step and you wanted them to throw out ideas on how to construct an experiment…
T	Yes, how the experiment should be constructed.
I	Did you expect that they can do it?
T	Actually, in each year, there are some students who can hint others about how to do it. And it was a secondary school project. Of course, there are some students who get sidetracked in the discussion, but there are also some students who can get it back on track. There was a year, the students were very weak in Science and I gave out the first step to them and asked them to think about the second step. **It depends on the interaction.** If the students have higher ability, I would give fewer hints. If the students have lower ability, I would

	give more hints.
I	What type of learning outcome do you expect to see today?
T	I don't expect they can catch all the variables. It is quite difficult for a junior secondary student to master it. Even in Form 4 or Form 5, the students studying Physics, Chemistry or Biology still cannot grasp it. Some higher ability students may know better I think.
I	What do you mean by variables?
T	Independent, dependent, control variables. These are the key concepts in a fair test. Sometimes, students in senior forms still cannot master it. But in my opinion, if they can prepare well at junior level, they will benefit from it when they are promoted to senior forms.
I	What difficulties have you observed in your students during today's lesson?
T	With regard to the competition, you can see that some of the students were at a loss about what to do. Or they said some ideas that were not very good. But you can also see that some students are interested in Science. For me, I want to select those who are interested in Science and nurture them to join some competitions and **explore the horizon of the world.**
I	Have you come across any moments that are out of your expectations?
T	The thing out of my expectations is that I don't expect that they could get close to the experiment so quickly. This is quite unexpected, especially the method came from that student and it surprised me which was good.

a) **Student Interview:**

I	What have you learnt from the science lesson today?
S1	**Firstly, I've learnt how to distinguish between independent variables, control variables, dependent variables, etc. My experience is also broadened by seeing how my teacher claimed a first-runner up prize in a science competition with such an amazing experiment.** **Remark: In this lesson, they actually had done worksheet and workbook but he only shared what he has learnt from the teacher's Science competition.*
I	Okay, do you think it is a good lesson today?
S1	Yes, definitely.
I	Why?
S1	The teacher's amazing experimental set up on his Form 4 Science competition really broadened my view. **It triggered a heated discussion between students, including me**. I listened to others' suggestions and although my guess was wrong, **I still have learned a lot.** **Remark: From this student perspective, it was a good lesson because it involved dynamic learning with whole class. The dialogue among students and between the teacher and students is a significant learning process for him to build knowledge.*
I	That's all?
S1	Yes, I made a guess on how to manipulate the control variable, that is,

	the participants should have the same meal within one month. **It raised many discussions on how to make sure the test works**
I	During the lesson, you suggest that the experiment could be conduct in a camp, right?
S1	Yes
I	**What sparked your idea?**
S1	**As camp.... I assume what it feeds on inside a camp is the same, and the daily routine too, it's better if it's a military camp.**
I	**How did you know about it? Did you visit it before?**
S1	**Last August, I went to Hong Kong Association of Youth Development Training Centre in Quarry Bay, where they held a training camp. The dishes were basically the same, although it still differed from day to day, but everyone ate the same thing. Secondly, the daily routine hours were standardized, we slept and woke up "uniformly".** **Remark: In the lesson, this student suggested that they could conduct the experiment in a camp. This idea was based on his experience in camping. Technically, it is not wrong if the project has enough budgets to conduct such a large scale experiment. But in the lesson, the teacher addressed that he did not have so much money at that time. It was one of the limitations of the experiment and students needed to think other methods to manipulate the control variables.*
I	That's all?
S1	Yes.
I	Can you tell me now what the most important thing from today's lesson is?
S1	**It's to have a curious and inquiry mind, 探索精神, (repeat in Chinese), it led me to understand how to conduct an experiment under various limitations.** I was taken by surprise, when was even more surprising is the spitting, forty people spitting at the same time, how spectacular! Then, it took me by bigger surprise is all the saliva were mixed and distributed, wow! I am a straightforward thinker, I really am, sometimes too much, I don't usually think out of the box.
I	Like you said earlier, your teacher shared a F.4 science competition with you, it's an example out of the book and more real-life, do you like this kind of sharing?
S1	Yes, of course.
I	Why?
S1	Because **with a more daily sharing, it's more familiar and light-hearted, not too serious, and a little bit interesting, it's true.**
I	Do you think it helps you in learning science?
S1	**It helps, there's no doubt.**
I	Why?
S1	Like those teeth. And also, in the workbook, True / False question. There is a question about whether two acids added together would form a stronger acid. I have heard an example previously, using milk to dilute gastric acid, which does not enhance the acidity and concentration of the acid, so I became sure the claim was wrong. *The teacher also initiated a discussion with students on why drinking milk could ease a stomach ache. It was also a fruitful discussion. Students raised many explanations and they learnt from wrong and gain from the dynamic learning process. In that dialogue, he has*

	learnt that milk is acidic and gastric acid is also acidic, when they are mixed together, it does not give a stronger acidic solution but it can ease stomach ache. This student expressed that he has learnt from the daily example and he can apply it in doing workbook. *In that lesson, we have also interviewed two students, one of the student also answered that the discussion on why drinking milk could ease a stomach ache is the most impressed episode that the teacher explained very clear in that lesson.*
I	**So it's through daily examples you became certain of the answer.**
S1	**Yes.**

I	Your teacher has shared with you a science competition during his secondary school life. Did you listen to him?
S1	Yes.
I	Actually it is an experience from daily life. The teacher asked your class the way to test for the best toothpaste. What were you thinking at that moment?
S1	I think I will mix them with water and test with some test paper.
I	That’s the same as the first student said.
S1	Yes.
I	Did the teacher say whether it works or not?
S1	Not working.
I	Then, the teacher led your class to an experimental set-up, did you understand the set-up?
S1	**As I remember, he found some teeth from a pig and collected the saliva from over 40 students. Then, mixed them all and immersed the teeth into it. Then, he brushed the teeth of the pig every day.** **Remark: This student could briefly give out the main points of the experiment after the lesson. At the beginning of the interview, I asked him what he has learnt from today’s science lesson, he only said they do some classwork and kept silence for 11 seconds. He did not give us much information in the whole interview but at least in here, when we were talking on the teacher’s competition, he talked more. We can see that he actually concentrated in the discussion in class and he could remember what they discussed. Effective learning may be achieved through co-constructed learning?*
I	Is that all?
S1	Yes.
I	**Is that good for your teacher to teach you knowledge out of your textbooks?**
S1	**That’s good.**
I	Why?
S1	**Since we cannot learn those in our textbooks and we seldom encounter them. We can understand more if the teacher is willing to share.**
I	**Can it facilitate your study and how?**
S1	**It can facilitate.**
I	Why?
S1	**Since I can acquire more common sense which allows me to make better judgments.**
I	Okay, thank you.

Annex A (Transcript)

Ex	M	Teaching purpose	P	Discourse (V+NV)	Alexander's five principles	Alexander's Repertoires talk	Mortimer & Scott's communicative approach
1	I	Open up the problem: T introduces his Science competition in secondary school and he tries to arouse students' interest to conduct the procedures of the experiment.	T	When I was Form 4, I participated in a science competition. Ok. <I participated in a science competition. At that time,> my task, my task… <you imagine that you are me at that time. What would you do?> [T erases the board.]		***Instruction:*** ***The teacher introduces his Science competition and asks students how to do it.***	***Authoritative and non-interactive:*** ***The teacher ignores the voice of the student and keeps talking on the topic competition. At the end, he stops the student and tells the student that he should tell them how to conduct the experiment but not give out arbitrary guesses.***
	R		S1	<Tell us more details>			
 2	R I		T	Ok. My task…			
	R		S1	<What experiment you have done and XXX>			
	I		T	[T starts to write on the board] My task is to… [T writes 'To test which toothpaste is the best?' on the board] <Good. My experiment is on acid and alkali. You consider if you were there at that time, what would you do?> Ok, my test is to find out, is to test which toothpaste… Toothpaste <what is it?>			
	R		SS	<Toothpaste>			

	F		T	<Toothpaste> is the best, is the best. [T writes on the board]			
	R		S1	<Black person toothpaste?>			
3	I		T	[T ignores the question and continues.] Ok. By applying the pH value concept <to the experiment. How will you do it? >			
	R		SS	XXX			
	I		T	<I want to know which toothpaste is the best. The best is of course not on their taste, not the prettiest. It should be most effective in preventing tooth decay. Ok?>			
	R		S1	XXX toothpaste			
	I		T	[T writes on the board without answering student's response] To prevent tooth decay. <To prevent tooth decay.> <Anyone suggest how you will do it?>			
	R		S1	XXX			
	F		T	<(student name), you can lower your hand. I am asking you how to conduct the experiment. Not to tell me an answer from your guessing.>			
	R	Exploring and work on students' views: T probes students' views and understandings of specific ideas and phenomena.	S1	<I know. Can I give you an answer that is long?>	***Collective:*** ***S questions the length of time of the experiment and T addresses that the experiment could be long.*** ***Reciprocal:***	***Discussion:*** ***Exchange of idea with a view to share information and solve problems.***	***Dialogic and interactive:*** ***The teacher listens to student's suggestion and writes it on the blackboard. He respects for the student's view.***
	F		T	<It can be long. I conducted this experiment for a month.>			
	R		S1	<Get a pH paper>			
	F		T	Ok. Use a pH paper. [T writes on the board]			
	R		S1	After that XXX			
	F		T	Ok. <Listen to what King (S1) has to say> [T points at S1]			
	R		S1	<I guess…>			

	I		T	pH paper and then.	***After WKY shared his suggestion, T asks others to comment on his suggestion. They listen to each other, share ideas and consider alternative viewpoints.***		
	R		S	<I guess to put a small amount of toothpaste in beaker and add water.>			
	F		T	Ok. <There is a beaker> [T draws a beaker] <Assume that there is some toothpaste in there. >			
	R		S1	<Mix it.>			
	F I		T	<Mix it.> And then?			
	R		S1	<After that, take a > dropper			
	F I		T	<Take a dropper. Then, test the pH value?>			
	R		S1	pH…			
4	F I		T	Ok. <Let's say that there are A, B and C. Three brands of toothpastes. Which one is the best? How will you show the answer? pH paper, then? > [Another student (S2) rises his hand.] <Wait. Wait.>	***Supportive:*** ***Ss articulate their ideas freely without fear of embarrassment over "wrong" answers; and they help each other to reach common understandings. They are willing to comment on others' ideas and they learn from others' viewpoints.***		
	R		S1	<Three brands of toothpaste.>			
	I		T	<Three brands of toothpaste. Let's assume that this one is pH 7, the other one pH 8 and this one pH 9.> [T writes these values on the board.] <Then, what?>			
	R		S1	Huh….Huh			
	I		T	<Which one is the best?>			

	R		S1	C			
5	F I		T	<Brand C. Meaning the most alkali is the best.> [T underlines pH 9] <I want others to comment on this experiment. Is this experiment ok?> [S2 raises his hand. T points at him to grant him his turn.]			
	R		S2	<I say> ok.			***Authoritative and interactive: Although the teacher asks for student's view, when the student does not give out the required answer, his suggestion Is put to one side.***
6	I		T	Why?			
	R		S2	<Each toothpaste contains sugar in it. It sweetens (with water.)>			
7	F I		T	<Sweetens>… Anyway, anyway, <A, B, C toothpastes have pH 7, 8, 9. I don't consider their sugar nor sweeten. After brushing, the tooth has pH 9. Then, what's next?> [T points at S3]			
	R		S2	<Maybe the chemical protects the tooth is alkali. The amount contains…>			***Authoritative and interactive: The student does not finish what he want to explain and the teacher just stops him again.***
	I		T	<What's next? Therefore, you will say that C is the best.>			
	R		S2	<Yes. Correct.>			
8	R		T	<Yes.> [T responses to S3			***Dialogic and interactive:***
	R		S3	XXX			

	I		T	<Why is it A?>			***Even though the student is not answering what the T wants, he explains the weakness of S3'ssuggestion.***
	R		S3	<Acid and alkali.>			
	I		T	<Tooth is alkali.>			
	R		S3	<No. If it is acidic, you brush the tooth.>			
	R		T	Mmh.			
	R		S3	XXX (28:17)			
9	F I	Guiding students to work with scientific meanings, and supporting internalization: T providing opportunities for students to talk and think more in scientific ways and to talk about the experiment. T is promoting curiosity and open-ended answers.	T	<But I really want the tooth to be alkali. But after you brush the tooth, it is only 7. Then, it is the same as brushing with only water. Right?> [S3 doesn't know how to response and smiles.] <First of all, we don't consider pH 7, 8, 9. First, do you think that this experiment will work or not?>	*Collective:* ***After Ss shared their suggestions, T asks whether the experiment works in sense. Firstly, they think that the experiment could be worked out, but when T questions whether the experiment is good enough for testing the effectiveness of the toothpaste, they realize that it does not work. In this stage, they only address the workable of different ideas***	***Dialogue:*** ***The achievement of common understanding through structured, cumulative questioning and discussions which guide and prompt, reduce choices, minimise risk error and expedite 'handover' of concepts and principles.***	
	R		SS	<Of course,> work.			
10	F I		T	If this experiment works, the toothpaste commercials will show the mixing of toothpaste in water with pH 9.> Very good. [T shows two thumbs up. S2 laughs hysterically.] <Good. (Student 4) you speak.> <If you were to alter this experiment, how would you change it?>			***Authoritative and interactive: When the student (TSP) does not give the required answer, the teacher ignores it. It is clear that the T has an answer in mind and pay little attention to the student's idea.***
	R		S4	<Test what these three toothpastes contain something. >			
	I		T	<Contain what?>			

	R		S4	<Three toothpastes contain something different. Something that work.>	***but still do not address a completed experiment.*** ***Reciprocal: Then, they immediately share alternative viewpoints.*** ***Supportive: Ss articulate their ideas freely without fear of embarrassment over "wrong" answers; and they help each other to reach common understandings. They are encouraged to give out alternative ideas and they learn from the T's comments.***		
	F R		T	<It should work. If not, I don't need to do it for three months, for one month. Know it instantly.> [S2 raises his hand. T points at S2.] <Yes.>			
	R		S2	<Find a group of people.>			***Dialogic and interactive: Teacher listens to Ss viewpoints, tries to elicit Ss views and guides them to think in reasonable way to build up an experiment step by step.***
	I		T	<Good. Listen. Sh. Find a group of people to?>			
	R		S2	<Record people using different brands of toothpastes and they should follow the same diet within one month, then…>			
	F		T	Ok. Very good. <For a month…> [T starts to erase the board.]			
	R		Ss	XXX (inaudible)			
	F		T	<I cannot request their mothers to cook what kinds of meals.>			
	R		S6	XXX (inaudible)			
	F I		T	<They are students and have to return home. > [T start to write on the board.] Ok. <Assuming that> three students, they follow same menu. Ok. <Eat (from the meals ordered) from the same menu. Then?>			

	R		S3	Then, testing for one month.			
	F		T	Ok. <Use these three. A, B, C… toothpastes.>			
	R		S2	<Some will use more toothpaste or use less.>			
11	F I	Guiding students to apply and expand on the use or the scientific view, and handing over responsibility for its use: T supports Ss to apply fair test in the toothpaste experiment.	T	[T points at CKM.] <Good. I want you to answer this kind of thing.> S7), in the experiment, which one is the dependent variable?	*Collective:* *T and Ss address what a fair test is and how to apply in the toothpaste experiment.*	***Recitation:*** ***The accumulation of knowledge and understanding through questioning of what a fair test is. T also cues Ss to work out the answer together.***	***Authoritative and interactive:*** ***The teacher questions how to apply fair test in the toothpaste experiment, at the same time he ignores Ss ideas when those ideas are not required from him. He ignores the student's questioning but pays attention to what he says because the student says something that the teacher wants them to think about.***
	R		S7	What is dependent variable?			
	F		T	Dependent is the one you change.			
	R		S7	Independent…			
	F		T	Ar, sorry. This one is independent variable. The one you change…			
	R		S7	XXX (inaudible)			
	F		T	No. The one, you change.			
	R		SS	XXX (inaudible)			
	I		T	Sorry. <Listen first.> Independent variable <independent variable>. Independent variable			
	R		S7	<independent variable>			
	F		T	<independent variable> Yes.			
	R		S7	Toothpaste.			
	F		T	Toothpaste. Yes. [T writes on the board.]			
	I		S3	Ar Teacher			
	R		T	<Yes.>			
	R		S3	<Since toothpaste cannot XXX>			

12	I		T	Ok. <In a fair test, you need to memorize this firmly.> Independent variable, the factor you change. <You alter it. > [T stares at a student (CYY)] <Have you finished day-dreaming yet?>			
	R		S3	<Dreaming while I am listening.>			
	I		T	<Good. You answer me which is dependent variable?>			
	R		S3	XXX [S5 laughs]			
	F		T	<You think this is ok. You think that is very funny!>			
	R		S3	<Not funny.>			
	F		T	<Hilarious.>			
	R		S3	<I didn't say it is hilarious.> [T looks away at another student.]			
	I		T	Ar <S8 what is dependent variable?>			
	R		S8	<Don't know.>			
	I		T	<Dependent variable. Dependent variable. Which one is dependent variable?>			
	R		S8	…			
13	I		T	Wow. [T looks at S3 and recalls her previous statement without saying a word first.]			

	R		S3	<What?> [S3 wonders why T looks at her.]			
	I		T	[T points at S3] <Good. S3 You said previously that they something?>			
	R		S3	<Some people use more. Other uses less.>			
	F I		T	<S3 said that someone will <use> more <toothpaste> than other guy. Ok. <What is this variable?> <This is …> Those, some factors that you have to keep unchanged…			
	R		S9	Control.			
14	F I		T	Controlled variable. This is controlled variable. <Controlled variable or non-changing variable. What is dependent variable?>			
	R		S2	The result.			
	F I		T	The result. Yes. The result. What is the result?			
	R		S2	Prevent tooth decay.			
	R		S2	The result			
15	I		T	<The result. What can you measure? Who will choose the pH value?> <Please. This is a reminder that Form 1 fair test that you have learnt. Fair test. In Form 2, you know from the photosynthesis experiment with a bunch of controlled variable, dependent variable, independent variable.		***Exposition: T summarizes what a fair test is and how to apply it.***	***Authoritative and non-interactive: The teacher makes a summary on what they just reviewed on***

				In a fair test, if, if some factors you are going to keep it always the same. Ok. <The same size. Use the same amount. The same duration. Eat the same thing.> Those are controlled variables. [T underlines ‘controlled variables’ on the board.] Ok. You keep it unchanged, among all the experiments. And then, the one when you change it. [T draws a box around A, B, C toothpastes.] <You change A, B, C toothpastes.> This is independent variable. <You alter it.> And then, <after you alter it, the measurement of the results is the dependent variable.> You are going to measure. <You have to measure.> <The most ideal experiment is to these students, in one month. The duration of their meals, the size of their portions, the kinds of food. Then, their duration of their brushing, the amount of toothpaste used, the number of rinse should be the same. Then, this is really> fair. <Which one’s mouth…>			***applying the fair test to the toothpaste experiment.***

	R		S2	XXX Inaudible			
	R I	Maintaining the development of the scientific story: T Provides comments on the unfolding experiment and he helps Ss to follow its development and to solve the existing problems.	T	<Quiet. Which one's mouth with pH value that can be kept (the same) is healthy.> Always alkali <is the best.> Ok. Yes. This is impossible to do it in a school. <Right? > I cannot request your mother [T points at S2] to cook the same food as her mother [T points at S10]. And then you have the dinner [T points at S2] same as her (S10). Same time. And then, wake up at the same time in the morning. And then, have the same breakfast. <This doesn't make sense.>	**Reciprocal:** **T and Ss listen to each other, share ideas and consider alternative viewpoints. After T reviewed and explained how to apply a fair test, they continue to share ideas on manipulate the control variable.** **Supportive:** **Ss articulate their ideas freely without fear of embarrassment over "wrong" answers; and they help each other to reach common understandings.**	***Exposition:*** ***Telling the pupil what to do, and / or imparting information, and / or explaining facts.***	***Dialogic and interactive:*** ***The teacher listens to Ss viewpoints, tries to elicit Ss views and guides them to think in reasonable way to reach a completed toothpaste experiment.***
	R		S7	<Triplets?>		***Discussion:*** ***The exchange of ideas with a view to sharing information and solving problems.***	
	F		T	<Triplets wouldn't work. One of them cannot go out at night.>			
	R		S7	<Then?>			
	F		T	<Go out and eat other food.>			
	R		S7	<Triplets?>			
	F		T	<Triplets, are they always holding hands together?> [T pretends to be holding hands and walk. Students laugh at the impression. T laughs] <Triplets can…>			
	R		S7	<Triplets live in the same home. >			
	F		T	Oh, ok. <Yes.> It is better to do it with twins or <it is better to have a 20-pets at the same home.> [Students laugh]		***Dialogue:*** ***The achievement of common understanding***	

16	I			<Good. I want to say that> this is the ideal. <Enough. Does not matter how many twins are there.> This is the most ideal experiment. <Ok, you cannot do it. At that time, I could not do it. How can you alter this experiment?>		***through structured, cumulative questioning and discussions which guide and prompt, reduce choices, minimise risk error and expedite 'handover' of concepts and principles***	
	R		S2	<Change> one month to one day.			
	I		T	One day?			
	R		S11	<Too fast.>			
	F		T	<Don't do that.> One day…			
	R		S4	XXX			
	F		T	<Use an animal? [WKY laughs] Meaning to brush mouse's tooth.> <It is ok to use mouse.> But, but <mouse's food cannot cause the same tooth decay as us. Because…>		***Dialogue: The achievement of common understanding through structured, cumulative questioning and discussions which guide and prompt, reduce choices, minimise risk error and expedite***	
	R		S7	<Give them coke to drink.>			
17	F I		T	<Give them coke to drink? Abuse animal. > [Ss laugh] <My method was to… anyone want to guess?>			

