Exclusive use of the second language in classroom interaction in English Medium Instruction science classrooms: The beliefs of students and their monolingual teachers.

ABSTRACT

Previous research on English Medium Instruction classrooms has almost exclusively documented the interaction between a teacher and students where the teacher is able to understand and use the first language (L1) of the students. We present data obtained from science classrooms in EMI high school programs in China where the teacher had almost no L1 proficiency and therefore spoke only English in class. The beliefs of both teachers and students were elicited with regard to L2-only English use in classroom interaction through questionnaire and post-lesson interviews with references to lesson observations. 231 questionnaires were collected, together with 60 interviews with students and teachers following 30 lesson observations. Our findings suggest that teachers divided into three categories of beliefs – virtual position, maximal position, and optimal position (already identified in previous literature - Macaro (2001&2009)), but that students tended to prefer a classroom environment in which some L1 was permitted, or even encouraged, in order to facilitate their understanding of complex science constructs. With increasing teacher mobility and a growing demand of EMI education worldwide, pedagogical suggestions are made to EMI programs with monolingual teachers.

1. Introduction

English Medium Instruction (EMI, sometimes referred to as Content and Language Integrated Learning, CLIL) is now well established as an educational practice in higher education (HE) and in secondary education (Barnard & McLellan, 2013; Kirkpatrick, 2011; Macaro et al., 2018; Wächter & Maiworm, 2014) EMI is when academic disciplines such as mathematics, science and the social sciences are taught through the medium of English but where English is a second language (L2) for the majority of the population being taught. In the majority of these classrooms, the teacher is also someone for whom English is not their first language (Lasagabaster, 2013; Lo, 2015). The main differences between the two terms (EMI and CLIL) are twofold. First EMI is usually (but not exclusively) associated with HE whilst CLIL is usually (but not exclusively) associated with secondary or primary education. Second, the acronym CLIL has built into it the notion that language learning is to be integrated with content learning, whereas EMI makes no such assumption or requirement.

In the last ten years the research field which has investigated EMI/CLIL has also become well established and we now provide an insight into the areas that the field has investigated and are relevant to this study which focused on the beliefs of EMI students and of their teachers. The latter had English as their L1 and did not speak the L1 (Mandarin Chinese) of their students, thus constituting a hitherto under-explored EMI population of teachers. We

used the term ‘monolingual teachers’ to highlight a key feature of the interaction in that these teachers cannot use the students’ L1 functionally in their teaching, setting them apart from the bilingual teachers commonly explored in the existing literature, who speak the L1 of the students. The term ‘native speaker teachers’ is not used because of the connotations attached to it (see Llurda, 2005) and also because it is the teachers’ inability to use the students’ L1 that this study focuses on. Justifications for using ‘monolingual teachers’ are also given in An et al.'s (2021) work. The current study is set in secondary science classrooms in China where the term CLIL is rarely used and therefore we use the term EMI unless referring specifically to a CLIL context. The purpose of this study was to investigate, in EMI science classes in China where the teacher could not use the students’ L1, (i.e., an L2-only environment for teacher-student interaction), the beliefs held by the monolingual teachers and the Chinese students regarding L1 use in classroom interaction and whether these views converged or diverged.

2. Literature review

The role of interaction in learning

Interaction has long been established as an important mechanism for learning. Vygotsky's (1986) sociocultural theory (SCT) describes how cognitive developments originate from the interpersonal plane through interaction with others and semiotic tools, and then internalizes to the intrapersonal plane. The social nature of learning described in SCT inspired the socio-constructivist view of learning, which considers learners as an active player in their knowledge reconstruction (Ernest, 1998; Gredler, 2001), and the dialogue-based teaching approach in science, where learners are encouraged to arrive at conceptualizations through extended interaction (Littleton & Mercer, 2013; Mortimer & Scott, 2003). In SLA, key mechanisms of interaction which facilitate L2 development have also been widely recognized, including comprehensible input (Krashen, 1982), output (Swain, 1985), and corrective feedback (Gass, 1997). Long’s (1996) Interaction Hypothesis highlighted interactionally modified input and output, through negotiation of meaning, as particularly beneficial for L2 development. During negotiation of meaning, learners can obtain comprehensible input through signalling a communication breakdown and can be pushed to produce output by receiving corrective feedback. These theoretical frameworks point to the benefits of interaction in learning science and language, which are particularly relevant to this study as we focus on EMI science classes where the learning of science and English are both of interest.

The impact of L1 on EMI classroom interaction

Given the value of interaction for learning, in EMI literature there is now quite a large body of research on the classroom interaction between teachers and students, and some has focused on the impact the use of the L1 has on classroom interaction, given that (as mentioned above), most EMI teachers can use the students’ L1. Pun & Macaro (2019), in the Hong

Kong secondary context, found that teachers who used more L1 tended to ask higher order questions of their students and those that used less L1 tended to be more monologic in their interaction. Lee (2014), situated in the Korean EMI university context, identified student English proficiency level and the lecture-centred teaching approach as factors behind students' lack of participation in interaction in which students contribute and thereby learn or signal to the teacher where further understanding is needed. As Lee states: 'a considerable mismatch appears to exist between a professor's desire to achieve student learning, and the actual learning activities taking place' (p.109). The suggestion is that comprehension (or 'meaning-making') is sometimes facilitated by L1 use. Meaning making through the interaction also featured in a study by Evnitskaya and Morton (2011) in CLIL classrooms in Spain who found that interaction worked best when it was a 'joint enterprise' (p.123) but this involved drawing not only on English as the language of instruction but also the students' other linguistic resources (in this case Catalan and Spanish). To do this of course necessitated a level of teacher competence in the students' L1.