						'handover' of concepts and principles.	
	R		S3	<Wait, think awhile longer.>			
	F		T	<Good. A while longer. We have lot of time. >			
	R		S2	<Change to> one week			
	F		T	One week. <T sighs> One month <is the same. You cannot make sure they eat the same food.>			
	R		SS	XXX			
18	F		T	Ok. <First of all, these variables are unchanged. >			
	R		S7	<Use the same method as before>			
	I		T	<How?>			
	R		S7	<Add water>			
	R		S7	<Can I add something?>			
	I		T	<What to add?>			
	R		S7	<Alkaline or acidic things. >			
	F		T	Ah			
	R		S7	<If the acidic thing and mix it>			
19	I		T	<First, we have to think. Sh. [T use a box to desk to draw the class's attention.] I hope next year I can take you out to have some science competitions for fun. In that year, I won the competition and could go oversea to UK for three weeks.>			
	R		SS	Wow.			
	I		T	Wow. <For free. For free. Need to win. You have to think about… Students learn science with an> investigation mindset. <To think. To solve some problems. How to solve. Not through meaningless nor useless talks is not			

				alright.> [T looks at S4]			
	R		S4	<Who useless talks>			
20	I		T	<Yes. You can think about if I cannot control everyone’s food to be the same. How can I accomplish the same thing.>	Collective: T and Ss address the procedures of the toothpaste experiment. Reciprocal: T and Ss listen to each other, share ideas and consider alternative viewpoints Supportive: Ss articulate their ideas freely without fear of embarrassment over “wrong” answers; and they help each other to reach common understandings. Cumulative: Teachers and students build on	***Dialogue: The achievement of common understanding through structured, cumulative questioning and discussions which guide and prompt, reduce choices, minimise risk error and expedite ‘handover’ of concepts and principles***	***Dialogic and interactive: Teacher listens to Ss viewpoints, tries to elicit Ss views and guides them to think in reasonable way to reach a completed toothpaste experiment.***
	R		S12	<I have a solution. >			
	F		T	<Good.> [T points at S6]			
	R		S12	<The whole experiment is conducted in a camp.>			
	F		T	<In a lab.>			
	R		S12	<In a camp.>			
	F		T	<In front of a camera> Ok.			
	R		S12	<C. A. M. P. >			
	F		T	C. A. M. P. Oh, <at a> camp site. Ok.			
	R		S12	<I can control with demand on what time to wake up and when to go to sleep. >			
	F		T	<If I don’t have that kind of money to invite		***Dialogue:***	

				them to a camp for a month. And school doesn’t allow these students to have a month of just eating and sleeping without learning anything. Does not work.>	their own and each other’s ideas and chain them into coherent lines of thinking and enquiry. And finally, they reach the procedures of the toothpaste experiment.	***The achievement of common understanding through structured, cumulative questioning and discussions which guide and prompt, reduce choices, minimize risk error and expedite ‘handover’ of concepts and principles.***	
	R		S12	<During summer time>			
	F		T	<These were my fellow students. There are 40 people.>			
	R		S4	<No need to use peoples. Buy some teeth’s material and brush them. Then, it’s ok. Isn’t this clever?>			
	F		T	<This is pretty good. If I go to a hospital and collect a lot of teeth. I brush them every day. [S2 laughs] But I want to say that if I am a judge, I will comment that these teeth don’t have saliva. Then, it wouldn’t decay.>			
	R		S3	<Spike saliva to them. Immerse them in it every day.>			
21	F I		T	Very good. <It starts to take shape. Use saliva to immerse the teeth.> Where does saliva come from?			
	R		SS	XXX (inaudible)			
22	I		T	Ok. <These 40 people. My approach was to buy pig teeth. >		***Exposition: Teacher explains how to holds the control variable to be constant during the experiment.***	***Authoritative and interactive: Ss still raise questions when the teacher explains his approach but the teacher tries to control the class and finish what he wants to***
	R		Ss	<Pig teeth>			
	I		T	<Because the butcher didn’t want them. Uncle, can I have those teeth? Those teeth are useless. Take them. Don’t cost anything.>			
	R		Ss	XXX (laughing)			
	F		T	<What do you need the pig teeth for? Why do I need to pay for them? Pig teeth and cow teeth are ok. Pig teeth are better. >			

				Because we are more similar to a pig than a cow. [Students laugh.]			***say.***
	R		S2	<Why don’t you say monkey.>			
	I		T	<Listen up.> [S3 rises up his hand] <I say it one more time. Sh.> Why we are similar to a pig than a cow? Is that…			
	R		S2	XXX			
	F		T	Yes. We are <omnivore> omnivore and the pigs are also <omnivore>.			
	I		S4	Pig eats grass, isn’t?			
	R I		T	<Pig also eats meat. You give it meat and it will eat it.> However, <I am speaking now.> However, a cow…			
	R		Ss	Only eat grass.			
	F		T	Only eat grass. <Therefore, their teeth are different from ours. At that time, I bought a lot of teeth, took a lot of teeth.>			
	R		S	XXX			
23	I		T	[T looks at S3.]<You don’t need to cover your mouth. I know you are talking.> I collect the saliva from those forty guys. [Students laugh] After their lunch. I have to		***Exposition: Teacher explains how to holds the control variable to be constant***	

				make sure that there is some food left in their saliva. I have to make sure that there are some bacteria in their saliva. <Ok, they have to spike saliva into the test-tube. > Ok. And also, I have to, I have to make a similar condition with the human body. <Because today is so cold that it is only in its teens. Right?> So, I set, set a water-bath of about 37 degree. [T looks at a student while talking.] <I set a water-bath. Put the test-tube in it one by one. > At the very beginning, I record the pH value. <At the beginning, I mark down the pH value. After eating, let's say it is about 7.5. Sorry, 7.4. >		***during the experiment.***	
	R		S3	XXX (inaudible)			
	F I		T	[T looks at S3] <I don't want to be similar to you.> Sorry. <7.4 or 7.5 something.> And then, I add some drops of toothpaste solution. <I mix it into the water and put droplet into it. > Ok. For the best toothpaste, it is able to make the pH value, not decrease very fast.			

				<A good toothpaste is not that it can clean your tooth very well. It is to keep, keep the pH value not to drop very fast. Right? When you watch the toothpaste commercial, they would say it keeps your mouth clean for 12 hours of protection. And the next 12 hours (cycle) you will brush your teeth.> Ok. So, after one month, <I keep measuring the pH values. I obtain a curve. Ok. I can show…> [T draws a curve on board.]			
23	R		S6	<Is it a > graph?			***Dialogic and interactive: Teacher listens to student's question and asks students which one is the better toothpaste shown on the graph.***
24	R I		T	Curve. Curve. <It is a line.> Ok. Assuming that this is toothpaste A, toothpaste B is like this. [T draws a second curve above the first curve.] <Which one is better?>			
	R		S6	B			
	I		T	<Toothpaste B, right? The pH value doesn't drop as quickly. Ok. This is the experiment that I have done on pH value. Ok. It is not a complicated experiment.> [T puts up a stop sign towards S3] <I don't want to be similar to you.> Don't mention that you are similar to me. Sorry. No. [T shakes his head.]			
	R		S3	<I am same as you.>			
25	R I		T	Sorry. <Not the same.> <Remember that in an exam, I will ask you> dependent variable, independent variable and		***Exposition: Telling the pupil what to do, and / or imparting***	

				controlled variables. Ok. With a similar ways. Ok.		***information, and / or explaining facts.***	
	R		S3	<Which toothpaste is the best?>			
	I		T	What? Which toothpaste is the best? I will not tell you. <Recording me as a commercial, it is unthinkable.> Go back to the worksheet.			

APPENDIX XIV

FINDINGS RELATED TO RESEARCH QUESTIONS: CASE EXTRACTS

RQ1)
What linguistic competencies and knowledge are required for students to participate in mathematics and science discourses and practices? (students' knowledge)

Example 1:

Issue:
- Encouraging student-initiated questions in class to stimulate curiosity, classroom discussion and meaning making.

Lesson Background
In the teacher's science classroom, students are relatively active in participating in classroom discourse. It is not uncommon to see T-Ss classroom interaction especially through student-initiated questions. In interviews with students on why they initiated particular questions in class, it is revealed that one of the ways they participate in classroom discourse is by bringing their prior knowledge or everyday observations into the classroom, and asking questions to the teacher which arise from their own prior knowledge, everyday observations, speculations or hypotheses. They are bridging their own prior knowledge with new materials introduced by the teacher or other students, through participation in classroom discussions.
However, although student-initiated questions may stimulate students to generate explanations for things that they are curious about and to propose solutions to problems (Chin & Osborne 2008, p. 3), we argue that the prerequisite for such meaningful learning is the *effective communication* of the questions by the students themselves. Based on the 3 cases below, it seems that the full potential of these students-initiated questions has not been fully tapped.

Reference:
Chin, C., & Osborne, J. (2008). Students' questions: a potential resource for teaching and learning science. *Studies in science education*, *44*(1), 1-39.

Interview with student:
According to one student in post- lesson interview, the reason he commented in classroom that ice must be at zero degrees is that it was his father who told him so. What he would like to speculate based on this prior knowledge was that if ice does not need to stay at zero degrees always, then will the temperature of ice drops to -273 degrees at its absolute zero degrees (絕對零度).

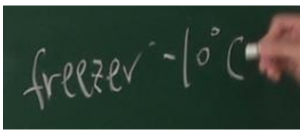
<…….>: in Cantonese

I	**(05:24)** Okay. <I would like to ask. The teacher said>"good question". <Can you tell me> what exactly were you asking? <What are you asking actually?>	
S	<Ice must be at zero degrees.>	
I	<Yes.>	
S	<Must ice be at zero degrees?>	
I	<Oh, so just now (*in classroom*) you were asking whether ice must be at zero degrees.>	

S	<Yes.>	
I	<Why would you ask this question?>	
S	**(05:48)** <Because my father is a Chemistry professor in the University of Hong Kong. Previously I have asked him some questions regarding this and he told me ice must be at zero degrees.>	
I	**(06:01)** Okay. <When the teacher mentioned “for example> freezer <is at -10 degrees”>	
S	<But is -10 equals to negative 10 degrees Celsius?>	
I	<Yes, negative 10 degrees Celsius. Why did you ask this question?>	
S	**(06:18)** <I am curious. >	
I	<What did you want to know?>	
S	**(06:23)** < I would like to know, if ice was not at zero degrees, will it really go to -273 degrees*, which is 絕對零度(*absolute zero degrees*) ? >	*(*Note: At zero Kelvin (minus 273 degrees Celsius) the particles stop moving and all disorder disappears. Thus, nothing can be colder than absolute zero on the Kelvin scale.*)
I	**(06:35)** Okay. Okay. <So at that time, the teacher said> “will come back to you later”.	
S	<But she didn’t mention that at the end.>	
I	(*Chuckles*)	
S	<I had been attentive to that.>	
I	(*Chuckles*) <What have you expected from the teacher in addressing you question? What do you want to know from her> answer?	
S	**(06:54)** <Actually it’s uncertain. But my father said ice must be at zero degrees, so I only believe the answer partially.>	
I	**(07:05)** Okay.	

Lesson Transcript:
However, in the classroom the prior knowledge that the student holds regarding -273 degrees (absolute zero degrees) and his query about whether ice always stays at zero degrees or not are the reasons why his comment, “Ice is only at zero degrees” in line 6, is not verbalized clearly. Although the teacher mentions that it is a good question (line 7), the absence of explicit reasoning in the student’s question might be the reason why the teacher is not able to pick up the clues, which leads her to drive the conversation in another direction instead, i.e. water at 23 degrees being cooled to -10 degree (line 7). This highlights the importance of students learning how to enhance their linguistic competency in communicating their questions more effectively, in order to better participate and engage in science inquiry discourse.

Line	**M**	**P**	**Discourse**	
1	I(T)	T	So, for example, both melting point and freezing point of water	

			is zero degree Celsius. So do give example and mention that is zero degree Celsius. For example, if, for water, okay liquid water, and originally when we put a cup of water here, maybe, twenty three degree Celsius, and, when we put it into the freezer, then, what will be the temperature of the --	
2	R	S	Zero degree Celsius.	
3	R	S	Zero	
4	F	T	It will drop to zero, okay, or lower. Now,	
5	R	Sx	About zero.	
6	R	S	冰只係零度咋喎 (*Translation: Ice is only at zero degrees.*)	
7	F	T	Okay, I'll- I'll mention this later. A very good, question okay. I'd like to, mention. So, for this one, now, water, twenty three degree Celsius, at room temperature (*writes on blackboard*). Okay when we put it into the freezer of course it will cool down, it will be cooled down, okay (*draws on blackboard*).	  

			And, if the freezer is set as negative ten degree Celsius, (*writes on blackboard*)	

Example 2:

Issue:

- Encouraging student-initiated questions in class to stimulate curiosity, classroom discussion and meaning making.

Interview with student:

According to the student in the post- lesson interview, the reason he asked if human bodies would melt is that a book has informed him about the possibility of putting certain substances in dead bodies and freezing them (perhaps to bring them back to life later). He expresses the idea of putting human bodies inside a bottle, or human bodies transforming into solids or even a gas to escape places. When asked if he is satisfied with the teacher's answer to him that human bodies will melt and that "every substance has a melting point", he shares how he thinks the teacher's answer is incorrect as he believes that different body organs have different melting points, freezing points and boiling points. This interview reveals the rich imagination and creative thinking behind the student's simple question to the teacher: "Will people melt?"

<….> : in Cantonese

I	Again, so why did you ask this question at that point?
S1	<If humans could> melt, <if human could become> gaseous state-- <if after human's death and human's> form <could be changed, it might be easier for storage. In the past, I had come across a book which mentioned some researches regarding putting certain substances in dead bodies and to> freeze <them. And maybe those dead bodies could have a chance for rebirth. But I don't have the exact idea. So I don't know why I would ask that question at that time. But then I saw a water bottle which was full of water, and I thought maybe we can put human beings inside a bottle?>
I	(*Laugh*) <Put people inside the bottle? You mean in> liquid form <or> gaseous form?
S1	<If a person is in> liquid form <and he/she can transform into> solid, <or even> gas, <suppose when the> locker <door is locked, I can become> gaseous form <to go inside the locker to unlock the door then come out again.>
I	<Okay, okay.> Very very interesting. <The teacher said that> 'every substance has a melting point' <and you asked if > 'human <will> melt.' <What do you think about her reply?>
S1	<I don't think this is correct.>
I	Okay. <Why?>
S1	<Because as a human, all of his/her> organs <have different> melting points, freezing points, <and> boiling points. <If only certain parts of you could melt but not the other parts, that could be a serious issue. For example, your head becomes> gaseous form <and your legs become> liquid form <and your stomach is in> solid <state, and I don't know what it will turn out.>
I	Okay. Interesting.

Lesson Transcript:
However, such rich imagination and creative thinking behind the student's question in line 1 "will people melt" is not made explicit, and is brushed off as a mere joke by peers' laughter as shown in lines 2 and 6, and the teacher's brief comment "Later, yes okay so every substance got melting point…" before T moves on to her intended topic. This again highlights the importance of students learning how to enhance their linguistic competency in communicating their questions more effectively, in order to better contribute to the classroom's science inquiry discourse.

Line	M	P	Discourse
1	I(S)	S1	**(1:09:55)** (*raises hand*) 咁人會唔會 melt㗎? (*Translation: Then will people melt?*)
2	R	Some Ss	(*chuckles*)
3	R	T	(*pause*)
4	Re-I(S)	S1	人會唔會 melt㗎? (*Translation: Will people melt?*)
5	R	T	Later. 會 (*Translation: Yes*), okay so every substance got melting point—
6	R	Ss	(*chuckles*)
7	I(S)	S2	(*holding up his water bottle*) Eh so uh, so --
8	I(T)	T	Now, so, shhh. In this case, now for the evaporation, if, that is dry (*points to upper part*), that means the air, can hold, certain amount of water vapour, **(1:10:13)**

Example 3:

Issue:

- Encouraging student-initiated questions in class to stimulate curiosity, classroom discussion and meaning making.

Interview with student:
During the post-lesson interview, the student reveals that the reason why he asked the teacher if water at 23 °C or 70 °C will cool down faster in the classroom is that he has observed how his mother has used hot water to make freezing packs. Hence he would like to know which of the ice packs of water will freeze first at different temperatures.

I	Just want to ask why you asked this question (*in classroom*).
S1	Because at that time I just saw some degrees and simply asked a question because sometimes my Mom used some hot water to make some freezing packs. Just like if I get hurt, I can use them immediately. So I was wondering is different temperature of water, if you heat the ice pack, which one will freeze first.
I	Okay. What do you think the answer is actually?
S1	Actually is at the beginning, I think it's the lower (temperature) because if you freeze the lower first, it will become lower and it would be easy. But simply I just thought maybe it would be the higher (temperature). Because the higher the temperature is the ice pack, then it will just like the polar region, it will freeze immediately because the freezer will make some freezing effects just like very cold. And just simply 45 seconds, it will just make it very cold. **(06:55)**

However, the student's initiated question to the teacher in the classroom which stems from his prior knowledge regarding ice packs and cooling rate, does not see its potential being fully realised; teachers need to try and exploit these interactional moments when they arise and not shut down opportunities for extending classroom discourse and inquiry.

Example 4:

Issue: (Students' difficulties in understanding key vocabulary and terms (academic English)

Student competencies and knowledge:

Students need to know some mathematical terms (academic language) such as 'co-efficient', 'opposite sign' or some everyday terms such as 'cancel', to describe mathematical procedures or reasoning. From lesson observations and also student interviews, we found that students do not understand the meaning of words in application problem.

Mediating process:

- From Lines 1-23 the teacher waits for the student's answer and he encourages the student to find the word "Cancel".
- In Line 23 the teacher increases the demands made on the student by asking "How to cancel 'y' then?" But the student is not answering "How", so in Line 25, the teacher continues to ask for clarification, "What would you do with those two equations?"
- From Lines 27-37 the teacher wants the student to make the reason why he chooses one plus two but not minus two. The student seems to lack academic language (such as 'coefficient', 'opposite sign', etc.) to explain the reasons. At this point, the teacher helps him to answer this question. He gives hints and asks closed and narrow questions such as "positive or negative?" and "Are they the same sign?"

The teacher gives opportunities for students to make self-corrections and he encourages him to use English in his reasoning.

Lesson Extract:

Lesson background:
The teacher gives one more example which is not in their worksheet for students to do. He asks students to solve 4x + (y/2) = 5 and 5x - (y/2) = 4. After the teacher gives time for students to complete this he asks students to explain which method they should use to start with:

Line	M	P	Discourse (V + NV)
1	I (T)	T	Okay, before we get start with this question, which method you would use? [S1 raises his hand.] Yeah, which method would you use? Substitution or elimination? [T invites S1 to answer.]
2	R (S)	S1	Elimination.
3	I (T)	T	Why you choose elimination?
4	R (S)	S1	Er, because…XXX

5	F (T)	T	Sorry? Come on.
6	R (S)	S1	The…
7	F (T)	T	Be brave.
8	R (S)	S1	Okay. The…the y can be…
9	I (T)	T	How do we say this word, “Chip” [T makes a cutting sound.]
10	R (S)	S1	ER…
11	F (T)	T	Start with letter ‘c’.
12	R (S)	S1	[Student is thinking.]
13	I (T)	T	Okay, search your notes. [Teacher search on the student’s notes with him.] There are some words, did you write down some notes? You can find some words here. [Teacher points at the notes.]
14	R (S)	S1	Er… “can”… [Student is trying to pronounce the word “Cancel”.]
15	F (T)	T	“Can”? How to pronounce this word?
16	R (S)	S1	“Can”… [Student is trying to pronounce the word “Cancel”. He looks at the student behind him and seeks help.]
17	I (T)	T	“Can”, yes, “can” what? ‘c’, ‘a’, ‘n’, ‘c’, ‘e’, ‘l’. How to say?
18	R (S)	S2	Calculate. [The student behind the student gives a guess.]
19	R (S)	S1	Calculate.
20	F (T)	T	Calculate? Not calculate, come on.
21	R (S)	S1	[student checks with his peer for his mistakes.]
22	F (T)	T	“Cancel”, “Cancel”. [Teacher pronounces this word.] He just gave you some hints, but it doesn’t imply he is correct, okay? He wants to help you, okay? I think so, I think that.
23	I (T)	T	Ya, okay, you say that ‘y’ would be cancel, how to cancel ‘y’ then?
24	R (S)	S1	Er… ‘y’ over two can cancel.
25	F (T) I (T)	T	Okay, ‘y’ over two can cancel. What would you do with those two equations?
26	R (S)	S1	Er, one plus two. [Student means that equation one plus equation two.]
27	F (T) I (T)	T	One plus two. Why do you choose one plus two but not minus two?
28	R (S)	S1	Er, because the… because the… one ‘y’ over two is ... [Student wants to say that the coefficient of ‘y’ is one in both two equations.]
29	I (T)	T	Okay, is this positive or negative? [Teacher points at the "+" in equation one.]
30	R (S)	S1	Positive.
31	I (T)	T	[T point at the "-" in equation two.]
32	R (S)	S1	Negative.
33	I (T)	T	So?
34	R (S)	S1	Er…
35	I (T)	T	Are they the same sign? [T point at the "+" in equation one and "-" in equation two.]
36	R (S)	S1	No.

37	F (T)	T	Opposite sign and then add them together. Thank you.

Interview with student:

(This interview was conducted in Cantonese)

I	In application problems, are there any English words you do not understand? That's this part, this kind of word problems, any English words you do not understand? [Int shows the notes to student]
S1	Yes, yes.
I	Can you tell me which ones?
S1	Digit.
I	You do not know the meaning of digit?
S1	Hmm.
I	Do you understand the meaning of "two-digit"?
S1	Digit.
I	You do not know the meaning of digit. Okay, any others?
S1	Interchange.
I	You do not know the meaning of Interchange.
S1	Yes, denominator.
I	Denominator. But you know how to pronounce it. You can pronounce all those words you don't understand the meaning of it.
S1	I remember that I hear those words but I do not remember their meaning. Yes, numerator and denominator. I remember that numerator should be 分子 [Student uses the Cantonese of numerator.], denominator is 分母 [Student uses the Cantonese of denominator]

Example 5:

Issue: Encouraging students to use English in their answers and when self-correcting

In this case most of the students ask questions or give responses in Cantonese (L1). The teacher usually repeats students' questions or responses in English. But only in one situation, when they are giving answers verbally on an LAC activity worksheet, the teacher forces students to answer in full sentences and in English. The teacher would instruct students how to answer those scientific observations or experiment results before doing the LAC activity worksheet. That suggests students have already learnt this knowledge and sentence structures. Most of the time, when the teacher nominates a student to give answers in front of the whole class, he does not help to finish the sentences and would wait or encourage students to make self-correction.

Lesson Extract:

Lesson background: The teacher asks students to answer LAC activity I part IV questions verbally and he tries to encourage them to reformulate their answers in English.

Line			
1	I (T)	T	Tell me, tell me, Number 2a, what is this, you tell me. 第二題 <Question 2.>，what is this?下? You haven't done that? Okay, how to

			answer me, what is this?
2	R (S)	S1	It is vinegar.
3	F (T) I (T)	T	It is vinegar. Okay, write down. It is vinegar. Okay, you can write down, it is a bottle of vinegar. Okay, I ask you again, what happens when you add vinegar to the blue litmus paper? How would you answer? How would you answer? Okay, listen, listen to me. How do you answer? What happens when you add vinegar to the blue litmus paper? How do you answer?
4	R (S)	S1	I don't know.
5	F (T) Re-I (T)	T	You don't know? Anybody knows? Okay, another. Tell me, what happens when you add vinegar to the blue litmus paper?
6	R (S)	S2	When I add vinegar to the blue litmus paper, the litmus paper turns blue to red.
7	F (T)	T	Okay, good. When I add vinegar to the blue litmus paper, the litmus paper turns from blue to red. Okay, yes, it turns red also. Okay.
8	I (S)	S3	Turns blue to red 得唔得呀? <Is it okay to write turns blue to red?>
9	R (T) I (T)	T	得呀。好，<Yes, okay.> number 3, number 3. Ah, number 18, who is 18, okay,. Okay, I ask you first, what is this? This is this? It is? It is?
10	R	S4	Water ar.
11	F (T)	T	What water? What kind of water? It is?
12	R (S)	S5	Distilled water.
13	F (T) I (T)	T	Okay, it is distilled water. Okay, I ask you again. What happens when you add distilled water to the pH paper? You answer.
14	R (S)	S5	XXX.
15	F (T)	T	No, no, no. follow the sentence, when I?
16	R (S)	S5	When I add distilled water to pH paper, the pH paper turns yellow-green.
17	F (T)	T	When I add distilled water to the pH paper, the pH paper turns yellow-green. Okay, turns yellow-green, very good.

Example 6:

Issue: Giving time for students to understand teachers' questions and paying attention to students' answers

Lesson Background:

	Lesson Content	Experiments
	➢ Effect of air pressure ➢ Suction cup and drinking straw	• Activity: Blowing a balloon in a bottle • Experiment: Magdeburg hemispheres demonstration • Experiment: Part I Heating a solid

The episode below takes place at the beginning of the lesson when the teacher does her habitual review of content covered in previous lessons (i.e. in this case, properties of gases & gas pressure). The teacher starts the activity (i.e. question & answer session) by asking students to recall the properties of gases, which was taught two weeks previously. The episode being focused on shows the dialogue between the teacher and students after two students each share one property of gas (Lines 8 and 18) to the whole class.

The following analysis suggests that in order to participate in science discourse, students should have the following linguistic competencies and knowledge:

- Time to understand and make sense of teachers' questions as the student's answer in line 23 suggests that he does not know that the teacher wants him to NAME the force, see Line 19)
- Give extra attention when making scientific descriptions, especially when using scientific vocabulary since many scientific words are compound nouns. For example, in Line 25, the student just says 'the pressure' (missing the word 'gas' or 'atmospheric') and is thus required by the teacher to make clarifications in line 27. This suggests that students have to understand that every component of a scientific term is important in giving a complete meaning. Also, it can be inferred from the teacher's question in Line 26 that the term *pressure* is a hyponym that entails a 'category' of different types of pressures whereas *gas pressure* is a hyponym (Lemke claims that hyponymy is a common taxonomic relation in the Science discipline in appendix C of *Talking Science*). It is therefore important that when students want to refer to a particular member of a category, they make it explicit by using appropriate vocabulary precisely.

Line	M	P	Discourse (V + NV)
1	I(T)	T	(06:34) {To class} OK, close your textbooks. Question time. Question, shh. Close it. OK, so yesterday we start to talk about something about gases, the property of gases, please tell me the property of gases. Lucky draw. See if you're the lucky guy, number 3.
2	R	Ss	Woo
3	I(T)	T	Number 3 please stand.
4	R		[Student no. 3 stands]
5	I(T)	T	Shh OK, please tell me one of the property of gas.
6	I(S)	S1	Gas?
7	R	T	The gas particle…
8	R	S1	[Takes the microphone and says softly] Move all the time.
9	 I(T)	T	Yes, it can move all the time. OK, S1 is so gentle and such a soft lady. OK, so yes gases can move all the time. What else? Class number 11.
10	R	S2	[stands up]
11	I(T)	T	{To S2} What else? Try to think of the spaces between the gas particle.
12	R	S2	[inaudible responses]
13	Re-I(T)	T	You speak louder. {to class} Shh.
14	R	S2	The air particle is far apart.
15	I(T)	T	S3, please stand. And repeat her answer. {to S2} Sit down first.
16	R	S3	[silent]
17	F	T	{to S3} OK, so keep standing. (08:02) OK, so what is the second property of the gas? Apart from that the gas can move freely?

	I(T)		S4, yes, can be?
18	R	S4	[inaudible]
19	F I(T)	T	Yes, can be compressed. So yesterday when you played with the gas syringe, you can compress the gas. Ok, due to this property, because there are many spaces between the particles, they are far apart, OK? So they can be compressed and then something is produced, which make some force. **What do we call the force?** Class number 17.
20	R	Ss	Woo…[chatters]
21	R	S5	[stands up]
22	I(T)	T	[approaches S5] 17, yes?
23	R	S5	**The gas particle far away.**
24	F I(T)	T	Since that it can move and can compress, OK so yesterday when we play with the syringe, OK so when we decrease the volume, we will increase something. {to S5} Something will be increased.
25	R	S5	Yes, **the pressure**.
26	I(T)	T	**What kind of pressure?**
27	R	S5	The **gas pressure**.
28	F I(T)	T	Yes, the gas pressure. Well done! Sit down.
29	R	S5	[Sits down]
30	 I(T) I(T)	T	The gas pressure will increase. So what is the meaning of gas pressure? S6?
31	R	S6	[stands]
32	I(T)	T	What is the meaning of gas pressure?
33	R	S6	[silent]
34	F	T	This one is quite difficult.
35	R	S6	[talks to his neighbours]
36	I(T)	T	The particle hitting the?
37	R	S6	The surface of the [hesitating]
38	F I(T)	T	OK, partly correct. Sit down first, S6.
39	R	S6	[sits down]
40	F	T	{to S6} OK, you need to be more attentive. {to class} OK so we try to make the answer of

	I(T)		S6 to be perfect. OK, S6's answer mentions that pressure is equal to a particle hitting the surface. What kind of particle?
41		Ss	Air
42	I(T)	T	Yes, air particle. Or some gaseous particle. OK, hit the surface. OK? This will produce pressure. OK, and then we should add the frequency. OK, the frequency for the air particle to hit on the surface. OK, so if the frequency increases, then the gas pressure will? Number 6?
43	R	S7	[stands up]
44	I(T)	T	If the frequency increases for the air particle to hit the surface, then the gas pressure will?
45	R	S7	Increase.
46	F	T	Yes, increase. Remember this one. OK – well done.

Example 7:

Issue: Helping students to understand scientific ideas and vocabulary

In the pre-unit interview, the teacher identifies what linguistic and conceptual knowledge students are required to participate in classroom talk in the Unit "Matter as Particles". According to the teacher, there are two difficulties for students in the science class. First, the representational difficulty of describing and explaining scientific phenomena and causative relations by using accurate scientific terms and second, the linguistic difficulty of expressing scientific ideas in English due to their limited English vocabulary and grammatical structures (see the interview excerpts below).

Teacher interviews:

Excerpt 1: "Students need more thinking in three learning areas [air pressure, thermal expansion, and density]. If using the particle model to explain… It is fine for them to use their own words to describe the conversion of the three states of matter. But they will have problems if they are required to employ scientific terms. They may not be able to describe the scientific phenomena correctly. Or when they try to describe it, they cannot correctly explain the causative relations of which they might skip some points. After stating the first point, they might skip, for example, when the temperature increases, they will immediately skip to the conclusion that the density decreases. However, in fact they miss some points in between, because they need to use the particle model to describe. The right way to describe [the whole process] is, first, when the temperature increases, particles move further apart. Based on the concept of density, as the number of particles remains unchanged, the mass also remains unchanged. Since particles have moved further apart, the volume [of the substance] increases. When the volume [of the substance] increases whereas mass remains unchanged, the density decreases. Students often fail to describe the whole mechanism this way and they should be able to state that when the temperature rises, the density drops. Some students are capable of doing it, but they need more guidance."

Excerpt 2: "I do something like teaching English, for example 'further apart'. They should not say 'a long distance' because they need to highlight 'an increase' [of the distance] and describe the change, which is often omitted. They often say 'fast' instead of 'faster', 'slow' instead of 'slower'. They also say at times 'high temperature' rather than 'temperature becomes higher' [even when they need to describe the change]. These are different – we're describing the change; 'high temperature' and 'an increase in temperature' mean two different concepts."

Lesson extract:

Lesson Background:
In this episode, the teacher points out the difficulty in this Unit—using English to explain scientific ideas—and offers his advice on giving students time and space for "jotting down notes". The teacher's explicit guidance might raise students' awareness of the importance of using English language in learning science.

Line	M	P	Discourse (V + NV)
1	I (T)	T	Unit 6, OK? The unit is the most difficult unit in form 1. OK? Because it requires you to use a lot of English to explaining something. OK? So some students, if your English standards, OK, is not very good, you have, maybe, you need to jot down more notes, OK, on how to explaining something. OK, if you are quite good in English, OK, for example, I think S1's English is quite good, I think, I think OK maybe you will find explaining something is not very difficult. However, for some situations, for example, for S2 maybe, OK, he will find that it will be difficult. But never mind. Just use the pen. OK? When we have the lesson, you jot down more notes. [To S2] S2, remember, OK?
2	R	S2	[silent]
3	I (T)	T	[To Ss] Even though I, even though I didn't mention, it doesn't mean your English is very good, OK? If I were you, I will take out a pen or pencil. And then we will have the lesson, and you will try to write down more. OK, so that you can improve yourself.

RQ 2)
What are the distinctive features of L2 mathematics and L2 science classroom discourse that are conducive to the co-construction of content knowledge, and the effective learning of mathematics and science? (classroom discourse)

Example 1:

Issue:
Understanding an interactive but authoritative classroom discourse by using Alexander's (2005) and Mortimer and Scott's (2000) framework

Lesson Background:

Teaching Purpose	Exploring student's conceptual understanding of solid and liquid. This is then transitioned into teacher introduction and an explanation of a new definition for solid.
Content	Asking the students to explain what is solid and liquid in their own words.
Approach	"Non-interactive / authoritative" followed by "interactive / authoritative" and concluded with "non-interactive / authoritative"
Patterns of interaction	IRE with occasional uses of IRF chains
Forms of intervention	Selecting and sharing student ideas, checking student ideas, paraphrasing

Further Analysis:

This episode exemplifies an *interactive / authoritative* discourse and concluded with a *non-interactive / authoritative* segment. The teaching objective of this episode is to explore the student's current conceptual understanding in the properties of solid and liquid and to illustrate why their current conceptual understanding can be problematic. The purpose of this activity is to generate an opportunity for the teacher to transition into a new definition for the properties of solid to better explain the inconsistency caused by the conventional definition of solids.

This episode starts off with a *non-interactive / authoritative* approach in which the teacher provides instructions to the following discussion activity that the students will be engaging in. The approach of the discussion activity is labelled as *interactive / authoritative* that is because while the activity seems dialogic as evidenced by the numerous occurrences of "*initiation and response*" between the student and teacher. However, the teacher's response to the students' input is more of an *evaluation* rather than *follow-up or feedback*. As a result, while the teaching is willing to elicit student's ideas, the teacher is not utilizing their ideas to further develop a line of shared conceptual understanding. This agenda is clearly evident when on at least one occasion the teacher told the students "*Now, those whose answer is most similar to mine will receive a prize*". At the conclusion of the discussion activity, the teacher engaged in a *non-interactive/authoritative* approach in which he conducts a teacher's *exposition* in introducing the concept of "*maintain shape*" as a replacement to the concept of "*fixed shape*" when describing the properties of solid. The objective of introducing this new "*maintain shape*" concept is to address the inconsistencies that arise from the utilization of "*fixed shape*" from the discussion activity.

A further analysis of this episode's pedagogical intervention was conducted using Mortimer and Scott's (2003) framework of discourse. From our findings we can see that of the five categories in the framework (see Annex 1), the teacher's intervention in this episode did not place emphasis on *accepting student's ideas, co-constructing new ideas and checking for student's understanding*. This finding further re-enforces our belief that the discussion activity in this episode is an example of an *interactive and authoritative* approach.

Time	M	P	Discourse (Verbal +Non-Verbal)	Alexander's Principles	Repertoire Talk Type	Mortimer & Scott Type of Interaction
9:32	**N/A**	**T**	Ok, a small activity for you. Good, please close your books. Not dictation yet, I have something I would like for you to think about first. Please close your books. *Students closes their textbooks*		Instruction / exposition	Non-Interactive / Authoritative
9:57		**T**	Ok, *Mr XXX points to SS1* close your book. *SS1 closes his book*			
10:00		**T**	Ok with everyone being this old, I think you know how to identify solid liquid and gas, right? I think with you being this old I'm sure you know how to tell the difference between solid, liquid and gas, right? Except for certain situations where it's between two states. What is ice cream? Solid or Liquid?	Purposeful		
10:18		**SS**	Liquid… Solid, solid…		Discussion	Interactive / Authoritative
		T	Actually, it is a solid. How about oil?			
10:23		**SS**	Liquid.			
		T	Liquid, so I want you to do something.			
10:27		**SS26**	Solid.			
		T	Oil is a solid?!?! *Mr XXX stares at SS26*			
10:32		**SS26**	Oh no no….			
		SS?	Solid is solid.			

10:35		**T**	Ok listen. I want everyone to speak with the person next to you. Discuss with your classmates.	Collective		
10:46		**SS29**	Front or back? *Referring to the students sitting in front or back of her*			
	I	**T**	Front or back up to you? *Several SS giggles* Use one sentence. Use one sentence to tell me what is solid, what is liquid, and what is gas? I want you to give me a sentence that can precisely describe what is solid, what is liquid and what is gas. There is an alien that has just came to earth and this alien is called Mario. *Several SS giggles* And now, he doesn't know what is solid, liquid and gas. You use just one sentence to explain what it is.			
11:22	**R**	**SS23**	XXX Sir, I don't know how to speak in alien.			
	E	**T**	Ok, Ok, Ok…. It's not important. You can only use one sentence. Ok go discuss…			
	I	**SS21**	*inaudible*			
	R	**T**	Whatever you like.			
	I	**SS16**	One sentence to describe all three states?			
	R	**T**	No, each one sentence. One sentence describing what is solid. One sentence describing what is liquid. One sentence describing what is gas.			
11:37	**N/A**	**SS**	*SS chattering with neighbours about the task at hand*			
11:44		**T**	*Mr XXX walks into the prep room* Hey Kong Sir, I would like a syringe. *speaking to the lab technician*			
12:00		**T**	*Mr XXX returns with a syringe and check on each group*			
		SS21	*SS21 opens the textbook*			
		T	*speaking to SS21* Looking at the textbook is useless. The textbook isn't even correct; you will find out why later.			
12:19	**I**	**T**	*speaking to SS24 and SS23* So what is solid?			
	R	**SS23**	Ah sir, I have completely countered all his discussion points. *pointing to SS24*			

	E	**T**	Good, continue...			
12:29	**I**	**T**	*speaking to SS20* And you? What is solid?			
	R	**SS20**	Solid is solid.			
	E	**T**	Rubbish, what is solid? *Mr XXX walks away*			
12:42		**SS1**	*SS1 raises his hands*			
12:44		**SS?**	Don’t force me to think anymore. *Mr XXX walks over to SS1*			
12:48	**I**	**SS1**	What state is slime?			
	R	**T**	What? What is slime?			
	I	**SS1**	She doesn’t know. *SS1 points to SS6*			
		SS6	*inaudible*			
	R	**T**	What? Are you referring to the plastic things? What do you think? *Mr XXX points to SS1* Think of the definition first. Think about the definition, ok.			
	I	**SS?**	*inaudible*			
	R	**T**	Those should be solid... but… how would you define it?			
13:20	**I**	**T**	Ok, time is up. Shh… Ok, and now, this UFO *Mr XXX points to himself* will start asking people. What is solid, liquid and gas?			
	R	**SS26**	Here… Here... *points to the text in the textbook* *SS30 raises his hand*			
	E	**T**	I am telling you now that it is not correct. *Mr XXX points to SS30*			
	I	**T**	Now, those whose answer is most similar to ah sir’s answers will receive a prize. *points to SS30*			
	R	**SS30**	*SS30 stands up* Solid has a fixed volume and shape.			
	E	**T**	Ok… this student said *Mr XXX points to SS30* solid has a fixed volume and shape. Ok…			
14:04	**I**	**T**	Look here *Mr XXX holds up a rubber band and points to it* it is a circle, right? Circular… Is this a solid?			
	R	**SS**	Yes.			

	F	**T**	Yes, you said it has a fixed shape *Mr XXX points to SS30* *Mr XXX creates a star with the rubber band and holds it up* what is this?			
	R	**SS**	A star.			
	E/I	**T**	A star, just now it is circular and now it is a star. You said it is fixed shape. Who else? * SS28 raises her hand* Give it a try… give it a try… if you're wrong its ok. *SS23 raises her hand* Good *Mr XXX points to SS23* Go Go Go…	Supportive		
14:35	**R**	**SS23**	May I speak in Cantonese.			
	F	**T**	Ok… Go, go, go…			
	R	**SS23**	Liquid does not have a fixed shape.			
	E	**T**	Liquid has a fixed shape. *SS28 raises her hand*			
	R	**SS23**	Not fixed, not fixed…			
	E	**T**	Air is also not a fixed shape.			
	R	**SS18**	Liquid is also not fixed shape.			
	E	**SS26**	Liquid can also have a fixed shape.			
	R	**SS23**	But liquid is still not a fixed shape unless its placed in some air. *SS10 raises his hand*			
	F	**T**	It's the same with air in any cylinder. It's not fixed. Can you mold a piece of air and then throw it at people? *Mr XXX points to SS28*			
	R	**SS28**	Solid can hold and can touch. And liquid can touch and cannot hold. And the gas cannot touch and cannot hold.			
15:22	**E/I**	**T**	Cannot hold *Mr XXX turns on the faucet and scoops up some water with his hand* I hold some water for you. *SS giggles* *SS10 raises his hand* *Mr XXX points to SS10* You…			
	R	**SS10**	*SS10 stands up* Liquid can have a shape but not a fixed shape. You can touch it, but it doesn't have a fixed shape. It also has a physical constitution.			
	E	**T**	*Mr XXX points to SS10* No fixed shape…*Mr XXX create a star with the rubber band* Wei, does this star have a fixed shape? Or do you think ice cream have any fixed shape? What			

			is fixed shape? I don't understand. *SS22 raises his hand*			
15:54	**R**	**SS22**	Solid's molecular structure is more compact than liquid and liquid is more compact gas.			
	E/I	**T**	Oh… what is called student A? Student A is taller than student B. *SS giggles* What is called student C? Student C is fatter than student D. *SS giggles* I don't understand. What else? *SS11 raises his hand*			
	R	**SS11**	*SS11 stands up* Air molecules are spread out apart the most.			
	E	**T**	*Mr XXX looking at SS11* Again, what do you mean spread out apart the most? What is called Mr XXX? Mr XXX's head is balder than yours? *SS giggles*			
	R	**SS11**	There are spaces between the air molecules. So, there are more space between.			
	E	**T**	Wei, there you go again saying more. Oh, XXX sir's head has less hair than you. *SS giggles* No No No No No… Wei, remember in chapter 2. When you were categorizing the materials, you must be very precise in categorizing what it has and what it doesn't have. It is a classification.			
		SS26	*inaudible*			
		T	OK, anything else? *class silent* Ok, I want one more to try and then I will say the answer. *SS8 raises her hand*			
17:31	**I**	**T**	So, what do you think SS31? Ok SS8. *Mr XXX points to SS8*			
	R	**SS8**	You cannot touch the gas.			
	E/I	**T**	You cannot touch the gas. *Mr XXX starts fanning himself with his hand* Wow very comfortable. *SS giggles* I cannot touch the gas. *SS1, SS4, SS18 raises their hands* *Mr XXX points to SS4*			
	R	**SS4**	Solid has no movement.			
	E	**T**	Solid has no movement. What do you mean by movement?			
	R	**SS23**	You can place the solid inside the water… movement lor…			
		SS4	Err…			

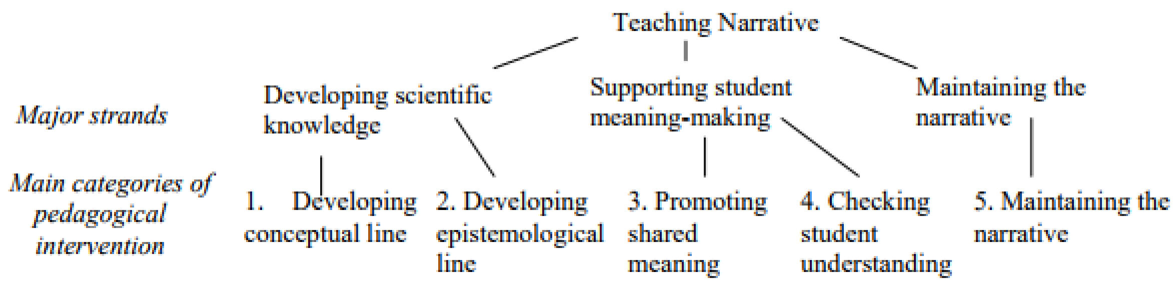
	I	**T**	Ok one more. *Mr XXX points to SS1*			
18:07	**R**	**SS1**	*SS1 stands up* Liquid has a fixed volume but not shape but air does not have a fixed volume and shape.			
	E	**SS23**	You just said that before.			
	E	**T**	Wei, wei, wei… *Mr XXX holds up the rubber band* Just now I said circular *Mr XXX creates a star with the rubber band* or star. No…			
18:28	**I**	**SS18**	*SS18 raises his hand* A fixed volume *(referring to solid)*			
18:30	**F**	**T**	A fixed volume… How about liquid? *Mr XXX looks at SS18*			
	N/A	**SS18**	*Silence*			
18:34		**T**	Ok, I think I need to tell you the answer. In your textbook, it wrote that solid, it has fixed shape. Ok in your textbook. Please turn to page 141…141. *SS opens their textbook and turns to page 141*		Instruction / exposition	Non-interactive / Authoritative
		T	Quick summary, it tells you that, solid it has fixed shape and volume. Now, volume I trust nobody will object to, right? But, what do you mean by fixed shape? What is fixed shape?			
19:10		**T**	Actually, the so called fixed shape *Mr XXX writes the definition of fixed shape on the board* I can say that it can maintain a shape. It can maintain a shape. Maintaining a shape.			
19:33		**T**	At least for the rubber band, a piece of rubber band, if I just put it here *leaves the rubber band on top of the table* could it maintain for some time? At least if I leave it there it won't move, right?			
		T	You go to McDonald's and buy the ice cream, it can maintain the shape for some time, right? But is liquid able to maintain its shape? Can I fill a cup with water then break the class and have the water maintain the shape of the cup for 10 seconds? No... it is impossible, ok.			
20:09		**T**	So, for the solid, a fixed shape means that it can maintain a shape. It can maintain a shape. OK.	Purposeful		
20:18		**T**	And also, some people say it has a fixed volume. *Mr XXX			

			writes fixed volume on the board* Fixed shape and fixed volume, ok. It is a solid. But you know what does it mean by fixed shape. Not fixed shape but it can maintain a shape. OK…			
20:47		**T**	Now everyone must understand the underlining meaning and not just read the textbook and consider it as the answer. OK, time is not enough because we need to do the dictation. So tomorrow I will continue to talk about the difference between liquid and a gas and also the other definitions. Ok…Good, the lesson ends today.			