Functions of L1 use in EMI classrooms

EMI/CLIL research has also focused on the functions to which the L1 is put. Haroon (2005), investigating L1 functions in Mathematics and Science classes HE in Malaysia, found that teachers switched to the L1 for checking comprehension, elaborating on a theme or topic, classroom management and for what the author calls 'linguistic insecurity', which is when the 'teachers faced difficulty expressing new concepts or the meaning of new terms/words' (p.14). Gierlinger (2015) identified similar functions of L1 use in CLIL secondary schools in Austria: behaviour management; task management; explanation of concepts; monitoring the students' comprehension; 'reactions to their own linguistic deficits' (p.358). In addition to these same functions, Méndez García & Pavón Vázquez (2012) reported EMI teachers using the L1 to tell anecdotes involving complex language. Lo & Lin's (2019) study, situated in Hong Kong, examined EMI secondary school teachers' use of L1 and L2 in curriculum genres, i.e., talk which has a specific social purpose, and in task structure, i.e., preparation, focus and elaboration of a point or topic. They concluded that the L1 can be deployed for certain genres and at various stages of the task-structure. Clearly none of these functions would be possible in the L1 if the teacher did not speak the L1 of their students. However, it should be noted that while teachers' switching to L1 was often found to be used to explain subject concepts, Hellekjaer (2017) found no substantial differences between comprehension of lectures taught through the L1 and those taught through EMI in a variety of humanities and sciences lectures in universities in Norway and Germany. Thus, it could be argued that there may be no guarantee that use of the L1 will automatically lead to ease of comprehension because of the technical nature of some of the vocabulary.

The students' L1 use in the classroom was the focus of a study, set in a CLIL primary school in Spain by Pavón Vázquez & Ramos Ordóñez (2019). Among the functions to which the students put the L1 were 'asking for instructions', 'appeals for help', and 'sentence-internal code-switching (p.39). Again, none of these uses of the L1 by students would be possible if

the teacher did not speak the L1. Nonetheless, the researchers do signal a note of caution. Whilst they conclude that some of these communication strategies in the L1 'allow [students] to connect with the lesson content' (p.44), they propose that excessive and non-systematic use of the L1 by them can be counter-productive. Other researchers (e.g., Macaro et al., 2020) have identified an additional potential downside for students: if difficult vocabulary is always translated into L1, will students be slow in developing the inferencing strategies that they will need when an L1 equivalent is not available to them?

EMI teacher and student beliefs about L1 use

In EMI/CLIL, studies have also investigated the use of L1 from the perspective of teacher beliefs. Generally, these studies have concluded that, where a teacher can use the L1 of the students, then that should not be discouraged. Yet, here too there is a lack of consensus as to when and how much to use. Lasagabaster (2013) investigated the beliefs of secondary CLIL teachers in Columbia and, whilst there was some consensus on the L1 for ensuring understanding of content, there was no uniformity of beliefs regarding when the L1 was appropriate at a more granular level. Interestingly, two teachers were 'native speakers' of English but are described as 'very proficient in Spanish' (p.7) and no differences in beliefs were found between them and the local teachers. Roothooft's (2019) study of the beliefs of lecturers in Spain found a difference between those that were teaching Humanities subjects and those teaching STEM subjects with the former declaring a belief in greater restrictions on L1 use. This suggests that teachers of different subject domains may hold different beliefs regarding L1 use. While in the EMI/CLIL literature to date no framework has been proposed for systematically categorizing teachers' views of L1 use, in SLA Macaro (2001, 2009), based on data from foreign language classrooms in secondary schools in the UK, identified a framework of three positions that teachers held on L1 use. These are virtual position, maximal position, and optimal position, respectively referring to a position supporting an L2 only approach, a compromise position of unavoidable occasional use of L1 but maintaining an L2 only ideal, and a positive attitude towards L1, recognising some pedagogical value in it.

Teachers' beliefs about L1 use in EMI classes have also been explored in relation to teacher identities. Studies have identified teachers' beliefs as reflecting their identities as 'translingual teachers' ability to use both linguistic resources (Jin et al., 2021). Teacher beliefs linked to identity were also explored by Lourenço & Pinto (2019) in Portugal where 'expatriate teachers' (with high English proficiency) were compared to 'home teachers'. Some respondents from the former category claimed that 'the fact that teachers are not expressing themselves in their native language detracts from the quality of interaction' (p.11) perhaps even leading to a 'limitation of divergent thinking' (p.11) on the part of students.

Whilst there has been some research on the beliefs of students regarding EMI in general there has been relatively less research on student beliefs about the available languages in EMI. One of these few studies is Liu's (2019) work, studying a 'private bilingual' school in Thailand. It was found that students adhered very strongly to the notion of the 'native speaker teacher'

and ‘native-speakerism’ where, presumably, the L1 would be excluded. Situated in Chinese universities, Macaro et al. (2020) found the students believed that the teacher ‘should attempt to use English at all times’ (p.394), although being open to teachers’ use of L1 when language problems arose. On the other hand, in Huang’s (2014) study of engineering students in Taiwan, some of the interviewed participants would have liked the teacher to provide L1 translation to assist in their EMI teaching ‘wherever appropriate’ (p.153). A similarly favourable view of L1 was also found in Zhou & Mann’s (2021) study where Chinese public university students preferred a small amount of translanguaging to help the learning of English and content. Thus, among the studies on student beliefs about the medium of instruction, findings are inconclusive. In addition, to our knowledge, teacher and student beliefs and attitudes to L1 use have not been compared in a single institution and, particularly in one where the teachers were L1 speakers of English with no access to the students’ L1.

The above existing research led us to formulate the following research questions:

1. What are monolingual EMI teachers’ beliefs about the exclusive use of L2 as the medium of instruction in the classroom interaction in science classes in EMI foreign high school programs in China?
2. What are Chinese students’ reactions to and beliefs about the exclusive use of L2 as the medium of instruction in the classroom interaction in these EMI science classrooms?
3. To what extent is there convergence in the beliefs/reactions between the students and their teachers?