Participant Coding Legend

T = Teacher
SS = Several Students
SS# = Identified individual student
SS? = Unidentified individual student

Annex 1



"Teaching Narrative" (Adapted from Mortimer & Scott, 2003)

Pedagogical Intervention Features	Featuring in episode
Developing the Conceptual Line	
Teacher introduces a new term or idea	YES
Teacher guides students through the steps of an argument or explanation by means of a series of key questions	YES
Teacher paraphrases student ideas	YES
Teacher differentiates ideas	YES
Teacher offers a direct choice between ideas	YES
Teacher selects a student response, or focusses on part of a student response	YES
Teacher implicitly accepts a student idea	No
Teacher retrospectively elicits a student response	YES
Teacher overlooks a student response	YES
Teacher repeats an idea	YES
Teacher asks a student to repeat an idea	NO
Teacher enacts a confirmatory exchange with a student	NO
Teacher poses a rhetorical question	YES
Teacher uses a particular intonation of the voice	YES
Developing the Epistemological Line	
Teacher introduces a specific epistemological feature	YES
Teacher refers to the validation of scientific knowledge	YES
Teacher makes a distinction between different kinds of knowledge	YES
Promoting Shared Meaning	
Teacher presents ideas to the whole class	YES
Teacher shares the experiences of individual students with the whole class	YES
Teacher shares group finding with the whole class	N/A
Teacher repeats a student idea/ response the whole class	YES
Teacher jointly review an idea with a student in front of the whole class	YES
Teacher uses the “collective we” form in making a statement to the class	NO

Checking Student Understanding	
Teacher asks for clarification of student ideas	NO
Teacher checks student understanding of particular ideas	NO
Teacher checks consensus in the class about certain ideas	NO
Maintaining the Narrative	
Teacher declares intentions / states aims	YES
Teacher refocuses discussion / maintain focus	YES
Teacher rehearses/anticipates possible outcomes	YES
Teacher reviews the progress of the narrative	YES

RQ3)
What linguistic competence, linguistic strategies and pedagogical strategies do mathematics and science teachers need to enable students to participate in the co-construction of content knowledge? (pedagogical strategies)

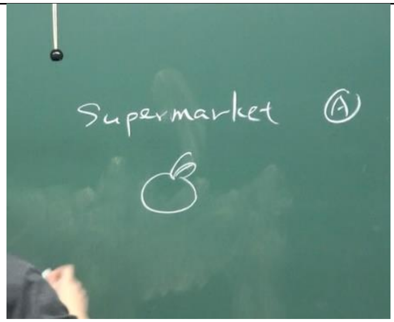
<u>Example 1:</u>

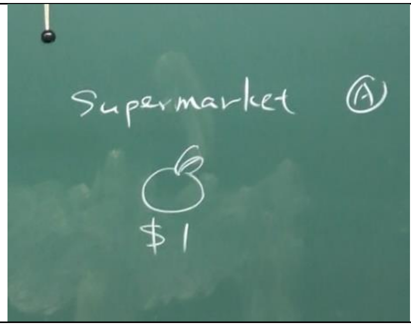
Issue: Allowing sufficient time for students to respond to questions and think about issues

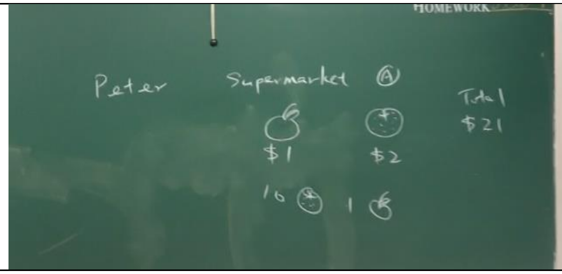
Pedagogical strategy:
- Providing reasonable wait-time
- Being open to and welcoming students' self-initiated answers

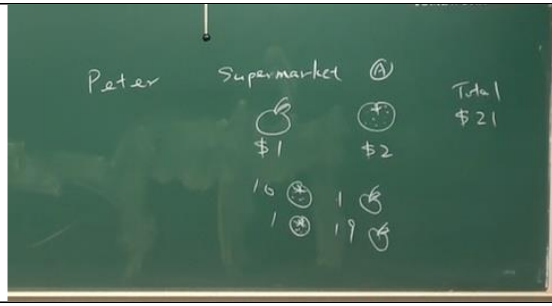
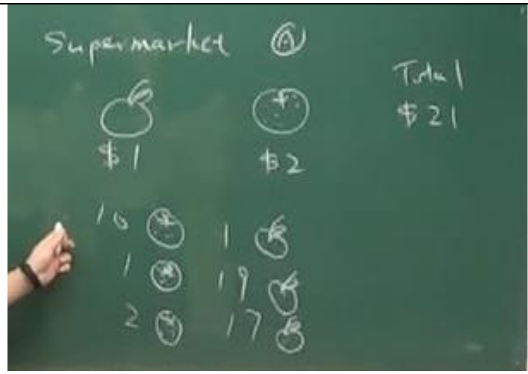
The following episode is taken from a lesson of a Mathematics teacher on "Linear Equations in Two Unknowns" (Method of Substitution). It shows that the teacher leaves time for students to think more deeply about the issues. He is also very welcoming to students' initiated responses.

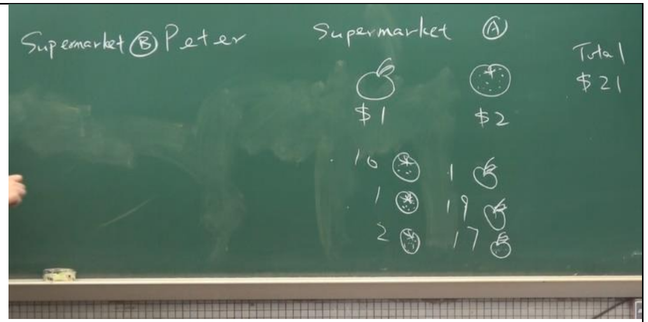
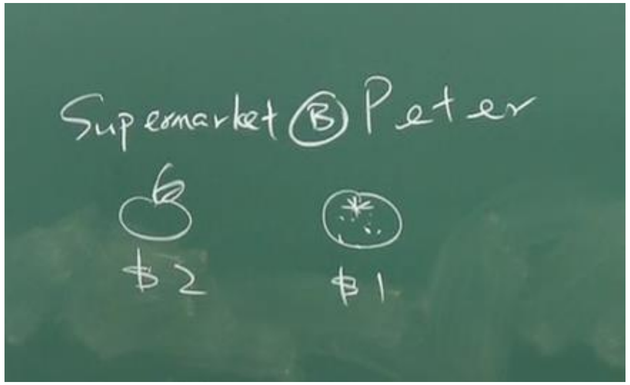
<u>Lesson Extract:</u>

Line	P	Discourse (Verbal + Non-verbal)	Visual aids
1	T	[T writes "Ch. 7" on the board.] (06:36) Let us consider a situation. Peter…[T writes "Peter" on the board.] Peter … ah…went to a supermarket. [T writes "supermarket (A)" which he has a typo for the word supermarket and corrects it.] Supermarket A. And he want to buy some … eh… fruit. And he found that… [At this point, T draws an apple.]	
2	S1	Apple! (07:11)	

3	T	… for an apple, it is one dollar each.	
4	S	Wow! [A student shouts and he sounds excited.]	
5	S1	Wow, so cheap! Like tomatoes! (07:24) T also draws an orange.	
6	T	What is that? [T invites answers from the class, referring to the orange that he has drawn.] **(07:29)**	
7	Ss	Orange. [The class give an enthusiastic response.]	
8	T	For an orange, it is two dollar each. And he buy the fruit for … twenty-one dollars. [T writes “Total $21”.] So, how many apples and orange did he buy?	
9	S1	[S1 raises his hand and wants to answer T’s question]	
10	T	(08:02) Yea? [T nominates S1.]	
11	S1	Ten oranges, one apple. [with hand gesture]	
12	T	Ten orange, one apple. [T repeats after S1, and draws 10 oranges and 1 apple on the board.]	

		Is it? [T invites responses from the class.]	
13	Ss	No. No.	
14	S1	Maybe yes, maybe no.	
15	T	No? [T extends his right hand and invites response from one student, seemingly S2.] (08:20)	
16	S2	Nineteen apple and one…	
17	T	Eh… Twenty-…?	
18	S2	Nine…	
19	T	Nineteen apple… [T draws 19 apples on the board.] … and…?	
20	S2	One orange.	
21	T	… one orange. [He also draws one orange. Some Ss laugh] Is it?	

		Anyone else?	
22	S	Five …	
23	S3	Seventeen apple and two oranges. [S3 mutters from her seat.]	
24	T	Eh… who's talking? (08:50) [T trying to identify the speaker]	
25	S3	[S3 raises her hand; other students laugh while a student points to S3.]	
26	T	Yah. [T nominates S3.]	
27	S3	Seventeen apples and …	
28	T	Seventeen apples … and …	
29	S3	One orange. No, two orange…	
30	T	… and two orange. (09:02) And you can see that for different pattern, we can also … The total is also eh… twenty-one, right? [T points to "Total $21" on the board.] So we don't know how many apples or orange he bought. Okay? (09:22) But it is also the possible answer. [T refers to the combination of numbers of apples and oranges on the board.] Okay? They are all the possible answers. (09:30) But if I give you one more scen… [T probably wants to say the word "scenario".] eh… condition, [T writes "Supermarket B" on the board.] He then go to Supermarket B. (09:49) And he found that the apples now are two dollar each [T draws an apple and writes "$2" under it.]	

			 
31	S1	Three….	
32	T	… and the orange is one dollar each [T draws an orange and puts “$1” under it.]. Okay? Now he buy it again, and it costs him eighteen dollars. **(10:19)** [T extends his right hand and invites S1 who raises his hand to speak up.]	
33	S1	He must bought orange.	
34	T	Eh… He bought the same amount of … eh… apples and oranges. So, how many he buy? **(10:40)**	

35	S1	Ah… ! [Feeling surprised]	
36	Ss	Same… same	
37	T	Yes, … same amount. Same number of apples, and same number of oranges. (10:49) [T waits for about 5 seconds, and looks at his watch.] So how many he buy? Let's try to find it out in your classwork. Try to find it out in your classwork. (11:09) And after two minutes, we will discuss it. [T counts the time with his watch.]	

RQ3)
What linguistic competence, linguistic strategies and pedagogical strategies do mathematics and science teachers need to enable students to participate in the co-construction of content knowledge? (pedagogical strategies)

Example 2:

Issue: Revising key words and concepts before starting a new unit

Pedagogical strategies:

- Repeated practice with different examples and exercises;
- Reading/observing a demonstration and students actually solving the equation (observing and doing);
- Bringing an awareness of the definition; and,
- Bringing an awareness of meaning of the text and the iconic (graphical) representation of the mathematical objects.

Lesson Background:

The related concept is the "solution" for a (linear) equation with two unknowns (x,y). Any ordered pair of (x,y) with values satisfying the equation is called a solution to the equation. The solution can be found by algebraic calculation without using any graphs. This is usually called the algebraic method.

Alternatively, an equation can have a graphical representation in the rectangular coordinate plane. By plotting all the ordered pairs satisfying the equation, we obtain the graph (or line) representing the equation. So, the ordered pair of a point lying on the graph represents a solution for the equation. In other words, we can read directly the solution for the equation without any calculation. This is called the graphical method.

The two methods can be taught and used independently. Very often students may learn the two methods without realizing the link between the two. Hence, being able to see the link between the two representations (algebraic, graphical), i.e. the solution satisfying an equation (by substitution usually) and the solution as a point lying on the graph, is a kind of understanding that the teacher wants the student to achieve.

<u>Teacher interview:</u>

In the teacher interview, the teacher perceived students' difficulties in learning Mathematics in English. The teacher said that students may have difficulties to understand the Mathematics meaning such as "roots", "solution", etc. And he will encourage revision on the meaning of Mathematics terms before opening a new chapter. As an example, in students' notes it shows some Mathematics keywords such as "solution", "satisfies" in algebraic perspective and "passes through" and "lies on" in geometric perspective. The teacher shows students that different words can construct the same meaning in a statement. The above mathematics words are used in the questions in Pages 34-36 for drilling. Students were supposed to understand the statements have the same meaning when they finished practices.

(This interview was conducted in Cantonese)

I	Do you think your students have any difficulties in learning Mathematics in English?
T	They may have some difficulties on handling Mathematics terms, for examples, some students may not understand what solution is, they may not catch up with roots, this kind of words, substitute, this kind of words. So, before moving on we may have revision to talk about the Mathematics meaning of the words and what they need to do. It is better for the students if we can have a revision before opening a new chapter.

How the teacher designed the notes in helping students to overcome the difficulties.

Extracted from teachers' notes:

Important Concepts

The following statements are in the same meaning.

Algebraic Perspective	Geometric Perspective
$x = 1$ and $y = 2$ is a solution of the equation $x + y = 3$.	The graph $x + y = 3$ passes through a point (1 , 2).
$x = 1$ and $y = 2$ satisfies the equation $x + y = 3$.	(1 , 2) lies on a graph $x + y = 3$.
The fact behind	
L.H.S. = 1 + 2 = 3 = R.H.S.	

3. If $(a, -1)$ satisfies the equation $2x - y = 5$, find the value of a.

Solution

Answer $a = 2$

4. If $(k, 3)$ is a solution the equation $2x + 3y - 1 = 0$, find the value of k.

Solution

Answer $k = -4$

5. If the point $P(-2, r)$ lies on the graph of $y = 6x - 3$, find the value of r.

Solution

6. If both $(1, m)$ and $(n, -1)$ are the solution of the equation $y = 2x - 1$, find the values of m and n.

Solution

Answer $m = 1, n = 0$

7. If both $(a, 0)$ and $\left(\frac{1}{2}, b\right)$ satisfy the equation $y = 2x + 1$, find the values of a and b.

Solution

Answer $a = -0.5$ $b = 2$

8. If the graph of $y = 3x - 4$ passes through $P(2, a)$ and a point Q on the y-axis, find the value of a and the coordinates of Q.

Solution

Answer $a = 2$ $Q\ (0, -4)$

9. Write down any three solutions of the equation $y = x + 3$.

Solution

10. Write down any three points lying on the graph $y = x + 3$.

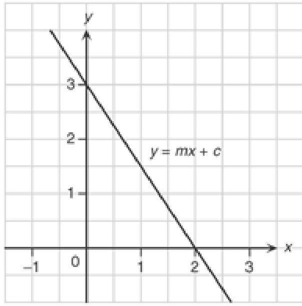
Solution

11. If the straight line $L: ax + 2y + c = 0$, where a and c are constants, passes through (3, 3), suggest a pair of possible values for a and c.

Solution

12. The figure below shows the graph of $y = mx + c$, find the values of m and c.

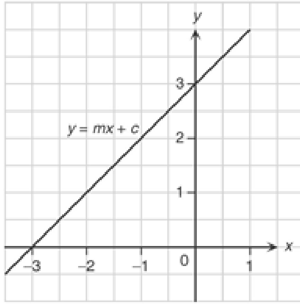
Solution



Answer $m = -1.5$ $c = 3$

13. The figure below shows the graph of $y = mx + c$, find the values of m and c.

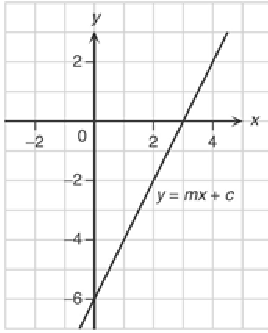
Solution



Answer $m = 1, c = 3$

14. The figure below shows the graph of $y = mx + c$, find the values of m and c.

Solution



Answer $m = 2$ $c = -6$

15. If points $P(0, 6)$ and $Q(-3, 0)$ lie on the graph of $ax + y + c = 0$, find the values of a and c.

Solution

Answer $a = -2$ $c = -6$

RQ3)
What linguistic competence, linguistic strategies and pedagogical strategies do mathematics and science teachers need to enable students to participate in the co-construction of content knowledge? (Pedagogical strategies)

Example 3:

Issue: Being receptive to questions from learners: Allowing extended student talk during student-initiated questions

Lesson Transcript:

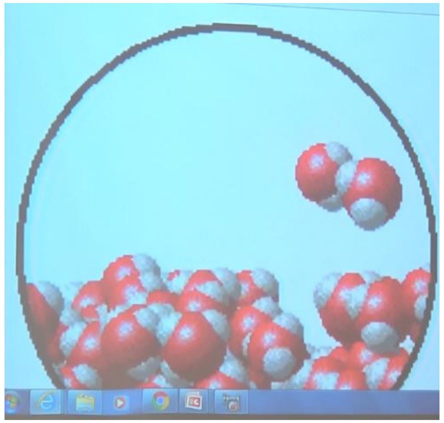
Several pedagogical strategies adopted by the teacher (T) in this extract include:

1. Allowing extended student talk during student-initiated questions.
2. Scaffolding through clarification requests and confirmation checks.
3. Counter-question turns using referential questions.

Lesson Background:

This episode starts with a student-initiated question which reveals a gap in the student's understanding regarding boiling and evaporation, in that vaporization (liquid changing to gas) will happen both at a particular temperature (at boiling point) as well as at lower temperatures (evaporation) . Water does not have to be heated at 100 °C degree, which is its boiling point, before it turns into water vapour.

Prior to this episode, the teacher was using a diagram (Figure 1) to explain how water particles escape from the attraction between particles and from the surface when they get enough energy. She explained that water will become steam when it boils, and that the water particles will move freely. She also added that the amount of water in this world will still stay the same: some water will evaporate, but at the same time some water will also condense.


(Figure 1)

In this episode, a student (S1) initiates a question by asking the teacher “But why is there water vapour in the air?” (Line 4). The teacher responds to S1 by repeating S1’s exact question and answers directly by saying, “Because in the atmosphere there is some water vapour” (Line 5). At this point, we can see that S1 fails to elicit a satisfactory answer from the teacher, as he further re-iterates (Re-I) and elaborates his question in Line 6: “Then, then if, then the temperature is not, does not make the water boil.” This reveals that there is a knowledge gap regarding the temperature of water, the boiling and evaporation of water, as well as the existence of water vapour in the air, as explained in first paragraph above.

In Lines 6 to 12, S1 has the opportunity to reiterate (Re-I) his question as many as 3 times in Lines 6, 8 and 10 through the teacher’s strategy of scaffolding in Lines 7, 9 and 11. The teacher’s scaffolding is mainly for confirmation checks, e.g. “When the... temperature is...?” in line 7, and for clarification requests, e.g. “You mean, you mean, why evaporation happens?” in Line 11. The teacher’s scaffolding through clarification request and confirmation check encourages the student to reiterate and elaborate his thinking *linguistically* with structurally more complex articulations, as well as *conceptually* with more explicit verbal reasoning regarding his idea of the causal relationship between temperature and evaporation, as shown in Lines 6, 8 and 10. Such negotiation of meaning can enhance message comprehension and also serves as input on L2 learning (Pica, Lincoln-Porter, Paninos & Linnell, 1996).

From Line 13 onwards, we note the teacher’s change of strategy by posing a counter-question turn with referential turns (Markee, 1995, p. 72).

After the negotiation of meaning in Lines 4 to 12 between T and S1, the teacher then uses a counter question in Line 13: "why you think so, that will not happen?" This puts the teacher back in sequential control of the conversation, compared to the exchanges before that which were driven by S1's question. However, the teacher uses referential questions, instead of display questions, during the counter-questioning sequence. The teacher's referential questions, as seen in Lines 13, 15 and 17, yield significantly longer and more syntactically complex student responses and contained greater numbers of connectives (Brock, 1986). This can be shown in S1's responses to the teacher's' counter-referential questions, e.g. Line 14 "Because, because I think that eh, water particle will stay (pause) stay as eh… stay as—" and Line 16 "Yes because eh, it is, not the boiling point". Such extended talk also opens up the floor for other students' questions and opportunities for learning, as shown from Line 24 onwards.

References

1. Brock, C. A. (1986). The effects of referential questions on ESL classroom discourse. *TESOL quarterly*, *20*(1), 47-59.
2. Markee, N. P. (1995). Teachers' Answers to Students' Questions: Problematizing the Issue of Making Meaning. *Issues in applied linguistics*, *6*(2), 63-92.
3. Pica, T., Lincoln-Porter, F., Paninos, D., & Linnell, J. (1996). Language learners' interaction: How does it address the input, output, and feedback needs of L2 learners? *TESOL Quarterly, 30*(1), 59-84.

Line	M	P	Discourse
14	I(T)	T	Okay so shh, ah any question?
15	R	S1	(*raises* hand) Yes.
16	F	T	Yes.
17	I(S)	S1	But why there is water vapour in the air?
18	R	T	(pauses) Why there is water vapour in the air. Because in the atmosphere there is some water vapour.
19	Re-I (S)	S1	Then, then if, then the temperature is not, does not make the water boil.
20	R	T	When the... temperature is...? (*to whole class*) Shh.
21	Re-I (S)	S1	Let's say in the air, there is water vapour.
22	R	T	Yes.
23	Re-I (S)	S1	Then how come it change to water vapour when it is, 20 something or 30 something, degree Celsius?
24	R	T	You mean, you mean, why does evaporation happen?

25	F	S1	Yea.
26	I (T)	T	Okay. Eh, do you think that, eh why you think so, that will not happen?
27	R	S1	Because, because I think that eh, water particle will stay (*pause*) stay as eh… stay as--
28	Re-I (T)	T	Stay? As? Water? What will it stay as?
29	R	S1	Yes because eh, it is, not the boiling point.
30	Re-I (T)	T	Okay so, you mean, do you mean that for the boiling it can get enough energy?
31	R	S1	(*silent*)
32	Re-I (T)	T	And so that --
33	R	S1	(*nods head*) the temperature
34	Re-I (T)	T	--it can escape? But eh, when at 25 degree Celsius it may not get enough energy, that is what you think, is that right?
35	R	S1	Yea.
36	F	T	Okay, so.
37	F	S2	Maybe because why, why evaporation happens.
38	F	T	(*do other matters*) Okay, a good question.
39		S3	(*raises hand for permission to go toilet*)
40	I (T)	T	Yes. **(1:09:07)** Okay now shh, ah S1 asked a good question that, why evaporation happen. We all know that okay, shh during boiling, okay we heat up the water of course, it can get certain amount of energy, so it escape. But, shh, for the evaporation, okay you think that it's not enough energy, but maybe that is just what you think--
41	I(S)	S2	(*holding up his water bottle*) And so you mean –
42	I(T)	T	And when we talk about evaporation, there's another factor, it's about the humidity. (*points to upper part of animation, pause*)
43	R	S4	Ohh
44	I(T)	T	So, when, the water, say, 100% humidity okay, that means here (*points to upper part of animation*) the air cannot hold more water vapour, then, in that case, it will not, okay evaporate.
45	I(S)	S2	(*holding up his water bottle*) Eh so you mean –
46	I(S)	S4	**(1:09:55)** (*raises hand*) 咁人會唔會 melt㗎?

47	R	Some Ss	(*chuckles*)
48		T	(*pause*)
49	Re-I(S)	S4	人會唔會 melt㗎? (*Translation: Will people melt?*)
50	R	T	Later. 會, okay so every substance got melting point—
51		Ss	(*chuckles*)
52	Re-I(S)	S3	(*holding up his water bottle*) Eh so uh, so --
53	I(T)	T	Now, so, shhh. In this case, now for the evaporation, if, that is dry (*points to upper part*), that means the air, can hold, certain amount of water vapour,
54	I(S)	S4	(*holding up his water bottle*) Uh so-
55	Re-I (T)	T	And actually, the water, the water particles will still have enough energy, okay. To, escape, we say, 'to evaporate'.
56	Re-I(S)	S4	(*holding up his water bottle*) So normally we still got some energy but not enough energy to make it boil?
57	R	T	Ya you can view it like this. So, shh, for all the water molecules they have, certain kinetic energy. Because they can move, okay you know that they can move, they must have kinetic energy.
58	I(S)	S4	**(1:10:42)** Where is the kinetic energy comes from?
59	R	T	Where is the kinetic energy comes from? Because… here, (*points to lower part of* animation) okay, inside – uh not inside, uh Lucas just mentioned there is actually ah smaller particles, the smaller components that make up that particles, and there will be some force, exist, between those smaller components, okay. And that is how, the vibration of particles, come from. Okay anymore questions?
60		Ss	(*no questions, then talking to each other*) (*gap time while T is loading materials on screen)* **(1:12:00)**

RQ4)

How do L2 content teachers support students' content learning through L2/L1? (teachers' role and pedagogy)

Example 1:

Issue: The use of Cantonese (L1) in Science Lessons

In this lesson observation we see a teacher who teaches English words by chunking syllables, and through the use of common suffixes. The teacher also facilitates the acquisition of scientific terminology in English and scaffolds knowledge through a judicious mix of L1 to explain key concepts and terms.

Teachers' role and pedagogy:

The teacher uses English as the MOI throughout the lessons but usually translates the key concepts and science terms in Cantonese after giving the explanation in English.

In the first episode, the teacher explains why there would be a smell of ammonia in the toilet and some places where dead bodies are found. He firstly explains it in English and then translates the explanation in Cantonese (L1) which helps to give conceptual support to students in their mother tongue.

In the second episode, the teacher is teaching two new chemical terms which are Sulphur dioxide and nitrogen oxide. He translates them in Cantonese and tells students how to write the Chinese words of these two terms.

Lesson Background:

Some students think that the smell of ammonia is like "toilet". The teacher asks why ammonia can be found in a toilet but not in the kitchen. A student answers that a human's urine has ammonia and the teacher corrects that our urine does not contain ammonia but it contains urea and bacteria changes it into ammonia. He firstly explains it in English and then explains again in Cantonese.

Line	Ex	M	P	Discourse (V + NV)
1	1	I	T	In Mainland China, why ammonia can be found in the toilet? Not in the kitchen?
2		R	S1	It's because…
3		F	T	It's because…
4		R	S1	Our urine…
5		F	T	Your urine?
6		R	S1	Also has ammonia.
7		F I	T	Also has ammonia?

				Ah, first of all, do you know what is urine? Urine, urine, urine.
8		R	S	Vee vee.
9		F	T	Vee vee, yes. Your vee vee. But do not use vee vee in the paper. Okay? You are not in the kindergarten. Urine, urine, that means your vee vee. In our vee vee, there is no ammonia. Okay? There is no ammonia. However, in our urine there is a compound called urea, that may change to ammonia by the bacteria. <細菌會將尿液入面一個物質叫做尿素，佢將佢轉化成阿摩利亞。Er, 俾 D 細菌轉變既。> Okay. Ammonia can be found in the toilet and in the, ar… in some places that dead bodies are found. <係 D 有屍體的地方呢，會…亦都有 D 阿摩利亞出黎。> Because the dead body will be eaten by the bacteria and release ammonia. Okay? <阿摩利亞會俾 D 細菌呢，Er，即係佢分解 D 屍體的時候呢，佢會放一 D 阿摩利亞出黎，所以。> If you smell, if you smell the ammonia, the special smell of ammonia. That, may be means that there are some dead body or some vee vee, some pieces in some places. Okay? <明唔明? 即係如果你聞到 D 阿摩利亞嘅樣的味道呢，即係就可能有人係果度痾殊殊啦，或者可能有 D 屍體，發現左 D 死貓死狗嘅樣，可能都有 D 阿摩利亞的味啦> Okay?

Lesson Background:

Episode description: The teacher mentions the Cantonese of Sulphur dioxide as "二氧化硫" and nitrogen oxide as "氮氧化物".

Line	Ex	M	P	Discourse (V + NV)
1	1	I	T	Sulphur dioxide in Chinese “二氧化硫", 硫係流水個流唔要三點水轉石字, “二氧化硫". Sulphur dioxide, yes. [T guides the students who is next to him.] And then nitrogen oxide, "氮氧化物".

Teacher Interview:

From the teacher interview, we asked the teacher "why do you always explain the concepts in English and then in Cantonese?". In the teacher's perspective, he was concerned about students' understanding of the subject matter. He preferred to explain the key concepts again in Cantonese. He believed that if he provides Cantonese explanations to the English, it would be easier for students to learn the concepts in English. If he just formally teaches the subject in English, the students may not understand what it means.

Extracted from the teacher's post-lesson interview

(This interview was conducted in Cantonese)

I	05:55 我見到你其實通常都係幾句英文跟住就用中文黎解釋返俾同學，點解你會噤樣做嫁呢? <I observed that you usually speak several sentences in English and then explain again in Cantonese. Why would you do in this way?>
T	06:05 – 07:00 其實我個人的諗法係，我都唔想佢地因為英文而有 D Science subject matter 的野唔明白。所以去到一 D 好 critical 的位，即係例如講彈牙呢 D 的 terms 呢，或者一 D 好 key concepts 呢，其實好多時我都會即係用中文 up 一次俾佢地聽。噤有 D 人可能會覺得，下，你噤樣 up 一次中文，英文咪可以唔聽囉。即係我的諗法係我 up 完果句中文，會對你之後睇返英文呢，可以 parallel 噤去對返 D 字。我覺得會更加去容易學習英文果個 version。我就唔想我 up 完一句好正統的英文，然後唔明。即係好似雙輸的局面。 < In my opinion, I don't want that… they cannot understand the science subject matters because of English. So, when it comes to some **critical points**, for example, when we talked about "al dente", **some English terms like this which is a key concept, I usually speak in Cantonese once again**. But someone may think that, if you speak once again in Cantonese, the students may not listen in English. Personally speaking, the sentence I spoken in Cantonese can help you more easily to learn in English when you read the English sentence again, you can match the English words with Cantonese in parallel**. I don't want that…I speak in English formally and they don't understand. It will become lose-lose situation.>**

Interview with students:

We played the second episode to the students and asked them, how the translation in Cantonese helped in their learning. They told us that they could have a better understanding of the meaning of the English words being introduced or used. It also helped to memorize the words, understand the exam questions or reuse the words in answering questions. We also asked the students whether their Science teacher provided support in helping them to learn Science using English. They believed that when the teacher provided Cantonese explanations to English it could help them understand the concepts better. They showed positive attitudes towards this and they thought that it is difficult to understand the concepts in English without Cantonese explanations.

Interview Extracts (These interviews were conducted in Cantonese)

Interview Question 1:	
I	<Did your teacher provide support in helping you to learn this subject using English?>
S2	<T provided Chinese explanations in ENG to help us understand.>
S3	<Agree with my classmates. Sometimes it's difficult to understand English words without Chinese explanations.>
S4	<(He) teaches in Cantonese sometimes.>

Interview Question 2:	
I	<How does the word translation in Cantonese help?>
S5	易聽得明, 以後理解一 D 理論都易 D 明。 <More easy to listen and understand, will be easier to interpret and understand the theories later.>
S6	我認為如果用中文解釋的話, 係我做果時候會更加快理解到個句子所問的問題。 <I think if it is explained in Cantonese, I can quickly understand the sentence when I do the questions.>
S7	我認為佢有講中文同英文的詞彙呢，噤樣互相去提供之下呢，就可以更加快去入腦，記得住果個詞語，用得更加靈活 D。 <I think that he talks in Cantonese and English in parallel, it can help to memorize the vocabulary and I can use it better.>
S8	我覺得中文的解釋有，可以幫助到理解呢個英文字的意思，亦都可以當係一個增益，多左一個字學到。 <I think if it has an explanation in Cantonese, it can help me to understand the meaning of the English word, I can learn one more word and improve my vocabulary.
I	但係你地做卷的時候係用英文，會唔會令你地記多個中文呢? <But you are using English to answer the paper, would it be a burden to memorize the Chinese word?>

S7	用得更加靈活，可以更加快去理解到。 <Can use it better, can understand it more quickly.>
S8	有時可能更加難的題目，有陣時先 translate，先係個腦海裡面轉左做中文先喇，然之後再諗下有咩字係岩用，然後將個答案轉返做英文，噤係答題上會容易左。 <Sometimes, may translate more advanced questions. First translate it in mind and then think what words are suitable to answer the question, then translate it into English. This makes it easier to answer the questions.>

Interview Question 3:	
I	<Do you think knowing the Cantonese word for chemicals is helpful in your Science learning?>
S9	容易 D 理解 <Easier to interpret.>
S10	抄低個字就可以知道點解 <Jot down the words and we will know its meaning.>
S11	容易 D 明白 <Easier to understand.>
I	<How does the Cantonese meaning help?>
S12	明白左中文意思就會記得 <Understanding the Chinese meaning of the word would make me memorize it.>
S9	噤明白到個意思, 再轉返英文, 就可以明白到個意思 <Understanding the meaning and translating it into English would make me understanding the meaning.>
S10	因為可以記住, 記得就可以理解到條題目 <If it can be memorized, the question is understandable.>
S11	可以將題目譯左做中文 <Can translate the questions into Chinese.>

Example 2:

Issue: Helping students to use more English in class: the use of Cantonese in science lessons to facilitate the acquisition of technical terminology in English

Many teachers told us that while the main MOI in their classrooms is English in the lessons the teachers often repeat explanations and instructions in Cantonese to ensure students understand the main points clearly. We were told that many teachers insist on students asking questions or responding to prompts in English, but most students prefer to speak in Cantonese.

Lesson Background:

The teacher uses English throughout lessons, except for an occasional translation of science-related, technical terms. One example is related to equipment in the laboratory. For example, in the following episode, the teacher would like his students to know the word "syringe" so as to discuss the issue of gas particles in a syringe. He may expect students to answer in English. But his students answer "syringe" in Cantonese. The teacher accepts students' answer in Cantonese, and then further probes students to think about the word in English. S7 gives an unexpected answer (i.e. "injection"). The teacher then specifies the question by stressing what he would like to ask is "針筒" in English. The teacher's use of Cantonese here not only acknowledges students' prior knowledge in their mother tongue, but is also likely to inspire students to speak out what they know in English. In doing so, the teacher uses Cantonese to facilitate students to master technical terms in English.

Episode:

Line	M	P	Discourse (V+NV)	Notes
1	I(T)	T	(13:16) [T Raises a syringe] So what is it?	
2	R	Ss	[silence]	
3	Re-I(T)	T	What is it? What is it?	
4	R	Ss	[silence]	
5	Re-I(T)	T	What do we call it?	T may expect students' answer in English.
6	R	S5	針筒.	
7	F	T	針筒, okay?	T accepts students' answer in Cantonese
8	Re-I(T)	T	So what is it in English?	T further probes students to think about the word in English.

9	R	S7	Injection. Injection. Injection.	
10	F	T	針筒.	T specifies the question by stressing what he would like to ask is “針筒” in English. T’s use of Cantonese here not only acknowledges students’ prior knowledge in their mother tongue, but is also likely to inspire students to speak out what they know in English, though not necessarily the right answer (i.e. “plunger”), hence facilitating students to master scientific terms in English.
11	R	S7	Injection. Injection.	
12	R	Ss	Plunger.	
13	Re-I(T)	T	This is called, what?	
14	R	Ss	Plunger.	
15	F	T	Plunger, this one. The one at the back that you can move. [T pulls and pushes the plunger] That is plunger.	
16	Re-I(T)	T	So what is the whole thing?	
17	R	S7	Injection.	
18	F	T	[T does not respond directly to S7’s answer] Syringe. Syringe, okay? Okay, syringe, and then by moving the plunger, we can adjust the volume in the syringe.	T gives the right answer at the end.

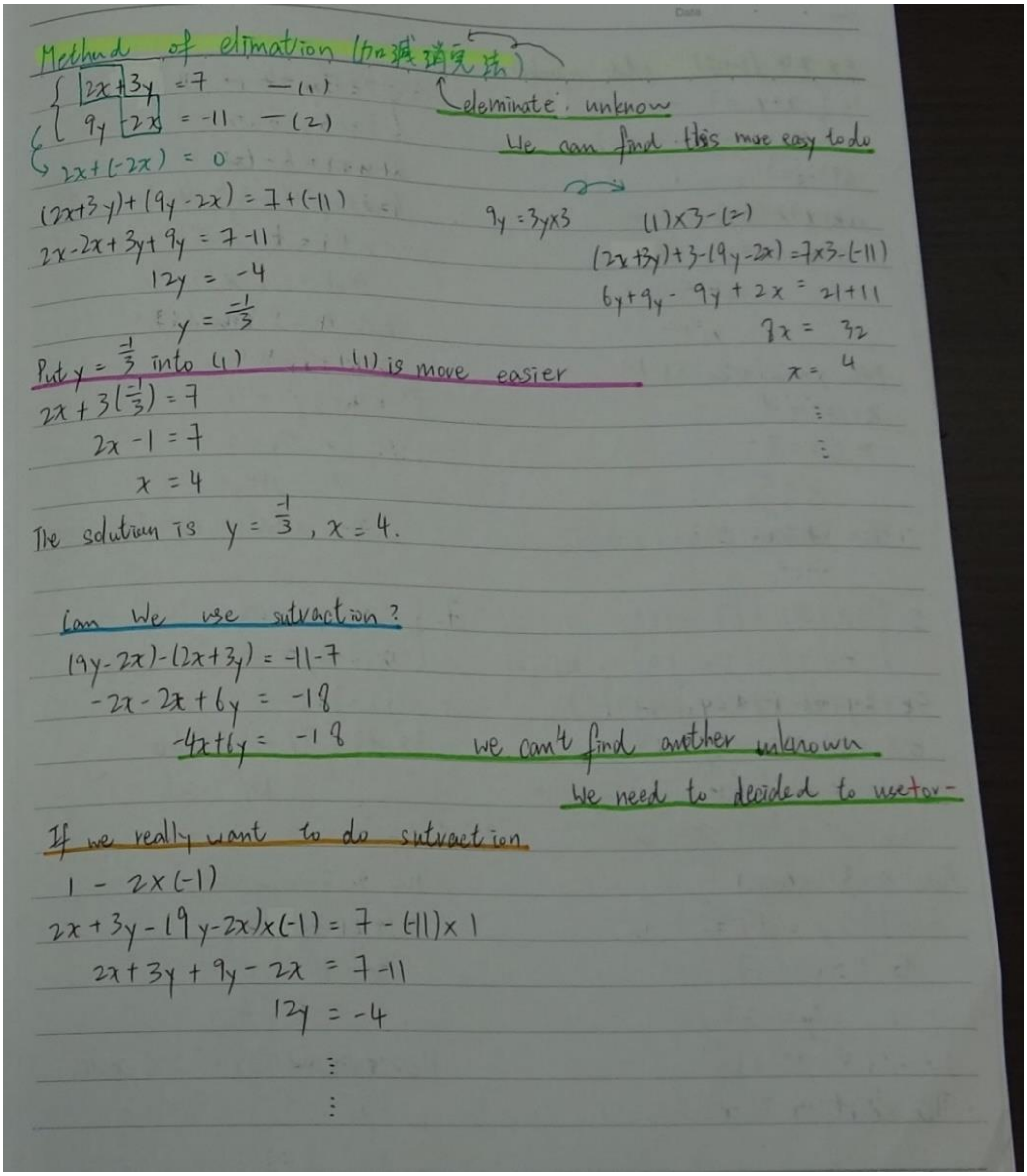
RQ5)

How do students experience the learning of mathematics and science in the construction of mathematical and scientific knowledge in L2 in the classroom? (And how do they experience the construction of such knowledge *outside* the classroom?) (student voice)

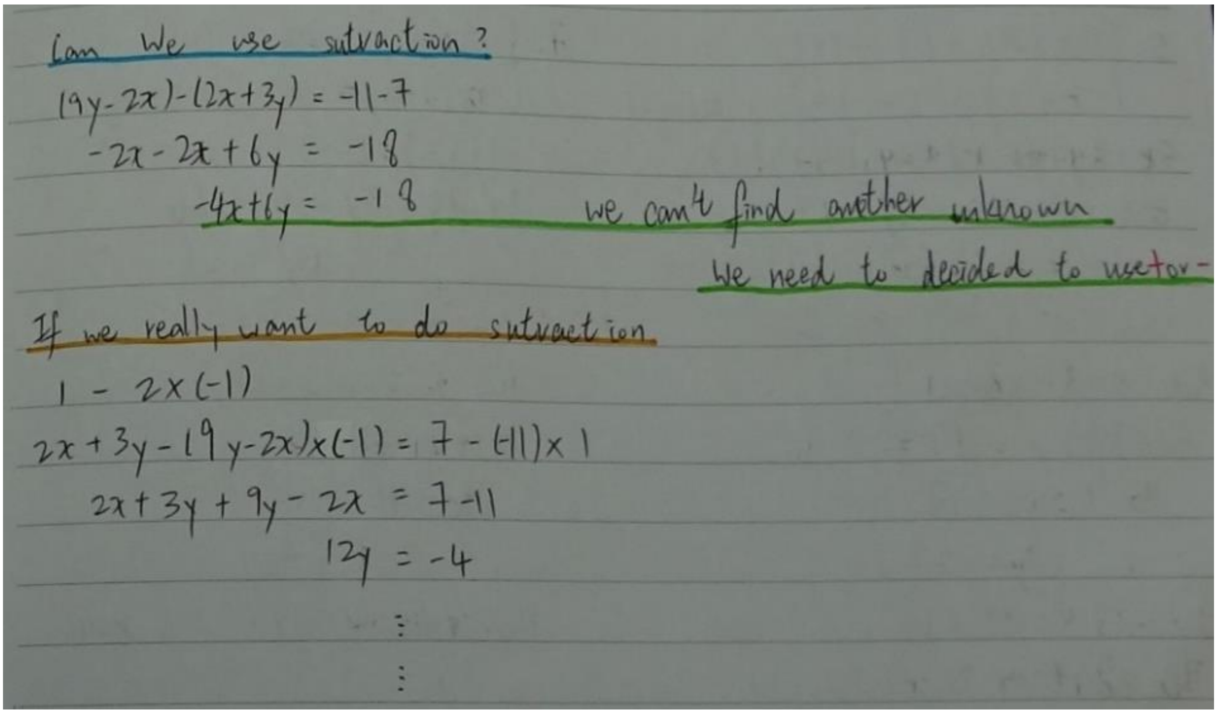
<u>Example 1:</u>

Issue: Organizing learning with note-taking in a F.2 Mathematics class

The Mathematics classwork page of a student (S1) (below) illustrates how she organizes her learning with instantaneous note-taking in class (also see below an excerpt of a post-unit interview with S1). The Mathematics teacher was also interviewed concerning students' note-taking practice.



[A page from a F.2 student's classwork book]



[Enlarged]

<The interview was conducted in Cantonese>

I	Okay, now I'd like to ask some of you specific question. Shall I start with S1? {to S1} We have looked at your classwork too. It's very tidy and organized.
S2	It's very organized…
I	… So I'd like to ask you… that's your classwork book…
S2	It's organized and very nice. Mine is similar too.
I	{to S1 and S2} Shall we look at it together, okay? (14:44) {to S1}You have used different colours. I'd like to ask you a bit more.
S1	Okay.
I	When did you write these notes and how did you do this? (14:59) [I refers to the page above in S1's classwork book]
S1	Our teacher wrote a sample question on the blackboard. He taught us and gave us more explanation at the same time. It's at those moments that I wrote these notes on my classwork book.
I	During the lessons, your teacher has taught a lot of things. How can you…? For example, you wrote "(1) is more easier". And you would jot down what your teacher has said. How did you organize all these? "Can we use subtraction?"
S1	How to organize? [asking for clarification]
I	Right. For example, did you write these while you listened to your teacher?
S1	Yes.

An interview with the Mathematics teacher also reveals how he thought about this student practice.

<The interview was conducted in Cantonese>

T	I encourage them to jot notes themselves, in their own wordings. And maybe to make the notebooks more colourful. They would find it more interesting when they do the revision. They might find it boring if it's just in black and white.
I	Yea, we observed that students use highlighters.
T	Yes, I encourage them to do so.