3. Methodology

This study adopted a mixed methods design (Creswell & Plano Clark, 2017) and used questionnaires and semi-structured post-lesson interviews to allow triangulation of findings on teachers’ and students’ beliefs about exclusive L2 use during classroom interaction. While the questionnaire allowed the exploration of a large sample (Dörnyei, 2003), the post-lesson interviews provided in-depth data that could reveal more personalized beliefs and allow discussion with reference to specific scenarios (Borg, 2003). Naturalistic class observations were also conducted, which provided a basis for the post-lesson interviews.

3.1 Research context

The research setting was the international departments of high schools and independent private high schools (Grade 10-12) in China which employed a high number of monolingual science teachers from the US, UK, Canada etc. to teach (often) an Anglophone curriculum. Typical curricula include Canadian provincial high school curricula, e.g. British Columbia and Alberta, IB (The International Baccalaureate), UK IGCSE (General Certificate of

Secondary Education) and A-level (Advanced level) curriculum, and American AP (Advanced Placement) curriculum. The student body is typically homogenous local Chinese students who plan to transition to tertiary education overseas.

3.2 Samples

Seven schools in five cities from three provinces in north, central and south China were recruited, involving 15 foreign monolingual science teachers and their 308 Chinese students. Convenience sampling (Paltridge & Phakiti, 2015) was used for reasons of gaining access to classrooms. Consistent efforts were made to ensure the schools selected could represent variations in the characteristics of the target school programs, such as the geographical location and the type of curriculum being taught. This is shown in Table 1.

Province	School	Curriculum	Teacher	Subject	Gender	Age	Nationality
Province A	Sch 1	Canadian British Columbia	1	Chemistry	F	33	Canadian
			2	Physics	M	54	Canadian
			3	Biology	F	52	Canadian
	Sch 2	British IGCSE, AS, A2	4	Biology	M	29	American
	Sch 3	Canadian British Columbia	5	Physics	M	25	Canadian
			6	Chemistry	M	59	Canadian
			7	Biology	F	24	Canadian
	Sch 4	Canadian Alberta	8	Physics	M	56	Canadian
	Sch 5	American AP program	9	Biology	M	34	American
Province B	Sch 6	IB program	10	Biology	M	36	American
Province C	Sch 7	Canadian British Columbia	11	Physics	M	24	Canadian
			12	Chemistry	F	23	Canadian
			13	Biology/Geology	F	31	Canadian
			14	Biology	F	29	Canadian
		British IGCSE, AS, A2	15	Biology	M	32	British

Table 1 School and teacher background

All 15 teachers specified in a background questionnaire that they did not have a functioning level of Mandarin and their most proficient language was English. This confirms their

monolingual teacher status, in the sense that they do not speak the students' L1. None of the teachers reported having had any training on EMI. All of them held minimally a bachelor's degree and were all qualified teachers in their respective home countries. All teachers had less than five years of EMI science teaching experience, mostly gained in China. The teachers are represented by a number, e.g., T1, to maintain anonymity.

As data from a student background questionnaire shows, the students in this study were 16-18 years old (M = 16.9), including 95 males and 121 females. As there are no standard examinations in China to evaluate students' performance in this type of school programs, the students' science teachers were consulted regarding the students' academic attainment and English proficiency. Most students were described as possessing an intermediate English level, with relatively weak spoken English but having a strong foundation of science knowledge. None of the students reported having attended EMI schools before entering the foreign high school program. 60 students participated in post-lesson interviews. They are numbered from 1-60 to maintain anonymity.

3.3 Data collection instruments and procedures

3.3.1 Questionnaire

A beliefs questionnaire regarding effective teaching and learning in EMI science classes was given to teachers and students. The item most relevant to this study is a multiple-choice question giving the options of different types of teachers with different degrees of L1 use, including a NS teacher, a bilingual teacher, and bilingual teaching assistant. The term 'NS teacher' was used in the questionnaire because it is a more commonly used term and more familiar to the participants to refer to the teacher population in this study, whereas 'monolingual teacher' may be obscure to them. However, to make it clear that the NS teachers in this case cannot speak the students' L1, thus meeting the requirements of 'monolingual teachers', in the options 'NS teacher' is always described as 'a native English-speaking teacher who doesn't speak any Chinese'.

The option of a bilingual teacher assistant was included on the basis of Macaro et al.'s (2014) work, which showed the effectiveness of bilingual teaching assistants in monolingual NS teachers' EFL classes in the UK. All 15 teachers returned the questionnaire, and 216 student questionnaires were returned with a response rate of 70%.

3.3.2 Classroom observation

Non-participant naturalistic observations were conducted by the first author of the 15 monolingual science teachers' classes. Each teacher was observed for two consecutive lessons, and in total 30 lessons, 1520 minutes, were observed and video-recorded by the first author from the back of the classroom with participants' written consent.

3.3.3 Post-lesson interviews

After each of the 30 lesson observations, a post-lesson interview was conducted with the teacher, and another interview was conducted with two students from the class, both by the first author. The two students were identified by their teacher to be of average academic attainment and English proficiency. Both teacher and student interviews are semi-structured, and used general, prepared prompts to elicit reflections on their experience, in the lesson just observed, regarding the exclusive use of L2. The teacher interviews were conducted in English. The students' interviews were mostly conducted in Mandarin Chinese to allow clear expressions of their views, but the students were instructed that they could use English at any time in the interview.

All interviews were audio-recorded with participants' consent and each lasted approximately 30-40 minutes. In total, 30 teacher interviews and 30 student interviews were conducted. Interview protocol is available on request from first author.

3.3.4 Ethics

Before data collection, teachers and students were briefed on the project and given participant information sheets and consent forms, which explained the content of the research, including the video recording of classes and audio recording of interviews, their right to withdraw at any time and the anonymity of their identity. As the students were above age sixteen, consent was sought directly via a consent form approved by the authors' institution ethics committee.