Example 2:

Issue: Consolidating what is learnt in EMI Mathematics lessons in other subjects/daily life experiences

The interview excerpt below illustrates recalls of what students have learnt in the unit “Rate and Ratio” in the medium of English. Students cited examples of daily experience where they see the application of rate and ratio.

<The interview was conducted in Cantonese>

I	Do you all still remember the difference between Rate and Ratio?
S26	I recall it.
S3	For “Ratio”, it’s having the same units. For “Rate”, we have to … if the units are not the same, we have to do a conversion of unit.
S15	XXX different rate. [Indiscernible]
S3	Right!
I	{to S5} Changed to? Excuse me, could you say it again for me please?
S15	They are used in different situations.
I	I see. Do you mean daily….? When would you use “rate”, when would you use “ratio”? (10:13)
S15	When we take minibuses, we can see a sign that shows the speed of the vehicle.
S8	Oh I see. That display panel.
S5	Yes!
S8	That shows the number of miles per hour.
S26	It would overspeed if it’s over eighty miles.
I	Alright. Daily life examples of such. How about “ratio”?
S8	‘Ratio’ …潔 潔 潔 潔咩嘢呀? [S18 tries to say something about cleaning]
S26	潔 … Ratio 呀?
S2	漂白水呀 <*Bleach*>
S8	Oh, 漂白水<*Bleach*> [giggle]
S2	Also, the dimension of the screen of mobile phones.
I	Alright.
S3	Also, that one in Geography. Coordinates… does that count too? <S3 asks 座標算唔算?>
S26	Those on maps. (10:48)

Example 3:

Issue: Difficulties facing students studying Science through English

Here is a summary of obstacles junior secondary students claim they have while learning Science using L2:

Difficulties involved in the participation of spoken discourse using English during lesson

Student:

"English is not my mother tongue… Sometimes I ***can't follow quickly enough and don't get what the teacher is saying***."(S1)

Student:

"During group discussions, … You might unconsciously speak some English, just one or two sentences, then you'll shift back to Cantonese. ***Cantonese is my mother tongue so I can speak more fluently in it and express what I really want to say.***" (S2)

" ***don't have the vocabulary that I need, grammar is not the main hindrance***." (S3)

Difficulties involved in the handling of subject-related written materials in English

Student:

"If I want to revise (the handout) thoroughly, I ***need to look up all the words in the dictionary***. However, I ***don't have enough time*** so I just remember the simple ones and skip the difficult ones." (S4)

"I know the chapter content well but ***didn't know what the exam questions are asking***." (S5)

Change of MOI (from Cantonese to English) from primary to secondary school

Student:

"It is more difficult and hard to get used to learning in English if only one subject is taught in English. However, if other subjects are also taught in English, we won't find it difficult because we are used to using English and learning the subjects in English." (S6)

Change of MOI (from Cantonese to English) from a CMI mainstream F.1 class to an EMI elite F.2 class:

Student:
"When I took the first test (in English in F.2), I felt very unfamiliar as it was hard to understand those questions and I didn't know how I should answer them. I feel that I should know as I get more

used to it.” (S7)

“I don’t understand what those words are about.” (S8)

Science teacher’s code-switching during lesson time:

Student:

‘Our teacher helps us learn English, because sometimes when we don’t understand some English sentences or vocabulary, she uses Cantonese to explain to help us understand better.’ (S9)

Lack of vocabulary in English when taking part in Science classroom talk in English

Group interview:

I	(15:00) Do you like taking part in classroom talk in English during Science lessons? Classroom talk includes asking teacher questions, answering teacher, doing presentation and group discussion during a lesson. Do you like it? If you dislike it or find it difficult, can you tell us more?
S1	I will answer first. I feel it’s ok for classroom talk. But sometimes during the group discussion, the pace is fast or during an experiment, (the language) switches back to Chinese. Unaware (of switching) to Chinese for one or two sentences. After all, Chinese is the mother tongue. Speaking in Chinese is more fluently. It can convey an idea completely. But, sometimes in using English, it does not have the same effect. If you don’t know the word, you can’t convey the idea that you want to express.
I	You don’t know the word or the grammar?
S1	Not because of grammar. Instead, it’s a matter of not knowing the word. Grammar is not an important factor. Maybe in writing letter or paper, grammar is more important. But in the daily conversation, there are spoken grammar mistakes that is not that important.
I	Good. Ok. Because don’t know the word hinders you from expressing your idea. Right?
S1	Yes.
I	S5, can you share with us?
S5	I also feel that using Chinese is better. Because when you answer or ask teacher questions, it is due to something new that you don’t understand. Or when teacher asks you something new, you answer the teacher. But, for the new keywords, you don’t know how to ask teacher. Therefore, we don’t know how to express in English. But, in Chinese, we can convey our ideas.
I	Ok. I will ask S6 and S5 first. If there are words that you don’t know, in an English conversation, do you have any strategy to solve this problem?
S6	I think that when you don’t know the English (word)… want to express an idea at that moment, (I) can ask people. Use similar words to ask people. If not, ask in Chinese and see if they can help you. In the daily life, you want to understand more keywords… Sometimes I go to library and borrow science books. They are related to the specific topic and borrow them. Though reading these books because they are written in English, you can learn the new English keywords. By searching online, you

	will find out the meaning. In the Science lessons, even though teacher has not taught this chapter yet, these words can be useful and it's pretty good.
I2	Who will you ask if you have questions?
S6	In a group discussion, I will ask students first. Because it is more convenient. After all, the teacher is busy resolving other group's problems. It is inconvenient to suddenly bust out and ask the teacher questions on the words. Ask students first. If (I) still don't understand, I will wait until teacher is less occupied to her.
I2	Will you ask parents or other people outside of school?
S6	Not to my parents. Because they don't know English. For asking people outside of school, I can ask my relatives, not my parents.
I	{to S6} Very good. You can talk to other students. Good. But I realized that … let's hear from S5 first. {to S5}What kind of strategy can you solve the problem or to improve your English?
S5	To improve, (I will) preview the next chapter by look up the new words. In the lesson, (I will) understand the words. But sometimes, even other students don't know the words in group discussion. Therefore, there will be problems in communication. Then, I will have to use similar words or use Chinese.
I	Ok. Good. Let's hear S2's ideas. Do you like taking part in classroom talk in English? Do you find it difficult? Why?
S2	I like to use English to learn Science. But sometimes, I find it difficult. Some words are not understood by everybody. In experiment, it will slow down the pace or obstacle the flow. Other people have finished already. But my teammates cannot understand what's going on. Therefore, I will switch to Chinese. It is better.
I	Good. I will ask S7 first.
S7	I also like to use English to learn Science. But, when it comes to conveying ideas, it is difficult. In the group discussion, not in Chinese, Science keywords in English are more difficult. There is miscommunication that doesn't convey the intended idea.
I	S8
S8	In my opinion, I like to use English to learn Science. But during group discussion, my teammates may wonder what do I mean when I use English. The process of finalizing the product will be longer. They may blame me.
I	You?
S8	They blame me for using English. Chinese is a faster way.
I	I realized that you have use English to communicate with your teammates. Is there any difficulty for you?
S8	It is not a big problem. If the words are not too difficult… The words are difficult if they are not taught yet. Then, I don't know them. In terms of grammar, I will construct a sentence inside my brain first. It is still ok.
I	Ok. Good. As S2 mentioned before, there are new words or cannot express their meanings. What are the strategies that improve these situations?
S2	After I have spoken in English, they may not understand. I can explain to them what the meaning of the word is. They can understand what you are saying and also they learn a new word. It accomplishes two goals.
I	In the conversation between you and classmate, your listener doesn't understand what you are saying. You may explain more. What do you explain? Do you say it in

	English or Chinese?
S2	First, I will use English. If they still don't understand it, then I will explain in Chinese.
I	Do you frequently help your classmates during lessons? Not helping, but in a conversation with your classmates, have you applied the explanation strategy frequently?
S2	Sometimes. But not often.
I	Good. I will ask S7 first.
S7	I agree with S3's strategy. Explain to them… First, ask them… explanation… Speak in terms of simply English. Apply the easily understood English to ask them. If they don't understand, then Chinese or similar English words. Look for words in the textbook's content, photos. It is easier to understand.
I	You are talking about the conversation between students in group discussion. Issues in communication.

Example 4:

Issue: The use of extra-curricular activities (ECAs) to support students in Science and Mathematics

- "Math Talk"

Math Talk in one school is a regularly held, extracurricular program open to students who are interested in Mathematics. The talk focuses on exploring the connection between Mathematical principles and everyday life. It is usually conducted in English but if the content is deemed too difficult for students, Chinese will also be used. Most of the attendants are from senior forms, but the Form 1 students who participated in this study also attended the Math Talk. In the observed talk on "Symbolic Logic", the Form 1 students demonstrated considerable interest.

- **Mini Science Project**

Another school conducts a Mini Science Project to arouse students' interest in exploring and solving scientific problems. The observed mini project was conducted by two teachers through consecutive lessons (6 and 8 lessons respectively, around 45 minutes for each) among two classes of Form 1 students (n=31; 32). Students were guided to design and build a frame structure with drinking straws and adhesive tapes. In each class, students were divided into 8 groups (3-4 persons in each group) and the group who built the frame structure which can hold the largest amount of weight per gram of its own weight won the competition.

Appendix XV

Record of completion of the student questionnaire by school and by class

School Code	EMI/CMI schools	Classes of teacher	No. of Ss in class	No. of Ss agreeing to do the questionnaire	No. of valid questionnaires returned	Language version of the questionnaire
School 1	EMI	T1A (Math)	33	26	26	English
		T1F (Sci)	33 *	33	32	English
		T1F (Math)	33 *	33	32	English
School 2	EMI	T2 (Math)	28	26	26	Chinese
School 3	EMI	T3A (Math)	22	22	21	Chinese
		T3B (Math)	23	22	21	Chinese
School 4	CMI	T4A (Sci)	32	32	24	Chinese
		T4B (Sci)	31	29	29	Chinese
School 5	CMI	T5 (Sci)	32	30	30	English
School 7	EMI	T7 (Sci)	31	28	28	Chinese
School 8	EMI	T8A (Sci)	31	31	30	Chinese
		T8B (Sci)	32	31	31	Chinese
School 9	CMI	T9A (Math)	31	27	27	Chinese
		T9B (Math)	35	33	33	Chinese
				Total of valid questionnaires returned	**390**	

* Same class of student

<u>Appendix XVI</u>

Student questionnaire statistical data by subject and MOI of schools with analyses

Table 1 Science EMI

Table 2 Science CMI

Table 3 Maths EMI

Table 4 Maths CMI

Table 5 School 1 Class of T1B

Annex A: Summary of more outstanding findings / analyses of the student questionnaire data

Table 1 – Science EMI

Q1 EMI

		School															
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q1_What is your mother tongue?	Cantonese	30	93.8%	30	93.8%	27	96.4%	27	96.4%	29	96.7%	30	96.8%	59	96.7%	116	95.9%
	Putonghua	0	0.0%	0	0.0%	2	7.1%	2	7.1%	0	0.0%	1	3.2%	1	1.6%	3	2.5%
	English	0	0.0%	0	0.0%	1	3.6%	1	3.6%	1	3.3%	0	0.0%	1	1.6%	2	1.7%
	Japanese	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	3.3%	0	0.0%	1	1.6%	1	.8%
	Cantonese and English	2	6.3%	2	6.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	1.7%
	Total	32	100.0%	32	100.0%	28	100.0%	28	100.0%	30	100.0%	31	100.0%	61	100.0%	121	100.0%

Q2 EMI

		School															
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q2_What language(s) do you use at home? (You may select more than one)	Cantonese	32	100.0%	32	100.0%	27	96.4%	27	96.4%	30	100.0%	30	96.8%	60	98.4%	119	98.3%
	Putonghua	2	6.3%	2	6.3%	8	28.6%	8	28.6%	5	16.7%	5	16.1%	10	16.4%	20	16.5%
	English	12	37.5%	12	37.5%	7	25.0%	7	25.0%	4	13.3%	5	16.1%	9	14.8%	28	23.1%
	Minnan dialect	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	3.3%	1	3.2%	2	3.3%	2	1.7%
	Korean	0	0.0%	0	0.0%	3	10.7%	3	10.7%	0	0.0%	0	0.0%	0	0.0%	3	2.5%
	Japanese	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	3.3%	1	3.2%	2	3.3%	2	1.7%
	Hokkien dialect	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	3.2%	1	1.6%	1	.8%
	Kaiping dialect	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	3.2%	1	1.6%	1	.8%
	Shanghainese	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	3.2%	1	1.6%	1	.8%
	Total	32	100.0%	32	100.0%	28	100.0%	28	100.0%	30	100.0%	31	100.0%	61	100.0%	121	100.0%

Q3 EMI

		School													
		School 1 EMI				School 7 EMI				School 8 EMI					Total
		Class				Class				Class					Class
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q3 _Whom do you use English at home with? (You may select more than one)	Parents/Guardians	18	64.3%	18	64.3%	11	57.9%	11	57.9%	13	61.9%	12	52.2%	25	56.8%	54	59.3%
	Siblings	8	28.6%	8	28.6%	10	52.6%	10	52.6%	7	33.3%	12	52.2%	19	43.2%	37	40.7%
	Domestic helper(s)	13	46.4%*	13	46.4%	2	10.5%	2	10.5%	3	14.3%	2	8.7%*	5	11.4%	20	22.0%
	Friends	1	3.6%	1	3.6%	0	0.0%	0	0.0%	1	4.8%	0	0.0%	1	2.3%	2	2.2%
	Teachers	1	3.6%	1	3.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	1.1%
	Tutors	1	3.6%	1	3.6%	1	5.3%	1	5.3%	0	0.0%	0	0.0%	0	0.0%	2	2.2%
	Relatives	1	3.6%	1	3.6%	1	5.3%	1	5.3%	0	0.0%	0	0.0%	0	0.0%	2	2.2%
	Total	28	100.0%	28	100.0%	19	100.0%	19	100.0%	21	100.0%	23	100.0%	44	100.0%	91	100.0%

* The proportion of Class of T1B of School 1 is statistically significantly higher than that of Class ofT8B of School 8 at 0.05 level of significance.

Q5 EMI

		School													
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q5_Could you tell us the language(s) used in your General Studies lessons in your primary school? (You may select more than one)	Cantonese	27	84.4%	27	84.4%	21	75.0%	21	75.0%	28	93.3%	28	90.3%	56	91.8%	104	86.0%
	English	18	56.3%*	18	56.3%	1	3.6%*	1	3.6%	1	3.3%*	2	6.5%*	3	4.9%	22	18.2%
	Mainly Cantonese with some English	7	21.9%	7	21.9%	8	28.6%	8	28.6%	4	13.3%	3	9.7%	7	11.5%	22	18.2%
	Mainly English with some Cantonese	5	15.6%	5	15.6%	3	10.7%	3	10.7%	0	0.0%	0	0.0%	0	0.0%	8	6.6%
	Putonghua	4	12.5%	4	12.5%	0	0.0%	0	0.0%	0	0.0%	2	6.5%	2	3.3%	6	5.0%
	Total	32	100.0%	32	100.0%	28	100.0%	28	100.0%	30	100.0%	31	100.0%	61	100.0%	121	100.0%

* The proportion of Class of T1B of School 1 is statistically significantly higher than those of Class of T7 of School 7, Classes of T8A and T8B of School 8 at 0.05 level of significance.

Q6 EMI

		School													
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q6_Could you tell us the language of your General Studies textbooks in your primary school?	Chinese	12	37.5%*	12	37.5%	27	96.4%*	27	96.4%	30	100.0%*	31	100.0%*	61	100.0%	100	82.6%
	English	6	18.8%	6	18.8%	1	3.6%	1	3.6%	0	0.0%	0	0.0%	0	0.0%	7	5.8%
	Chinese and English	14	43.8%	14	43.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	14	11.6%
	Total	32	100.0%	32	100.0%	28	100.0%	28	100.0%	30	100.0%	31	100.0%	61	100.0%	121	100.0%

* The proportions of Class of T7 of School 7, Classes of T8A and T8B of School 8 are statistically significantly higher than that of Class of T1B of School 1 at 0.05 level of significance.

Q7 EMI

		School																	
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q7_At this stage, do you have any difficulty learning science in English?	I find it very difficult.	0	0.0%	0	0.0%	2	7.1%	2	7.1%	0	0.0%	1	3.2%	1	1.6%	3	2.5%
	I find it difficult generally.	4	12.5%	4	12.5%	4	14.3%	4	14.3%	7	23.3%	7	22.6%	14	23.0%	22	18.2%
	I don’t have much difficulties generally.	15	46.9%	15	46.9%	20	71.4%	20	71.4%	21	70.0%	18	58.1%	39	63.9%	74	61.2%
	I have no difficulties at all.	13	40.6%*	13	40.6%	2	7.1%*	2	7.1%	2	6.7%*	5	16.1%	7	11.5%	22	18.2%
	Total	32	100.0%	32	100.0%	28	100.0%	28	100.0%	30	100.0%	31	100.0%	61	100.0%	121	100.0%

* The proportion of Class of T1B of School 1 is statistically significantly higher than those of Class of T7 of School 7 and Class of T8A of School 8 at 0.05 level of significance.

Q8 EMI

		School 1 EMI: T1B (N=33, R=32) Count	School 1 EMI: T1B (N=33, R=32) Column N %	School 1 EMI: Total Count	School 1 EMI: Total Column N %	School 7 EMI: T7 (N=31, R=28) Count	School 7 EMI: T7 (N=31, R=28) Column N %	School 7 EMI: Total Count	School 7 EMI: Total Column N %	School 8 EMI: T8A (N=31, R=30) Count	School 8 EMI: T8A (N=31, R=30) Column N %	School 8 EMI: T8B (N=32, R=31) Count	School 8 EMI: T8B (N=32, R=31) Column N %	School 8 EMI: Total Count	School 8 EMI: Total Column N %	Total: Total Count	Total: Total Column N %
Q8_What difficulties do you have when learning Science in English? (You may select more than one)	Understanding Science teachers' instructions in English in class	4	23.5%	4	23.5%	10	38.5%	10	38.5%	8	28.6%	11	42.3%	19	35.2%	33	34.0%
	Understanding scientific terms and/or concepts in English	10	58.8%	10	58.8%	18	69.2%	18	69.2%	22	78.6%	20	76.9%	42	77.8%	70	72.2%
	Understanding instructions/questions in the Science textbook in English	4	23.5%	4	23.5%	15	57.7%	15	57.7%	7	25.0%	6	23.1%	13	24.1%	32	33.0%
	Understanding instructions/questions of experiments in the textbook in English	6	35.3%	6	35.3%	10	38.5%	10	38.5%	8	28.6%	6	23.1%	14	25.9%	30	30.9%
	Answering questions in Science lessons in English	6	35.3%	6	35.3%	8	30.8%	8	30.8%	9	32.1%	12	46.2%	21	38.9%	35	36.1%
	Asking Science teachers questions in English	3	17.6%	3	17.6%	7	26.9%	7	26.9%	11	39.3%	6	23.1%	17	31.5%	27	27.8%
	Discussing questions about science with classmates in English	8	47.1%	8	47.1%	5	19.2%	5	19.2%	10	35.7%	5	19.2%	15	27.8%	28	28.9%
	Completing lab reports in English	10	58.8%*	10	58.8%	8	30.8%	8	30.8%	8	28.6%	3	11.5%*	11	20.4%	29	29.9%
	Carelessness	1	5.9%	1	5.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	1.0%
	Total	17	100.0%	17	100.0%	26	100.0%	26	100.0%	28	100.0%	26	100.0%	54	100.0%	97	100.0%

* The proportion of Class of T1B of School 1 is statistically significantly higher than that of Class of T8B of School 8 at 0.05 level of significance.

Q9 EMI

		School															
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q9_Do you have Science tutorial classes outside school (including private tutorial sessions and small tutorial groups)?	Yes	6	18.8%	6	18.8%	6	21.4%	6	21.4%	6	20.0%	4	13.3%	10	16.7%	22	18.3%
	No	26	81.3%	26	81.3%	22	78.6%	22	78.6%	24	80.0%	26	86.7%	50	83.3%	98	81.7%
	Total	32	100.0%	32	100.0%	28	100.0%	28	100.0%	30	100.0%	30	100.0%	60	100.0%	120	100.0%

Q10 EMI

		School													
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q10 _What language(s) does your tutor (private tutor or in tutorial centres) use? (You may select more than one)	Cantonese	3	50.0%	3	50.0%	3	50.0%	3	50.0%	1	16.7%	1	25.0%	2	20.0%	8	36.4%
	English	4	66.7%	4	66.7%	1	16.7%	1	16.7%	0	0.0%	1	25.0%	1	10.0%	6	27.3%
	Mainly Cantonese with some English	3	50.0%	3	50.0%	4	66.7%	4	66.7%	5	83.3%	2	50.0%	7	70.0%	14	63.6%
	Mainly English with some Cantonese	2	33.3%	2	33.3%	1	16.7%	1	16.7%	1	16.7%	1	25.0%	2	20.0%	5	22.7%
	Putonghua	1	16.7%	1	16.7%	1	16.7%	1	16.7%	0	0.0%	0	0.0%	0	0.0%	2	9.1%
	Total	6	100.0%	6	100.0%	6	100.0%	6	100.0%	6	100.0%	4	100.0%	10	100.0%	22	100.0%

Q11 EMI

		School													
		School 1 EMI				School 7 EMI				School 8 EMI						Total	
		Class				Class				Class						Class	
		T1B (N=33, R=32)		Total		T7 (N=31, R=28)		Total		T8A (N=31, R=30)		T8B (N=32, R=31)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q11_If you have a choice, which language do you prefer to use when learning Science in secondary school?	Cantonese	7	21.9%	7	21.9%	4	14.3%	4	14.3%	1	3.3%	2	6.5%	3	4.9%	14	11.6%
	English	11	34.4%	11	34.4%	0	0.0%	0	0.0%	3	10.0%	6	19.4%	9	14.8%	20	16.5%
	Mainly Cantonese with some English	20	62.5%*	20	62.5%	9	32.1%	9	32.1%	5	16.7%*	10	32.3%	15	24.6%	44	36.4%
	Mainly English with some Cantonese	3	9.4%^	3	9.4%	13	46.4%^	13	46.4%	22	73.3%^	14	45.2%^	36	59.0%	52	43.0%
	Putonghua	0	0.0%	0	0.0%	2	7.1%	2	7.1%	0	0.0%	0	0.0%	0	0.0%	2	1.7%
	泰文; 印度文; 俄文; 日文; 韓文; 朝鮮文; 巴基斯坦文; 法語; 德文; 台話; 福建話; 非洲話	0	0.0%	0	0.0%	1	3.6%	1	3.6%	0	0.0%	0	0.0%	0	0.0%	1	.8%
	日文	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	3.3%	0	0.0%	1	1.6%	1	.8%
	Total	32	100.0%	32	100.0%	28	100.0%	28	100.0%	30	100.0%	31	100.0%	61	100.0%	121	100.0%

* The proportion of Class of T1B of School 1 is statistically significantly higher than that of Class of T8A of School 8 at 0.05 level of significance.

^ The proportions of Class of T7 of School 7, Classes of T8A and T8B of School 8 are statistically significantly higher than that of Class of T1B of School 1 at 0.05 level of significance.

Table 2 – Science CMI

Q1 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q1_What is your mother tongue?	Cantonese	23	95.8%	29	100.0%	52	98.1%	29	96.7%	29	96.7%	81	97.6%
	Putonghua	1	4.2%	2	6.9%	3	5.7%	2	6.7%	2	6.7%	5	6.0%
	Minnan dialect	1	4.2%	0	0.0%	1	1.9%	0	0.0%	0	0.0%	1	1.2%
	Hakka dialect	0	0.0%	0	0.0%	0	0.0%	1	3.3%	1	3.3%	1	1.2%
	Total	24	100.0%	29	100.0%	53	100.0%	30	100.0%	30	100.0%	83	100.0%

Q2 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q2_What language(s) do you use at home? (You may select more than one)	Cantonese	21	87.5%	29	100.0%	50	94.3%	30	100.0%	30	100.0%	80	96.4%
	Putonghua	4	16.7%	5	17.2%	9	17.0%	5	16.7%	5	16.7%	14	16.9%
	English	4	16.7%	2	6.9%	6	11.3%	7	23.3%	7	23.3%	13	15.7%
	Minnan dialect	1	4.2%	0	0.0%	1	1.9%	0	0.0%	0	0.0%	1	1.2%
	Japanese	2	8.3%	0	0.0%	2	3.8%	1	3.3%	1	3.3%	3	3.6%
	Total	24	100.0%	29	100.0%	53	100.0%	30	100.0%	30	100.0%	83	100.0%

Q3 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q3 _Whom do you use English at home with? (You may select more than one)	Parents/Guardians	5	31.3%	11	47.8%	16	41.0%	10	50.0%	10	50.0%	26	44.1%
	Siblings	8	50.0%	10	43.5%	18	46.2%	7	35.0%	7	35.0%	25	42.4%
	Domestic helper(s)	4	25.0%	7	30.4%	11	28.2%	2	10.0%	2	10.0%	13	22.0%
	Friends	1	6.3%	0	0.0%	1	2.6%	0	0.0%	0	0.0%	1	1.7%
	Teachers	0	0.0%	0	0.0%	0	0.0%	1	5.0%	1	5.0%	1	1.7%
	Tutors	1	6.3%	0	0.0%	1	2.6%	2	10.0%	2	10.0%	3	5.1%
	Relatives	0	0.0%	1	4.3%	1	2.6%	0	0.0%	0	0.0%	1	1.7%
	Total	16	100.0%	23	100.0%	39	100.0%	20	100.0%	20	100.0%	59	100.0%

Q5 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q5_Could you tell us the language(s) used in your General Studies lessons in your primary school? (You may select more than one)	Cantonese	19	79.2%	26	89.7%	45	84.9%	28	93.3%	28	93.3%	73	88.0%
	English	2	8.3%	5	17.2%	7	13.2%	3	10.0%	3	10.0%	10	12.0%
	Mainly Cantonese with some English	7	29.2%	4	13.8%	11	20.8%	1	3.3%	1	3.3%	12	14.5%
	Mainly English with some Cantonese	0	0.0%	1	3.4%	1	1.9%	4	13.3%	4	13.3%	5	6.0%
	Putonghua	0	0.0%	1	3.4%	1	1.9%	1	3.3%	1	3.3%	2	2.4%
	Primary six with English	0	0.0%	1	3.4%	1	1.9%	0	0.0%	0	0.0%	1	1.2%
	Total	24	100.0%	29	100.0%	53	100.0%	30	100.0%	30	100.0%	83	100.0%

Q6 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q6_Could you tell us the language of your General Studies textbooks in your primary school?	Chinese	24	100.0%	28	96.6%	52	98.1%	27	90.0%	27	90.0%	79	95.2%
	Chinese and English	0	0.0%	1	3.4%	1	1.9%	2	6.7%	2	6.7%	3	3.6%
	Chinese, English and Putonghua	0	0.0%	0	0.0%	0	0.0%	1	3.3%	1	3.3%	1	1.2%
	Total	24	100.0%	29	100.0%	53	100.0%	30	100.0%	30	100.0%	83	100.0%

Q7 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q7_At this stage, do you have any difficulty learning science in English?	I find it very difficult.	1	4.3%	0	0.0%	1	1.9%	6	20.0%	6	20.0%	7	8.5%
	I find it difficult generally.	2	8.7%	9	31.0%	11	21.2%	9	30.0%	9	30.0%	20	24.4%
	I don't have many difficulties generally.	18	78.3%*	17	58.6%	35	67.3%	12	40.0%*	12	40.0%	47	57.3%
	I have no difficulties at all.	2	8.7%	3	10.3%	5	9.6%	3	10.0%	3	10.0%	8	9.8%
	Total	23	100.0%	29	100.0%	52	100.0%	30	100.0%	30	100.0%	82	100.0%

* The proportion of Class of T4A of School 4 is statistically significantly higher than that of Class of T5 of School 5 at 0.05 level of significance.

Q8 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q8_What difficulties do you have when learning Science in English? (You may select more than one)	Understanding Science teachers' instructions in English in class	7	33.3%	9	34.6%	16	34.0%	8	29.6%	8	29.6%	24	32.4%
	Understanding scientific terms and/or concepts in English	18	85.7%*	16	61.5%	34	72.3%	13	48.1%*	13	48.1%	47	63.5%
	Understanding instructions/questions in the Science textbook in English	11	52.4%	11	42.3%	22	46.8%	16	59.3%	16	59.3%	38	51.4%
	Understanding instructions/questions of experiments in the textbook in English	9	42.9%	10	38.5%	19	40.4%	16	59.3%	16	59.3%	35	47.3%
	Answering questions in Science lessons in English	3	14.3%	2	7.7%^	5	10.6%	10	37.0%^	10	37.0%	15	20.3%
	Asking Science teachers questions in English	3	14.3%	5	19.2%	8	17.0%	4	14.8%	4	14.8%	12	16.2%
	Discussing questions about science with classmates in English	5	23.8%	4	15.4%	9	19.1%	5	18.5%	5	18.5%	14	18.9%
	Completing lab reports in English	2	9.5%	5	19.2%	7	14.9%	7	25.9%	7	25.9%	14	18.9%
	Answering questions in English	0	0.0%	1	3.8%	1	2.1%	0	0.0%	0	0.0%	1	1.4%
	Concentrate	0	0.0%	1	3.8%	1	2.1%	0	0.0%	0	0.0%	1	1.4%
	Total	21	100.0%	26	100.0%	47	100.0%	27	100.0%	27	100.0%	74	100.0%

* The proportion of Class of T4A of School 4 is statistically significantly higher than that of Class of T5 of School 5 at 0.05 level of significance.

^ The proportion of Class of T5 of School 5 is statistically significantly higher than that of Class T4B of School 4 at 0.05 level of significance.

Q9 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q9_Do you have Science tutorial classes outside school (including private tutorial sessions and small tutorial groups)?	Yes	5	21.7%	8	27.6%	13	25.0%	10	33.3%	10	33.3%	23	28.0%
	No	18	78.3%	21	72.4%	39	75.0%	20	66.7%	20	66.7%	59	72.0%
	Total	23	100.0%	29	100.0%	52	100.0%	30	100.0%	30	100.0%	82	100.0%

Q10 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q10 _What language(s) does your tutor (private tutor or in tutorial centres) use? (You may select more than one)	Cantonese	1	20.0%	5	62.5%	6	46.2%	7	70.0%	7	70.0%	13	56.5%
	English	2	40.0%	5	62.5%	7	53.8%	5	50.0%	5	50.0%	12	52.2%
	Mainly Cantonese with some English	4	80.0%	2	25.0%	6	46.2%	2	20.0%	2	20.0%	8	34.8%
	Mainly English with some Cantonese	1	20.0%	2	25.0%	3	23.1%	1	10.0%	1	10.0%	4	17.4%
	Putonghua	1	20.0%	1	12.5%	2	15.4%	0	0.0%	0	0.0%	2	8.7%
	Total	5	100.0%	8	100.0%	13	100.0%	10	100.0%	10	100.0%	23	100.0%

Q11 CMI

		School											
		School 4 CMI						School 5 CMI				Total	
		Class						Class				Class	
		T4A (N=32, R=24)		T4B (N=31, R=29)		Total		T5 (N=32, R=30)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q11_If you have a choice, which language do you prefer to use when learning Science in secondary school?	Cantonese	0	0.0%	2	6.9%	2	3.8%	7	23.3%	7	23.3%	9	11.0%
	English	2	8.7%	3	10.3%	5	9.6%	6	20.0%	6	20.0%	11	13.4%
	Mainly Cantonese with some English	7	30.4%	8	27.6%	15	28.8%	12	40.0%	12	40.0%	27	32.9%
	Mainly English with some Cantonese	13	56.5%*	14	48.3%*	27	51.9%	5	16.7%*	5	16.7%	32	39.0%
	Putonghua	1	4.3%	2	6.9%	3	5.8%	0	0.0%	0	0.0%	3	3.7%
	韓文	0	0.0%	0	0.0%	0	0.0%	1	3.3%	1	3.3%	1	1.2%
	Total	23	100.0%	29	100.0%	52	100.0%	30	100.0%	30	100.0%	82	100.0%

* The proportions of Classes of T4A and T4B of School 4 are statistically significantly higher than that of Class of T5 of School 5 at 0.05 level of significance.

Table 3 – Maths EMI

Q1 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q1_What is your mother tongue?	Cantonese	24	92.3%	30	93.8%	54	93.1%	25	96.2%	25	96.2%	19	90.5%	19	90.5%	38	90.5%	117	92.9%
	Putonghua	0	0.0%	0	0.0%	0	0.0%	1	3.8%	1	3.8%	2	9.5%	2	9.5%	4	9.5%	5	4.0%
	English	2	7.7%	0	0.0%	2	3.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	1.6%
	Other dialects	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Cantonese and English	0	0.0%	2	6.3%	2	3.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	1.6%
	Total	26	100.0%	32	100.0%	58	100.0%	26	100.0%	26	100.0%	21	100.0%	21	100.0%	42	100.0%	126	100.0%

Q2 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q2_What language(s) do you use at home? (You may select more than one)	Cantonese	25	96.2%	32	100.0%	57	98.3%	26	100.0%	26	100.0%	19	90.5%	20	95.2%	39	92.9%	122	96.8%
	Putonghua	1	3.8%	2	6.3%	3	5.2%	3	11.5%	3	11.5%	0	0.0%	2	9.5%	2	4.8%	8	6.3%
	English	7	26.9%	12	37.5%	19	32.8%	0	0.0%	0	0.0%	1	4.8%	5	23.8%	6	14.3%	25	19.8%
	Kaiping dialect	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	4.8%	0	0.0%	1	2.4%	1	.8%
	Taiwan dialect	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	4.8%	0	0.0%	1	2.4%	1	.8%
	Chinese dialect	0	0.0%	0	0.0%	0	0.0%	1	3.8%	1	3.8%	0	0.0%	0	0.0%	0	0.0%	1	.8%
	Total	26	100.0%	32	100.0%	58	100.0%	26	100.0%	26	100.0%	21	100.0%	21	100.0%	42	100.0%	126	100.0%

Q3 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q3 _Whom do you use English at home with? (You may select more than one)	Parents/Guardians	8	44.4%	18	64.3%	26	56.5%	7	50.0%	7	50.0%	2	25.0%	6	35.3%	8	32.0%	41	48.2%
	Siblings	5	27.8%	8	28.6%	13	28.3%	3	21.4%	3	21.4%	3	37.5%	8	47.1%	11	44.0%	27	31.8%
	Domestic helper(s)	12	66.7%*	13	46.4%	25	54.3%	2	14.3%*	2	14.3%	3	37.5%	4	23.5%	7	28.0%	34	40.0%
	Classmates	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	5.9%	1	4.0%	1	1.2%
	Friends	1	5.6%	1	3.6%	2	4.3%	1	7.1%	1	7.1%	0	0.0%	0	0.0%	0	0.0%	3	3.5%
	Teachers	0	0.0%	1	3.6%	1	2.2%	2	14.3%	2	14.3%	0	0.0%	3	17.6%	3	12.0%	6	7.1%
	Tutors	0	0.0%	1	3.6%	1	2.2%	2	14.3%	2	14.3%	0	0.0%	0	0.0%	0	0.0%	3	3.5%
	Relatives	0	0.0%	1	3.6%	1	2.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	1.2%
	Total	18	100.0%	28	100.0%	46	100.0%	14	100.0%	14	100.0%	8	100.0%	17	100.0%	25	100.0%	85	100.0%

* The proportion of Class of T1A of School 1 is statistically significantly higher than that of Class of T2 of School 2 at 0.05 level of significance.

Q5 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q5_Could you tell us the language(s) used in your Mathematics lessons in your primary school? (You may select more than one)	Cantonese	14	53.8%*	21	65.6%*	35	60.3%	25	96.2%*	25	96.2%	17	81.0%	16	76.2%	33	78.6%	93	73.8%
	English	4	15.4%	9	28.1%	13	22.4%	2	7.7%	2	7.7%	1	4.8%	1	4.8%	2	4.8%	17	13.5%
	Mainly Cantonese with some English	8	30.8%^	3	9.4%^	11	19.0%	1	3.8%	1	3.8%	5	23.8%	6	28.6%	11	26.2%	23	18.3%
	Mainly English with some Cantonese	6	23.1%	9	28.1%	15	25.9%	1	3.8%	1	3.8%	0	0.0%	1	4.8%	1	2.4%	17	13.5%
	Putonghua	3	11.5%	1	3.1%	4	6.9%	1	3.8%	1	3.8%	0	0.0%	0	0.0%	0	0.0%	5	4.0%
	Total	26	100.0%	32	100.0%	58	100.0%	26	100.0%	26	100.0%	21	100.0%	21	100.0%	42	100.0%	126	100.0%

* The proportion of Class of T2 of School 2 is statistically significantly higher than those of Classes of T1A and T1B of School 1 at 0.05 level of significance.

^ The proportion of Class of T1A of School 1 is statistically significantly higher than that of Class of T1B of School 1 at 0.05 level of significance.

Q6 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q6_Could you tell us the language of your Mathematics textbooks in your primary school?	Chinese	20	76.9%	22	68.8%	42	72.4%	26	100.0%	26	100.0%	21	100.0%	19	90.5%	40	95.2%	108	85.7%
	English	6	23.1%	10	31.3%	16	27.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	16	12.7%
	Chinese and English	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	9.5%	2	4.8%	2	1.6%
	Total	26	100.0%	32	100.0%	58	100.0%	26	100.0%	26	100.0%	21	100.0%	21	100.0%	42	100.0%	126	100.0%

Q7 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q7_At this stage, do you have any difficulty learning Mathematics in English?	I find it very difficult.	2	7.7%	1	3.1%	3	5.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	2.4%
	I find it difficult generally.	8	30.8%	5	15.6%	13	22.4%	7	26.9%	7	26.9%	0	0.0%	1	4.8%	1	2.4%	21	16.7%
	I don't have much difficulties generally.	13	50.0%	10	31.3%*	23	39.7%	16	61.5%	16	61.5%	17	81.0%*	15	71.4%*	32	76.2%	71	56.3%
	I have no difficulties at all.	3	11.5%^	16	50.0%^	19	32.8%	3	11.5%^	3	11.5%	4	19.0%	5	23.8%	9	21.4%	31	24.6%
	Total	26	100.0%	32	100.0%	58	100.0%	26	100.0%	26	100.0%	21	100.0%	21	100.0%	42	100.0%	126	100.0%

* The proportions of Classes of T3A and T3B of School 3 are statistically significantly higher than that of Class of T1B of School 1 at 0.05 level of significance.

^ The proportion of Class of T1B of School 1 is statistically significantly higher than those of Class of T1A of School 1 and Class of T2 of School 2 at 0.05 level of significance.

Q8 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q8_What difficulties do you have when learning Mathematics in English? (You may select more than one)	Understanding Mathematics teachers' instructions in English in class	3	13.0%	5	35.7%	8	21.6%	7	31.8%	7	31.8%	3	17.6%	0	0.0%	3	9.1%	18	19.6%
	Understanding Mathematical terms and/or concepts in English	16	69.6%	10	71.4%	26	70.3%	16	72.7%	16	72.7%	8	47.1%*	13	81.3%*	21	63.6%	63	68.5%
	Understanding Mathematics questions in the textbook in English	6	26.1%	4	28.6%	10	27.0%	8	36.4%	8	36.4%	2	11.8%	3	18.8%	5	15.2%	23	25.0%
	Answering questions in Mathematics lessons in English	4	17.4%	3	21.4%	7	18.9%	4	18.2%	4	18.2%	5	29.4%	3	18.8%	8	24.2%	19	20.7%
	Asking Mathematics teachers questions in English	2	8.7%	3	21.4%	5	13.5%	3	13.6%	3	13.6%	5	29.4%	6	37.5%	11	33.3%	19	20.7%
	Discussing Mathematics questions with classmates in English	3	13.0%	5	35.7%	8	21.6%	1	4.5%	1	4.5%	3	17.6%	3	18.8%	6	18.2%	15	16.3%
	Understand how to solve problem	0	0.0%	1	7.1%	1	2.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	1.1%
	I can't remember the meaning of each reference	0	0.0%	1	7.1%	1	2.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	1.1%
	Teacher can't elaborate	0	0.0%	1	7.1%	1	2.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	1.1%
	Total	23	100.0%	14	100.0%	37	100.0%	22	100.0%	22	100.0%	17	100.0%	16	100.0%	33	100.0%	92	100.0%

* The proportions of Class of T3B of School 3 is statistically significantly higher than that of Class of T3A of School 3 at 0.05 level of significance.

Q9 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q9_Do you have Mathematics tutorial classes outside school (including private tutorial sessions and small tutorial groups)?	Yes	15	57.7%	16	50.0%	31	53.4%	13	50.0%	13	50.0%	5	25.0%	11	52.4%	16	39.0%	60	48.0%
	No	11	42.3%	16	50.0%	27	46.6%	13	50.0%	13	50.0%	15	75.0%	10	47.6%	25	61.0%	65	52.0%
	Total	26	100.0%	32	100.0%	58	100.0%	26	100.0%	26	100.0%	20	100.0%	21	100.0%	41	100.0%	125	100.0%

Q10 EMI

		School																	
		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q10 _What language(s) does your Mathematics tutor (private tutor or in tutorial centres) use? (You may select more than one)	Cantonese	5	33.3%	9	56.3%	14	45.2%	8	61.5%	8	61.5%	2	40.0%	5	45.5%	7	43.8%	29	48.3%
	English	1	6.7%	4	25.0%	5	16.1%	2	15.4%	2	15.4%	0	0.0%	2	18.2%	2	12.5%	9	15.0%
	Mainly Cantonese with some English	9	60.0%	6	37.5%	15	48.4%	6	46.2%	6	46.2%	2	40.0%	7	63.6%	9	56.3%	30	50.0%
	Mainly English with some Cantonese	1	6.7%	4	25.0%	5	16.1%	1	7.7%	1	7.7%	1	20.0%	0	0.0%	1	6.3%	7	11.7%
	Cantonese but English for question	0	0.0%	1	6.3%	1	3.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	1.7%
	Total	15	100.0%	16	100.0%	31	100.0%	13	100.0%	13	100.0%	5	100.0%	11	100.0%	16	100.0%	60	100.0%

Q11 EMI

		School 1 EMI						School 2 EMI				School 3 EMI						Total	
		Class						Class				Class						Class	
		T1A (N=33, R=26)		T1B (N=33, R=32)		Total		T2 (N=28, R=26)		Total		T3A (N=22, R=21)		T3B (N=23, R=21)		Total		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Q11_If you have a choice, which language do you prefer to use when learning Mathematics in secondary school?	Cantonese	5	20.8%	3	9.4%	8	14.3%	7	28.0%	7	28.0%	2	9.5%	0	0.0%	2	4.8%	17	13.8%
	English	5	20.8%	7	21.9%	12	21.4%	0	0.0%	0	0.0%	2	9.5%	3	14.3%	5	11.9%	17	13.8%
	Mainly Cantonese with some English	6	25.0%	3	9.4%^	9	16.1%	11	44.0%^	11	44.0%	2	9.5%	4	19.0%	6	14.3%	26	21.1%
	Mainly English with some Cantonese	7	29.2%*	13	40.6%	20	35.7%	7	28.0%*	7	28.0%	15	71.4%*	13	61.9%	28	66.7%	55	44.7%
	Cantonese and English	0	0.0%	3	9.4%	3	5.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	3	2.4%
	Cantonese and Mainly Cantonese with some English	0	0.0%	2	6.3%	2	3.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	2	1.6%
	English and Mainly English with some Cantonese	1	4.2%	1	3.1%	2	3.6%	0	0.0%	0	0.0%	0	0.0%	1	4.8%	1	2.4%	3	2.4%
	Total	24	100.0%	32	100.0%	56	100.0%	25	100.0%	25	100.0%	21	100.0%	21	100.0%	42	100.0%	123	100.0%

* The proportion of Class of T3A of School 3 is statistically significantly higher than those of Class of T1A of School 1 and Class of T2 of School 2 at 0.05 level of significance.

^ The proportion of Class of T2 of School 2 is statistically significantly higher than that of Class of T1B of School 1 at 0.05 level of significance.