3.4 Data analysis

The teachers' and students' answers to the multiple-choice question in the questionnaire were analysed quantitatively to show the distribution of the answers. The interviews were transcribed verbatim and the analysis followed an inductive thematic coding process. Common patterns or themes were identified. This process was iterative, and the themes were refined and modified throughout the process of coding to make sure all themes were systematically covered (Braun & Clarke, 2006). As the themes were emerging, three stances were revealed, which matched Macaro's (2001, 2009) framework of foreign language teachers' positions on L1 use, i.e., virtual position, maximal position, and optimal position. As Macaro described, the virtual position represents the views that L1 should be strictly banned in the classroom; the maximal position holds the same ideal of L2 exclusivity but with compromises to allow L1 use to a minimal degree if L2 becomes infeasible in reality; and the optimal position shows a clear belief that L1 has some pedagogical value and should not be excluded. Although this framework was developed based on data from foreign language classes in the UK, it aligns with the stances shown in this study and can represent the beliefs demonstrated by the teachers in this study. Thus, this framework is adopted as the overarching framework for presenting the findings, and discussion below. Another

researcher coded 10% of the interview data using this framework, including three teacher interviews and three student interviews, independently, and the stances aligned with the original coding.

The video recordings of the lessons were imported to NVivo 11, and the teacher-whole class interaction in all the lessons was transcribed verbatim. The lesson transcripts provided a reliable source to understand the teachers' and students' comments on any particular episode of the lessons referred to.

4. Findings

4.1 Questionnaire findings

Clear contrasts were found between the teachers' views and students' views. As shown in Table 2, most of the teachers preferred a native English-speaking teacher who does not speak any Chinese, i.e., monolingual teachers, with some teachers supporting the option of having a bilingual teaching assistant at the same time. In contrast, the vast majority of the students either preferred a bilingual teacher who occasionally uses Chinese or a bilingual teacher who uses Chinese half of the time.

Item: Suppose you have the following four choices for your EMI science classes, please circle the option you prefer and explain why.	*Frequency of teacher answers*	*Frequency of student answers*
a. having a bilingual science teacher (usually a Chinese person) who is highly proficient in both English and Chinese to teach mostly in English and occasionally in Chinese to help.	3	94 (43.5%)
b. having a bilingual science teacher (usually a Chinese person) who is highly proficient in both English and Chinese to teach half of the time in English and the other half in Chinese.	0	73 (33.8%)
c. having a native English-speaking teacher who doesn't speak any Chinese.	7	17 (8%)
d. having a native English-speaking teacher who doesn't speak Chinese, and a bilingual teaching assistant (usually a Chinese	5	32 (15%)

person) who is highly proficient in both English and Chinese to help individual students.

Table 2: Distribution of the teachers' and students' answers to the multiple-choice question in the questionnaire (Teacher N= 15; Student N= 216)

4.2 Interview findings

4.2.1 Teacher views of L1

The post-lesson interviews revealed more nuanced views on L1 use among the 15 teachers. The cross-tabulation of the 15 teachers' interview findings and the questionnaire findings is given in Table 3.

Interview findings	Teachers	Questionnaire findings
Virtual position (N=7)	T1, T2, T6, T8, T12, T13, T14	c. NST with no L1
Maximal position (N=2)	T7, T15	d. NST with a bilingual teaching assistant
Optimal position (N=6)	T3, T 9, T10	
	T4, T5, T11	a. bilingual teacher who occasionally uses L1

Table 3 Cross -tabulation of teachers' views in the interview and in the questionnaire (Teachers N=15)

Table 3 shows that the teachers' positions in the interviews aligned with their choices in the questionnaire, which confirmed the reliability of the interview coding. The virtual position entails a view of excluding L1 use, which matches with 'c. NST with no L1'. The maximal position allows some use of L1 as a compromise of an L2-only ideal, thus leading to a choice of an NST with a bilingual assistant, and the optimal position sees L1 as valuable resource, which could be realized either through an NST with a bilingual assistant or a bilingual teacher.

In the interviews, the teachers adopting the virtual position argued that for students to learn how to communicate science ideas in English listening to input and producing output in L2 only was the most effective approach. As T12 argued, - "*If I don't challenge them to interact in English, they are not going to improve their English and vocabulary*." Another explanation offered was '*students might not interact with you in English if they knew Chinese was available'* (T13). A strict disapproval of seeking L1 translations was seen, although a

problem was also recognized among the virtual position that the Chinese students '*knew the science concepts in their L1*' but '*can't quite verbalize it in English*' (T13). In elaboration of his virtual position, T8 reflected on his practice of modelling an L2 definition of a science concept in his physics class on reflection and refraction. This provides a clear example of the virtual position.

Lesson excerpt 1

Turn	Timespan	Content	Speaker
38	13:35 - 14:01	…OK, we will go over new vocabulary. OK, first of all, what's the main difference between reflection and refraction? Can someone tell me that? Tim, what's reflection?	T
39	14:01 - 14:08	Er, em, the, [using a hand gesture to show 'bouncing']	S
40	14:08 - 14:10	The bouncing of light [T showing the same hand gesture]	T
41	14:10 - 14:15	Er, em, [still using the hand gesture to show what reflection is]	S
42	14:15 - 14:19	OK, repeat after me. Reflection is	T
43	14:21 - 14:22	Reflection is	Ss
44	14:22 - 14:24	The bouncing of light	T
45	14:24 - 14:26	The bouncing of light	Ss
46	14:26 - 14:28	Off a surface	T
47	14:28 - 14:30	Off a surface	Ss
48	14:30 - 14:45	Off a surface, usually a piece of glass. It bounces off, ok, like a mirror, when you look into a mirror, you are seeing a reflection, your reflection in the mirror. Light is bouncing off.	T

Table 4 Lesson Excerpt 1

T8 commented that he was sure that the students knew the concepts. He explained that '*we have talked about this a lot in the past few lessons*', and he mentioned '*he (Tim) obviously understood the concept as he was able to gesture it'*. The problem was that '*he could not remember the word 'bouncing*'' and '*they (the students) don't have the language skills'*. T8 explained that he often asked students to repeat after him an L2 definition of a science concept when they were not able to explain it in English and argued this was most helpful for developing students' ability to discuss science ideas in English. This same view was also expressed in his reflection on his reportedly regular practice of providing L2-only definitions of new vocabulary, where he '*made sure the students were not translating*'. The disapproval of L1 translations for new vocabulary was also given by other teachers. T14 argued - '*bilingual dictionaries are counter-productive. How are they going to speak and use English if they constantly use a translator? It's a crunch*'.