Table 4 – Maths CMI

Q1 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q1_What is your mother tongue?	Cantonese	25	92.6%	31	93.9%	56	93.3%
	Putonghua	2	7.4%	2	6.1%	4	6.7%
	Total	27	100.0%	33	100.0%	60	100.0%

Q2 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q2_What language(s) do you use at home? (You may select more than one)	Cantonese	25	96.2%	33	100.0%	58	98.3%
	Putonghua	4	15.4%	3	9.1%	7	11.9%
	English	1	3.8%	0	0.0%	1	1.7%
	Minnan dialect	0	0.0%	1	3.0%	1	1.7%
	Total	26	100.0%	33	100.0%	59	100.0%

Q3 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q3 _Whom do you use English at home with? (You may select more than one)	Parents/Guardians	5	41.7%	9	45.0%	14	43.8%
	Siblings	8	66.7%	8	40.0%	16	50.0%
	Domestic helper(s)	1	8.3%	0	0.0%	1	3.1%
	Classmates	0	0.0%	1	5.0%	1	3.1%
	Friends	0	0.0%	1	5.0%	1	3.1%
	English teachers	0	0.0%	1	5.0%	1	3.1%
	Teachers	1	8.3%	0	0.0%	1	3.1%
	Neighbours' domestic helper(s)	1	8.3%	0	0.0%	1	3.1%
	Total	12	100.0%	20	100.0%	32	100.0%

Q5 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q5_Could you tell us the language(s) used in your Mathematics lessons in your primary school? (You may select more than one)	Cantonese	20	76.9%	28	84.8%	48	81.4%
	English	1	3.8%	0	0.0%	1	1.7%
	Mainly Cantonese with some English	4	15.4%	7	21.2%	11	18.6%
	Mainly English with some Cantonese	2	7.7%	0	0.0%	2	3.4%
	Putonghua	1	3.8%	0	0.0%	1	1.7%
	Total	26	100.0%	33	100.0%	59	100.0%

Q6 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q6_Could you tell us the language of your Mathematics textbooks in your primary school?	Chinese	24	92.3%	33	100.0%	57	96.6%
	English	2	7.7%	0	0.0%	2	3.4%
	Total	26	100.0%	33	100.0%	59	100.0%

Q7 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q7_At this stage, do you have any difficulty learning Mathematics in English?	I find it very difficult.	1	3.8%	2	6.1%	3	5.1%
	I find it difficult generally.	8	30.8%	12	36.4%	20	33.9%
	I don't have much difficulties generally.	15	57.7%	17	51.5%	32	54.2%
	I have no difficulties at all.	2	7.7%	2	6.1%	4	6.8%
	Total	26	100.0%	33	100.0%	59	100.0%

Q8 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q8_What difficulties do you have when learning Mathematics in English? (You may select more than one)	Understanding Mathematics teachers' instructions in English in class	7	29.2%	9	29.0%	16	29.1%
	Understanding Mathematical terms and/or concepts in English	14	58.3%	17	54.8%	31	56.4%
	Understanding Mathematics questions in the textbook in English	11	45.8%	11	35.5%	22	40.0%
	Answering questions in Mathematics lessons in English	6	25.0%	5	16.1%	11	20.0%
	Asking Mathematics teachers questions in English	6	25.0%	6	19.4%	12	21.8%
	Discussing Mathematics questions with classmates in English	5	20.8%	6	19.4%	11	20.0%
	Teachers' English 老師的英文	0	0.0%	1	3.2%	1	1.8%
	Mathematics 數學	0	0.0%	1	3.2%	1	1.8%
	Total	24	100.0%	31	100.0%	55	100.0%

Q9 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q9_Do you have Mathematics tutorial classes outside school (including private tutorial sessions and small tutorial groups)?	Yes	8	29.6%	11	35.5%	19	32.8%
	No	19	70.4%	20	64.5%	39	67.2%
	Total	27	100.0%	31	100.0%	58	100.0%

Q10 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q10 _What language(s) does your Mathematics tutor (private tutor or in tutorial centres) use? (You may select more than one)	Cantonese	3	37.5%	6	54.5%	9	47.4%
	English	1	12.5%	1	9.1%	2	10.5%
	Mainly Cantonese with some English	5	62.5%	6	54.5%	11	57.9%
	Mainly English with some Cantonese	1	12.5%	0	0.0%	1	5.3%
	Total	8	100.0%	11	100.0%	19	100.0%

Q11 CMI

		School					
		School 9 CMI					
		Class					
		T9A (N=31, R=27)		T9B (N=35, R=33)		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Q11_If you have a choice, which language do you prefer to use when learning Mathematics in secondary school?	Cantonese	5	18.5%	9	27.3%	14	23.3%
	English	1	3.7%	5	15.2%	6	10.0%
	Mainly Cantonese with some English	13	48.1%	16	48.5%	29	48.3%
	Mainly English with some Cantonese	8	29.6%*	3	9.1%*	11	18.3%
	Total	27	100.0%	33	100.0%	60	100.0%

* The proportion of Class of T9A of School 9 is statistically significantly higher than that of Class of T9B of School 9 at 0.05 level of significance.

Table 5 – School 1 Class of T1B

Q1 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q1_What is your mother tongue?	Cantonese	30	93.8%
	Putonghua	0	0.0%
	English	0	0.0%
	Cantonese and English	2	6.3%
	Total	32	100.0%

Q1 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q2_What language(s) do you use at home? (You may select more than one)	Cantonese	32	100.0%
	Putonghua	2	6.3%
	English	12	37.5%
	Other dialects	0	0.0%
	Total	32	100.0%

Q1 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q3 _Whom do you use English at home with? (You may select more than one)	Parents/Guardians	18	64.3%
	Siblings	8	28.6%
	Domestic helper(s)	13	46.4%
	Others	0	0.0%
	Classmates	0	0.0%
	Friends	1	3.6%
	English teachers	0	0.0%
	Teachers	1	3.6%
	Neighborhood's domestic helper(s)	0	0.0%
	Tutors	1	3.6%
	Relatives	1	3.6%
	Total	28	100.0%

MATHS Q5 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q5_Could you tell us the language(s) used in your Mathematics lessons in your primary school? (You may select more than one)	Cantonese	21	65.6%
	English	9	28.1%
	Mainly Cantonese with some English	3	9.4%
	Mainly English with some Cantonese	9	28.1%
	Putonghua	1	3.1%
	Others	0	0.0%
	Total	32	100.0%

SCIENCE Q5 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q5_Could you tell us the language(s) used in your General Studies lessons in your primary school? (You may select more than one)	Cantonese	27	84.4%
	English	18	56.3%
	Mainly Cantonese with some English	7	21.9%
	Mainly English with some Cantonese	5	15.6%
	Putonghua	4	12.5%
	Others	0	0.0%
	Total	32	100.0%

MATHS Q6 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q6_Could you tell us the language of your Mathematics textbooks in your primary school?	Chinese	22	68.8%
	English	10	31.3%
	Others	0	0.0%
	Total	32	100.0%

SCIENCE Q6 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q6_Could you tell us the language of your General Studies textbooks in your primary school?	Chinese	12	37.5%
	English	6	18.8%
	Chinese and English	14	43.8%
	Chinese, English and Putonghua	0	0.0%
	Total	32	100.0%

MATHS Q7 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q7_At this stage, do you have any difficulty learning Mathematics in English?	I find it very difficult.	1	3.1%
	I find it difficult generally.	5	15.6%
	I don’t have much difficulties generally.	10	31.3%
	I have no difficulties at all.	16	50.0%
	Total	32	100.0%

SCIENCE Q7 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q7_At this stage, do you have any difficulty learning science in English?	I find it very difficult.	0	0.0%
	I find it difficult generally.	4	12.5%
	I don’t have much difficulties generally.	15	46.9%
	I have no difficulties at all.	13	40.6%
	Total	32	100.0%

MATHS Q8 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q8_What difficulties do you have when learning Mathematics in English? (You may select more than one)	Understanding Mathematics teachers' instructions in English in class	5	35.7%
	Understanding Mathematical terms and/or concepts in English	10	71.4%
	Understanding Mathematics questions in the textbook in English	4	28.6%
	Answering questions in Mathematics lessons in English	3	21.4%
	Asking Mathematics teachers questions in English	3	21.4%
	Discussing Mathematics questions with classmates in English	5	35.7%
	Understand how to solve problem	1	7.1%
	I can't remember the meaning of each reference	1	7.1%
	Teacher can't elaborate	1	7.1%
	Total	14	100.0%

SCIENCE Q8 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q8_What difficulties do you have when learning Science in English? (You may select more than one)	Understanding Science teachers' instructions in English in class	4	23.5%
	Understanding scientific terms and/or concepts in English	10	58.8%
	Understanding instructions/questions in the Science textbook in English	4	23.5%
	Understanding instructions/questions of experiments in the textbook in English	6	35.3%
	Answering questions in Science lessons in English	6	35.3%
	Asking Science teachers questions in English	3	17.6%
	Discussing questions about science with classmates in English	8	47.1%
	Completing lab reports in English	10	58.8%
	Carelessness	1	5.9%
	Total	17	100.0%

MATHS Q9 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q9_Do you have Mathematics tutorial classes outside school (including private tutorial sessions and small tutorial groups)?	Yes	16	50.0%
	No	16	50.0%
	Total	32	100.0%

SCIENCE Q9 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q9_Do you have Science tutorial classes outside school (including private tutorial sessions and small tutorial groups)?	Yes	6	18.8%
	No	26	81.3%
	Total	32	100.0%

MATHS Q10 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q10 _What language(s) does your Mathematics tutor (private tutor or in tutorial centres) use? (You may select more than one)	Cantonese	9	56.3%
	English	4	25.0%
	Mainly Cantonese with some English	6	37.5%
	Mainly English with some Cantonese	4	25.0%
	Putonghua	0	0.0%
	Cantonese but English for question	1	6.3%
	Total	16	100.0%

SCIENCE Q10 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q10 _What language(s) does your tutor (private tutor or in tutorial centres) use? (You may select more than one)	Cantonese	3	50.0%
	English	4	66.7%
	Mainly Cantonese with some English	3	50.0%
	Mainly English with some Cantonese	2	33.3%
	Putonghua	1	16.7%
	Total	6	100.0%

MATHS Q11 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q11_If you have a choice, which language do you prefer to use when learning Mathematics in secondary school?	Cantonese	3	9.4%
	English	7	21.9%
	Mainly Cantonese with some English	3	9.4%
	Mainly English with some Cantonese	13	40.6%
	Putonghua	0	0.0%
	Cantonese and English	3	9.4%
	Cantonese and Mainly Cantonese with some English	2	6.3%
	English and Mainly English with some Cantonese	1	3.1%
	Total	32	100.0%

SCIENCE Q11 EMI School 1 Class of T1B

		School	
		School 1 EMI	
		Class	
		Class of T1B (N=33, R=32)	
		Count	Column N %
Q11_If you have a choice, which language do you prefer to use when learning Science in secondary school?	Cantonese	7	21.9%
	English	11	34.4%
	Mainly Cantonese with some English	20	62.5%
	Mainly English with some Cantonese	3	9.4%
	Putonghua	0	0.0%
	Total	32	100.0%

Annex A

Summary of more outstanding findings / analyses of the student questionnaire data

Quantitative: Questionnaire Data

The questionnaire was conducted with agreeing participating students to solicit their language use background; Mathematics and Science classroom experience; and preference of the medium instruction of these subjects, if they have a choice. 390 valid questionnaires were returned (Mathematics n = 186; Science n = 204) [see Appendix XV *Record of completion of the student questionnaire by school and by class*].

Cantonese was reported as the dominant mother tongue and the language use at home for over 90% of the returns. For the responses of using English at home, students mostly use English with their parents, siblings and domestic helpers. In view of the diverse nature of Mathematics and Science subjects, two sets of questions were designed to obtain a clearer presentation of students' views on their learning experience of each subject.

Science

Experience of learning General Studies in primary education

Since prior related learning experience in General Studies (GS) in primary education should contribute to the knowledge construction of Science, students have been asked for the language(s) used in the GS lessons and that of the textbooks concerned in their primary schooling. A majority of students indicated that Cantonese was the main language used in their GS lessons, and Chinese textbooks were often used among CMI school students. It is notable that for EMI school students, most of them still had the experience of using Chinese GS textbook only, whereas 18.8% of students from one of the participating schools and 43.8% students of the class whose GS textbook has been in English and in Chinese and English respectively. The data revealed that even students from this class expressed their more "intensive" use of the English language in GS lessons (56.3%) as well, potentially along with Cantonese. A small proportion of students from some CMI schools (e.g. Schools 4 and 5) nevertheless have reported that some English was used with Cantonese in their GS lessons. This suggests that even the GS textbooks were mainly in Chinese, some schools have been preparing students with Chinese-English instruction in senior primary levels.

General difficulties in learning Science in English at this stage

A similarly high percentage of students (57.3% of CMI school students; 61.2% of EMI students) responded that "I don't have many difficulties generally" in learning science in English at this stage. That said, more CMI school students than their EMI school counterparts expressed that they find the learning experience in English difficult (8.5%) or difficult generally (24.4%) (cf. EMI school students' responses for 2.5% and 18.2% respectively for these items).

Concerning the kind of difficulties that students have in learning Science through English, a high percentage of respondents chose "understanding scientific terms and/or concepts in English" (63.5% for CMI school respondents; 72.2% for EMI school respondents); For CMI school respondents, the next challenge lies in "Understanding instruction/questions in the Science textbook in English" (51.4%) and "Understanding instructions/questions of experiments in the textbook in English" (47.3%). For their EMI school counterparts, 36.1% found "Answering questions in Science lessons in English" challenging (cf. to 20.3% for their CMI school counterparts). This result might suggest that EMI school students are required to respond more in English (from challenges to strategies / linguistic competence).

Science tutorial classes outside school

18.3% of the EMI school respondents indicated that they have Science tutorial classes outside school (including private tutorial sessions and small tutorial group); whereas 28% of CMI school respondents reported that they have tutorial support. When EMI school are asked about the language(s) that their tutors (private tutor or in tutorial centres) use, 63.6% of students responded that their tutors use mainly Cantonese with some English; while 34.8% CMI school respondents reported the same. However, given that students can select the language options more than once, 56.5 % of CMI school respondents indicated that their tutors use "Cantonese" and 52.2% chose "English". This suggests that students generally receive out-of-school academic support in both English and Cantonese.

Preferred language of instruction in learning Science in secondary school

Students were asked if they had a choice, which language they would prefer to use when learning Science in secondary school. For the EMI school respondents, 43% of students expressed a preference to learn Science mainly in English with some Cantonese; while 36.4% prefer to learn mainly in Cantonese with some English. In comparison, only 11.6% of EMI school respondents prefer learning Science in Cantonese and 16.5% prefer to learn through English only. Whereas for the CMI school students, most respondents (39%) also prefer learning Science mainly in English along with some Cantonese; while 32.9% prefer having Cantonese as the main medium of instruction supported with some English. 11% of the respondents prefer to use only Cantonese in learning Science while 13.4% prefer English. In general, the preference of MOI in Science is consistent across respondents from Chinese or English medium schools. The finding that a smaller proportion of respondents prefer learning Science only in Cantonese or English deserves close attention.

<u>Mathematics</u>

Experience of learning Mathematics in primary education

73.8% of the EMI school respondents reported that Cantonese was used in Mathematics lessons in primary schools; 18.3% responded that Cantonese was mainly used with some English while 13.5% indicated that English was mainly used with some Cantonese. Only 13.5% of the respondents had English-medium Mathematics classes in primary school. For the CMI school counterparts, 81.4% indicated that Cantonese was used in Mathematics lesson and only 1.7% responded that English was used in Mathematics lessons. As different from the EMI school counterparts, a lower percent of respondents (3.4%) reported mainly English was used along with some Cantonese in the Mathematics lessons in primary school; while a higher percentage (18.6%) was recorded for having Cantonese mainly with some English as the medium of instruction. The majority of CMI school respondents (96.6%) and their EMI school counterparts (85.7%) reported that their Mathematics textbooks in primary education were in Chinese. The percentage of EMI school students to have English Mathematics textbooks in primary education (12.7%) is significantly higher than that of their CMI school counterparts (3.4%).

General difficulties in learning Mathematics in English at this stage

More than half of the respondents reported that they do not have much difficulty generally in learning mathematics in English (56.3% of the EMI school respondents and 54.2% of their CMI school counterparts). 16.7% of the EMI school respondents reported that they found it difficult generally while 33.9% of the CMI school respondents found it so. This is somehow consistent with the finding that 24.6% of EMI school students felt that they have no difficulties at all whereas only 6.8% of the CMI school students had this feeling.

When asked about what difficulties students have when learning Mathematics in English from the given items, a high percentage of both EMI and CMI school respondents (68.5% and 56.4% respectively) selected "Understanding Mathematical terms and/or concepts in English". 40% and 29.1% of the CMI school respondents expressed that difficulties lie in "Understanding Mathematics questions in the textbook in English" and "Understanding Mathematics teachers' instructions in English in class" respectively. This finding suggests that CMI school respondents face challenges with both listening and reading in EMI Mathematics lessons, which might relate to the prevalence of the spoken and written mathematical discourses.

Mathematics tutorial classes outside school

Nearly half of the EMI school respondents (48%) reported that they have mathematics tutorial classes outside school; whereas a lower percentage of the CMI school respondents (32.8%) attended tutorial classes for Mathematics.

When asking students for the language(s) their Mathematics tutor uses, the responses of the EMI and CMI school respondents are similarly noticeable with "mainly Cantonese with some English" (50% and 57.9% respectively). The percentages for responses with Cantonese use only are also quite close for the EMI school respondents and the CMI school counterparts (48.3% and 47.4% respectively).

Preferred language of instruction in learning Mathematics in secondary school

If given a choice, 44.7%, a majority, of the EMI school respondents prefer to use mainly English with some Cantonese to learn Mathematics in secondary school. 48.3% of the CMI school respondents prefer to use mainly Cantonese with some English, and 23.3% prefer learning in Cantonese, and only 18.3% of them prefer to use mainly English with some Cantonese. For both cohorts, only a minority of respondents prefer to have purely English-medium instruction in mathematics lessons (13.8% for English school respondents and 10% for CMI school respondents).

APPENDIX XVII

Presentations for this research project at international conferences

Language-related conferences

Title of presentation	**Author(s)**	**Conference**	**Location and Date**	**Addressing**
Speaking metaphorically? Conceptual Awareness in L2 Mathematics and Science Junior High Classroom Talk (paper)	Poon, S., Chan, C., Chan, K.H., Fung, D.C.L., Harfitt, G.J., Lee, A.M.S., Mok, I.A.C., Tsui, A.B.M., & Yip, V.W.Y.	The American Association for Applied Linguistics (AAAL) Annual Conference 2017	Portland, Oregon, USA; 18-21 March 2017	RQ 4
A Critical Examination of Teachers' Analysis of Language Use and Scaffolded Interaction in CLIL Science Classrooms (poster)	Xu, D., Chan, C., Chan, K.H., Fung, D.C.L., Harfitt, G.J., Lee, A.M.S., Mok, I.A.C., Tsui, A.B.M. & Yip, V.W.Y.	The American Association for Applied Linguistics (AAAL) Annual Conference 2017	Portland, Oregon, USA; 18-21 March 2017	RQ 3
Language Play in L2 Junior Secondary Science Classroom Talk (paper)	Poon, S. & Harfitt, G.J.	The British Association for Applied Linguistics (BAAL) Annual Meeting 2017	Leeds, UK; 31 August-2 September 2017	RQs 1, 3, 4 & 5
Learners' Coping Strategies in L2 Mathematics Junior Secondary Classroom Talk: Optimizing L1 Interference and Language Play (paper)	Poon, S. & Harfitt, G.J.	5th Combined Conference of the Applied Linguistics Association of New Zealand (ALANZ), Applied Linguistics Association of Australia (ALAA) and the Association for Language Testing and Assessment of Australia and New Zealand (ALTAANZ)	Auckland, New Zealand; 27-29 November 2017	RQs 1, 3& 5

Optimizing the Use of Deixis in L2 Mathematics Junior High Classroom Talk (paper)	Poon, S. & Harfitt, G.J.	The American Association for Applied Linguistics (AAAL) Annual Conference 2018	Chicago, Illinois, USA; 24-27 March 2018	RQs 1 & 4
Conceptual Scaffolding through L2 Mathematics Junior Secondary Classroom Talk (paper)	Poon, S. & Harfitt, G.J.	The Asia TEFL/MAAL/HAAL International Conference	Macau; 27-29 June 2018	RQ 3
Decoding Metaphors in L2 Mathematics Junior Secondary Classrooms: Learner Motivation and Rapport Building (paper)	Poon, S. & Harfitt, G.J.	The 12th International Conference of the Association for Researching and Applying Metaphor (RaAM)	Hong Kong; 27-30 June 2018	RQ 3
Unpacking Teacher Language Awareness in L2 Mathematics Classrooms (poster)	Poon, S. & Harfitt, G.J.	The 14th Conference of the Association for Language Awareness (ALA)	Amsterdam, The Netherlands; 4-7 July 2018	RQ 3
Hedging in Teacher's Mathematical Talk: An L2 Classroom Case Study (paper)	Poon, S. & Harfitt, G.J.	The British Association for Applied Linguistics (BAAL) Annual Meeting 2018	York, UK; 6-8 September 2018	RQs 2, 3 & 5

Education conferences

Title of paper presentation	Author(s)	Conference	Location and Date	Addressing
Speaking in the right language? Collaborative Meaning-making in L2 Junior Secondary Mathematics Classrooms (paper)	Poon, S. & Harfitt, G.J.	The British Educational Research Association (BERA) Annual Conference 2017	Brighton, UK; 5-7 September 2017	RQs 3, 4 & 5
Spaghetti, anyone? Application of spaghetti diagram to second language (L2) Hong Kong secondary school mathematics and science classrooms (poster)	Mak, K.K.J., Chan, C., Chan, K.H., Fung, D.C.L., Harfitt, G.J., Lee, A.M.S., Mok, I.A.C., Tsui, A.B.M., & Yip, V.W.Y.	The Australian Research for Research in Education (AARE) Annual Conference 2017	Canberra, Australia; 26-30 November 2017	RQ 3
Students' perceptions of English medium instruction in Hong Kong junior secondary science classrooms (paper)	Wong, J.W.Y., Leung, C.Y.T., & Harfitt, G.J.	The Australian Research for Research in Education (AARE) Annual Conference 2017	Canberra, Australia; 26-30 November 2017	RQ 5
An investigation into the influence of classroom discourse patterns on conceptual understanding (paper)	Poon, K.J.H., Harfitt, G.J., & Yip, V.W.Y.	The Australian Research for Research in Education (AARE) Annual Conference 2017	Canberra, Australia; 26-30 November 2017	RQ 5
Scaffolding Word Problem Solving in Junior Secondary L2 Mathematics Classrooms (paper)	Poon, S. & Harfitt, G.J.	The British Educational Research Association (BERA) Annual Conference 2018	Newcastle, UK; 11-13 September 2018	RQs 1, 2, 3 4 & 5