Apart from verbalizing science ideas in L2, the use of L2 only as the language of thought was also considered important by the teachers holding the virtual position. T6 provided a detailed explanation - '*students who routinely think things through in Chinese before answering in English make more mistakes in grammar, structure of sentences and are less able to demonstrate their understanding of the subject matter in English.*' T2 further elaborated– '*they are having the word in English, but they have to learn to think about it in English, too'.*

This demonstrates a belief that L2 should be the only language of thought to process concepts and organize ideas, and L1 is a hinderance.

Contrary to the virtual position, the teachers holding the optimal position expressed clear belief about the benefits of L1 for students' science learning. The teachers often expressed the wish they could provide L1 equivalents in time themselves for students to access previous knowledge. For example, T10 commented that he wished he could '*give students the Chinese equivalent for molecule'*. He explained - "*I think they do know it (molecule)…And I take a look at their homework, their notes, and I see many times in the margins of their homework the Chinese written above the word."* He also commented that when some students shouted out an L1 translation for words, he often saw '*a lightbulb go off*'. In elaboration of her optimal position, T3 reflected on her practice of actively eliciting L1 translations from the students in her biology class on biomes. This practice is shown in Excerpt 2, where a group of students were writing similar and different characteristics of different biomes on the blackboard.

Lesson Excerpt 2

Turn	Timespan	Content	Speaker
80	13:14 - 13:17	Can you get one more thing the same?	T
81	13:17- 13:44	Yes. [students discussing in front of the class and writing on the board]	Ss
82	13:44 - 13:53	Yeah? You have that Chinese word. Does anybody remember in Chinese what lichen is?	T
83	13:53- 13:57	[Wait time, students looking up the word in their bilingual e-dictionary]	T
84	13:57 - 14:03	Anybody remember the Chinese word for lichen?	T
85	14:03 - 14:12	[Wait time, students looking up the word in their bilingual e-dictionary]	
86	14:12 - 14:20	Sam and William? Lichen and …? Mosses. Lichen and moss. Anybody remember what lichen is in Chinese? Have we got the e-dictionary? Lichens? L-I-C-H-E-N?	T
87	14:15 - 14:17	地衣 (lichen).	Ss
88	14:17- 14:19	Ah! Very good.	T

Table 5 Lesson Excerpt 2

In this excerpt, T3 was eliciting the L1 equivalent of '*lichen*', a common plant found in the Tundra, from her students, and provided substantial wait time for students to look for the L1 equivalent, shown in Turn 83 and 85. In Turn 86, T3 also spelled out the word and encouraged the students to use their e-dictionary to look for L1 explanations. She explained that '*lichen*' could be a new word for some students and *'if they are not getting it, it makes sense to let them use Chinese, so they understand the definition. What's the point of telling them a word if they don't understand it?'.* In the end, some students provided the correct Chinese word for lichen – '地衣'. T3's reflection demonstrates a priority of ensuring immediate comprehension, with the help of L1 translation. The issue of language of thought was also mentioned and it was

argued that thinking about science in students' L1 '*is natural to them'* (T10) and '*as long as they can give ideas in English, you know, sufficient for what I asked of them*' (T4), it is acceptable.

Two teachers demonstrated the maximal position. They held a similar view to the virtual position that L1 use was not beneficial, and they argued against the practice of actively integrating L1 use. As T15 explained - '*I don't think being able to speak to the kids in Chinese would be an advantage to them because they have to learn the course in English.'* However, they recognized the students' need of L1 in understanding vocabulary, which they described as a practice that they '*do not encourage but they do it themselves anyways'*. The teachers commented they were willing to accommodate such need. T7 explained – '*If they really need to, I will give them time to let them look up words in their dictionary and write down the Chinese explanation of words they don't know*.' While holding the same ideal of L2 only as the virtual position, a key difference of the maximal position is that the teachers did not strictly disapprove of L1 translations but saw them as unavoidable given the students' level of English.

Given that the teachers in this study could not speak the students' L1, L1 was in fact mostly observed in student group discussions and this was frequently commented on in the interviews. The virtual position argued that only L2 should be used in group discussions. T13 provided such an argument - '*if you get them to practice speaking with someone about what they have learnt in English, they are going to progress with their English skills and also improve their ability to explain specific information about science*.' This attitude echoes with the virtual position's view of teacher-student interaction, where speaking in L2 only was believed to naturally improve students' ability of describing science ideas. However, the challenge of this approach was also recognized, as T12 proposed, '*they all sit and look at each other'*. The teachers holding the maximal position, on the other hand, recognized the infeasibility of an L2 only approach, and demonstrated a compromise attitude. T7 explained that '*because they (the students) never learnt it in English, they did not know how to explain it in English'*, and with the allowance of L1, *'they can have more in depth discussion, and overall improve their ability of explaining science ideas*'.

The teachers holding the optimal position showed a clear favourable view of L1 use during group discussion for the purpose of maximizing the benefits of it for science learning. A typical explanation is from T4 - "*During group discussion, more capable students will be able to translate the information to Chinese for the students who do not get it*." T9 argued – '*The ultimate goal for an international program is that the students can talk about science and debate in English, but that does not happen. They always go back to Chinese.'* He thus raised the question- *'if they can't express themselves correctly in English, what's the point of demanding it? They would just be sitting there and doing nothing.'* This demonstrates a view of prioritizing the learning of science in an L2 class where L1 is realistically needed for accurate communication about science.

4.2.2 Student views of L1 use

Unlike the teachers' range of views, the students showed clear and consistent need of L1, which aligns the closest with the optimal position.

The students' view of L1 was frequently elaborated in terms of the missed opportunities of interaction with the monolingual teachers in class, and the obstacles this caused in their science learning. A common theme was that the L2 only input without references to L1 was too dense, leaving students little time to process all the information (see also An & Thomas (2021)). The practice of translation in their minds to L1 was often reported. S41 after T11's first physics lesson provided a typical explanation - '*I often need to translate the teachers' talk into L1 and then go through the information in my head, and then I could not keep up.*' Comments like this indicate students' reliance on L1 as a language of thought to comprehend L2 input, and how this additional cognitive processing step of translation caused delays in their comprehension.

More specifically, the lack of timely connections with the L1 equivalents of science terms, learnt previously, was reported as having prohibited comprehension in particular. S27 from T7's first biology lesson on the structure of plants explained that she was eventually able to connect *xylem* and *phloem* with their Chinese equivalents (导管 and 筛管), and then realized that she had already learned this in her previous CMI (Chinese medium instruction) middle school, thus allowing her to access her prior knowledge about the functions of them (see more in An & Thomas (2021)). Interestingly, their teacher, T7, explained that she had no idea what the students had already learnt, and that '*when it has been like a crossover, it hasn't really helped because it's in English, and so they have to relearn the word anyways.'* Thus, a contrast was shown between the teacher's views and students' views in the matching of L2 science terms with their L1 equivalents.

Similar examples of preferring L1 equivalents were also found in other lessons. After T13's first biology lesson on continental drifting theories, S49 and S50 explained that they did not understand the meaning of '*magma*', a key word repeated several times in the lesson and used in the explanation of plate tectonic theory, until they found the L1 equivalent, as shown in Excerpt 3.

Lesson excerpt 3

Turn	Timespan	Content	Speaker
16	17:52-18:14	Ok? Um because Harry has um knew that there's an eruption in the ocean floor. Em, this eruption is producing magma. You all know what magma is? Where does magma come from?	T
17	18:14-18:17	[wait time]	T
18	18:18-18:19	Jack?	T
19	18:19-18:23	Er, coal? coal?	S1
20	18:24-19:17	So, it basically comes from beneath the earth. But, when we think of magma, it comes from volcanoes. Right? That's magma. Ok? It's like molten rock. Ok? And what happens is that the magma pushes the older rocks away from the ridge, ok? which I illustrated earlier	T

		for you. Now, the magma, ok? is basically molten basalt. When the magma cools down and it hardens, it becomes molten basalt which contains a lot of iron. Ok? Remember? Iron from the core of the earth? Liquid iron? Well...basically...it's magnetic! It's magnetic. OK? Now,	
21	19:24-19:25	What is the molten basalt?	S2
22	19:25-19:26	Sorry?	T
23	19:26-19:28	What is the molten bare...basalt?	S2
24	19:28-19:50	Molten basalt? Oh, ok. So basically, when magma is not yet solidified, right? It's going to cool down, it's going to harden, which turns into molten basalt, ok? And this molten basalt contains a lot of iron, which is magnetic. Magnetic. Ok?	T

Table 6 Lesson Excerpt 3

In Excerpt 3, the students did not seem to know the meaning of 'magma' when the teacher checked in Turn 16. After a long wait time, a student provided an incorrect answer that magma comes from 'coal'. Then the teacher provided a lengthy L2 explanation in Line 20. However, a key phrase contained in this explanation, 'molten basalt', caused further comprehension problems, demonstrated by the student's question in Turn 23. In the post-lesson interview, S49 and S50 explained that they only understood one feature of magma, which is it contains iron, but immediately understood the meaning of it when they looked it up in their bilingual dictionary after the class and saw the L1 equivalent '岩浆', which was a common everyday word they knew. The students explained that a timelier provision of this L1 equivalent would have helped them in understanding plate tectonic theory, where 'magma' was contained. Given the monolingual teachers' inability of providing L1, S51 stated - '*I wish the teacher could pause her teaching from time to time, giving students some intervals to look up new words in our Chinese -English dictionary*'. The strong hope for connecting with L1 to access meaning was also demonstrated in students' appreciation of classmates providing L1 to each other - '*when the teacher said some new words in class, and then students used the e-dictionary to look them up and told the class in Chinese, that was very helpful*' (S14). These comments show that from the students' perspective, L1 equivalents of either science terms, or unknown everyday words, like 'magma', were perceived as highly beneficial, allowing more efficient comprehension of teacher input.

Apart from comprehending L2 input, difficulties with asking questions in L2 was another aspect of classroom interaction that was frequently commented on. The students often mentioned they had questions about certain topics in the lesson observed but did not ask the question in class due to the pressure of phrasing the question in L2. S36 explained - '*I did not have enough time to organize the language to ask this question.*' S35 also mentioned - '*if the teacher is Chinese, I will be able to ask the question right away*.' Phrasing a question accurately in L2 to obtain the answer they wanted emerged as another issue. S57 explained -

'*with a bilingual teacher if we can't figure out the question in English, we will ask in Chinese. This way the answer we get is much better and our understanding will be better*.'

Excerpt 4 shows an example of a missed opportunity of asking questions to the teacher, observed in T4's first Biology lesson on biomolecules, where the students resorted to L1 to express their concerns to each other.

Lesson excerpt 4

Turn	Timespan	Content	Speaker
142	14:30-14:35	OK. Does anyone drink, er, what's it called, dihydrogen monoxide?	T
143	14:35-14:37	Dihydrogen...?	Ss
144	14:37-14:45	Dihydrogen monoxide. Do, do you like to drink dihydrogen monoxide?	T
145	14:45-14:47	[wait time]	Ss
146	14:47-14:51	Do you like to drink it? Have you ever had it before?	T
147	14:51-14:53	[wait time]	Ss
148	14:53-14:58	Dihydrogen monoxide? Ever had that before?	T
149	14:58-15:03	H two O, 那不是水吗？是啊. (Isn't that water? Yes, it is.) [Ss talking to each other]	Ss
150	15:03-15:10	You never had it? Yeah if you... So, have you had it before?	T
151	15:10-15:11	Yes.	Ss
152	15:11-15:18	H two O, 为什么不这么说？Di 不是二吗? (H two O, why doesn't he just say that? Di is two, isn't it?)	Ss
153	15:18-15:25	All right, so, we were talking about carbohydrate, right? …..	T

Table 7 Lesson Excerpt 4

Here, the students were confused by the teacher's use of the chemistry term 'dihydrogen monoxide' to refer to 'water'. Clearly the monolingual teacher did not understand the students' questions to each other in L1 in Turn 149– 'H two O, 为什么不这么说 ('H two O, why doesn't he just say that)'. The students even tried to use their understanding of the prefix 'di' to confirm with each other their guess in Turn 153 – 'Di 不是二吗' (Di is two, isn't it). The teachers' several repetitions of the question in Turns 142, 144, 146, 148, 150, without a response from the students, also revealed the students' lack of clarity. This issue seemed unresolved at the end, as no one raised the question in L2 to the teacher. After receiving the answer 'yes' from a few students in Turn 151, the teacher moved on to the next topic. When reflecting on this excerpt, S13 explained that '*we were confused then and did not react quickly enough with a question in English*'. This shows again the difficulty of phrasing questions in L2 promptly in class, which may leave issues unresolved. As a result, many students mentioned they gave up interaction with the teacher to seek clarifications, and instead they '*preferred working out problems with peers in L1 in class or after class*' (S7).

In connection with Excerpt 1 on the science concept 'reflection', S29 and S30 from this class explained that they did understand the concept of 'reflection', which they gave the correct L1

equivalent for '反射' (reflection), in the interview. They explained that they actually learnt this concept in their CMI middle school, but the problem was that they could not explain it in English. This comment also justified the student's lack of verbal explanations in Excerpt 1. As a result, they stated that an important thing they learnt in this lesson was '*how to use English to explain concepts*' (S29), and the monolingual teacher's '*modelling of L2 explanations of concepts*' (S30) was very valuable to them. This view demonstrated that when the students could not phrase in L2 a description of a science concept they already understood, they appreciated the L2 only input. However, this view was found only when they were focusing on learning the appropriate use of the scientific language. When the students were still trying to comprehend the science concept itself, they much preferred provision of L1 equivalents of key words, and the option of interacting in L1.

5.Discussion and conclusion

We will begin this discussion of the current study by listing what we believe to be the key findings:

1. Most teachers in the sample did not favor the bilingual-teacher options proposed to them.
2. More than half of the teachers believed in L2 only instruction for the purpose of promoting L2 development.
3. There was some support among teachers for a system of an English-only (monolingual) teacher with a bilingual teaching assistant.
4. Some teachers believed in the importance of the language of thought being the L2.
5. On balance, students preferred a bilingual teacher, and the option of using L1.
6. Students believed that the classroom interaction was restricted because of L2 exclusivity.
7. Students had difficulties fully understanding a science concept only explained in the L2, and needed L1 equivalents for immediate access of prior knowledge.
8. Students used the L1 in group work believing it to allow more in-depth discussion.
9. In this study, and in relation to data already published (An et al., 2021), having a highly proficient L2 speaker teacher did not lead to greater interaction and therefore student participation – the classroom was not noticeably more student-centred.

First, clear divergence was found among the monolingual EMI teachers themselves, where the L2-only ideology emerged to be a popular belief, reflected in the virtual position and maximal position. This belief shows an underlying assumption that immersing students in an L2 only classroom would naturally lead them to learn how to communicate in L2. Such a belief is not uncommon in bilingual programs. Studies often find that many EMI teachers, mostly bilingual teachers, are in favour of a monolingual approach and regard the use of L1 a deficiency for students' L2 development (Galloway et al., 2017; Paulsrud, 2016). However, although an exclusive L2 environment can provide maximum L2 exposure, the L2 input the students receive may not be comprehensible (Krashen, 1982). Indeed, as the students

explained, often they had problems comprehending the ‘dense’ L2 input from the teacher, thus indicating an unfavorable condition for L2 development to occur. In addition, interactionally obtained comprehensible input, through negotiation of meaning (Long, 1996), also reportedly seemed rare, given the students’ difficulties in asking for clarifications and their avoidance of interacting with the teacher. The lack of student output, recognized by teachers across all three positions, shows another unfavorable condition for L2 development (Swain, 1985). Without much comprehensible input, output and interaction, opportunities for L2 development were reduced, which undermines the very concern that motivated the L2-only belief.

In contrast to the teachers’ virtual position and maximal position, the optimal position held by some teachers and all the students seemed to be mostly concerned with students’ science learning, believing it to be inhibited by the lack of interaction caused, it appears, by L2 exclusivity. Given that the students often reported that there were concepts they had not fully grasped through L2 only, it is clear that greater interaction would be needed in which further explanations would be provided. However, the students reported various challenges in engaging in interaction in L2 only with their teacher to seek clarifications. Findings published elsewhere using classroom observation data from the context of this study (An et al., 2021) also showed a low level of interaction, which was no more than there is between bilingual teachers and students reported in other research. In other words, while there was a clear need for more interaction to solve comprehension problems in these L2 only EMI classes, this in fact did not happen. Findings from An & Thomas’ (2021) study on student beliefs about the role of interaction for learning also added further details of the challenges the students experienced in the specific processes of interaction through L2 only. Together these findings indicate that the use of L2 exclusively may be a strong factor for the limited classroom interaction.

Facing the restraints L2 put on interaction, the students pointed to the various ways timely use of L1 could facilitate interaction, such as easing comprehension and enabling accurate and prompt phrasing of questions to obtain clarifications. Furthermore, given that science discourse is highly technical, decontextualized and packed with high lexical density (Lemke, 1990; Seah & Silver, 2020), EMI students are likely to face challenges in using contextual clues to infer the meanings of unknown words. As Sweller (1998) argued, working memory has limited capacity, only able to hold and process a certain amount of information at any one time. Thus, the additional language challenge for L2 EMI students may lead to cognitive overload while simultaneously trying to make sense of the new science knowledge, and hence giving rise to a feeling of the input being ‘dense’. As Excerpt 3 shows, when an explanation is being given about one word, clarifications of other words contained in that explanation may also be needed, e.g., ‘molten basalt’ contained in the explanation of ‘magma’. When the students feel they cannot ‘keep up’, or phrase a question in L2 accurately and quickly, L1 is a much-needed tool to reduce their cognitive load. What was found with monolingual teachers in this study also adds evidence to the roles L1 has been observed to fulfill in bilingual EMI teachers’ classes, e.g., students’ use of L1 to appeal for help (Pavón Vázquez and Ramos Ordóñez, 2019), teachers’ use of L1 to explain language to make subject concepts comprehensible (Gierlinger, 2015; Macaro, Tian & Chu, 2020).

A particularly strong reason cited by students for needing L1 was to access previous knowledge. This may be due to the fact that the students in this study had already previously acquired substantial science knowledge in L1. However, the divergence between the students' need of matching the L2 label with concepts they already learnt and some teachers' belief that L2 is the best vehicle for thinking showed misalignment of their understandings of bilingual learners' cognition. It has been well established in the literature that bilingual learners utilize their whole linguistic repertoire to make meaning. Cummins' (1979) idea of common underlying proficiency states that multilingual students did not have to relearn the concepts previously learnt in L1 in a new language, they just need to learn the label for an intellectual skill they have already learned. Moreover, in the more recent literature on 'translanguaging', a psycholinguistic case is made that languages available to the students cannot even be separated or easily siloed (García & Li, 2014). A growing number of classroom-based studies have also shown how translanguaging as a pedagogy can allow more effective content learning by integrating students' L1 (e.g., Lin & Lo, 2017; Poza, 2018; Zhou & Mann, 2021). In the SLA listening comprehension literature, prior knowledge of the topic of the input has also been argued to compensate for linguistic deficiencies to enhance listening comprehension (Macaro et al., 2016). Thus, in this context where the students' English proficiency was limited but they possessed a fair amount of prior science knowledge, access to this knowledge, by integrating L1, is particularly important in increasing their ability to comprehend teacher input.

Given the challenges of interaction with the teacher in L2 only, unsurprisingly the students sought more interaction opportunities with peers during group discussion through L1. They believed that in group work the L1 allowed them to interact around the topic in question in much greater depth. It should be noted that in Macaro et al.'s (2014) study, the bilingual teaching assistant also mainly supported student group work, not up-front teaching, and the oral fluency of the class with a bilingual assistant progressed more than the other classes. However, the contextual difference between this study and Macaro et al.'s (2014) study, which was an EFL one, means there may be some differences on the functions of L1 use. In an EMI class L1 may be used more for explaining concepts and students' articulation of their content knowledge over others when compared to an EFL class where the objective is to demonstrate growing competence in the language itself. Given the students' experiences in this study, a bilingual teaching assistant in an EMI class could be a helpful resource in their monolingual teachers' classes to bridge the teachers' L2 input and the students' existing subject knowledge in L1, help students phrase their questions to obtain timely clarifications and compose their answers clearly in L2 in order to demonstrate understanding.

Finally, this desire for L1 frequently expressed by students and some teachers in this study requires some theorizing. A slightly cynical perspective would lead one to propose that by expecting a teacher to provide L1 equivalents for words, phrases or whole explanations of complex concepts this is the easy way out for students. Understanding would require less mental effort. Moreover, the students had only experienced EMI science classes at the high school level, not L1 science classes at this level. Thus, they might be not able to compare accurately learning monolingually (English-only) or bilingually, and have an accurate idea of how much L1 would be needed, i.e., how much of the difficulties of comprehension was

caused by the science content itself, and how much was caused by the L2. Another important concern is that in their current learning situation they would need, as some of the teachers intimated, to be able to demonstrate their understanding of science (in formal assessments) through the medium of English. As some students explained, they did appreciate the L2 modelling of appropriate use of scientific language, as illustrated in Excerpt 1. Thus, the amount of L1 use also needs to be regarded with caution.

Thus, the EMI pedagogical options (if available) would seem to be three-fold:

1). The first is that the monolingual teacher spends considerably longer time interacting and engaging with the students in L2 to ensure a sound understanding of the concept in question. This means the curriculum will inevitably take longer to 'deliver'. Monolingual teachers may also want to integrate more group work so the students can have frequent opportunities to help each other to 'catch up' through L1.

2). The bilingual teacher, should they choose the optimal position with principled L1 use, may take less time to deliver the curriculum but may find that the use of L1 possibly leads the students to be slower in developing their ability to use L2 to demonstrate understanding and learning the appropriate ways of using the scientific language.

3). A further pedagogical option is the use of a bilingual assistant as a form of support for the students, alongside a monolingual teacher (where the institution requires/appoints such a teacher), particularly during group discussion. This last option of course has resource implications for the educational institution in question, and may not always be available. Similarly, the degree of students' dependence on the bilingual teaching assistant also needs to be evaluated.

All in all, the rare monolingual teacher sample in this study allowed exploration of teacher and student beliefs in an authentic L2-only scenario, which adds a different perspective from the previous studies with bilingual teachers. While three pedagogical options are proposed above, further investigation through carefully controlled comparative research would be beneficial. Additionally, as this study only focuses on science subjects, future research is needed to explore teachers' and students' beliefs in other subjects, as implications for teaching may be different.

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