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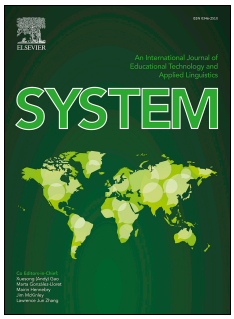

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Title:

Classroom interaction in EMI high schools: Do teachers who are native speakers of English make a difference?

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Abstract

English Medium Instruction (EMI) in secondary education has increasingly become a focus of research. One dimension of this research has been on whole-class interaction patterns of teachers and students, interaction having been established as important for learning in both second language (L2) contexts and in content subjects such as science. Previous EMI studies have reported teacher dominance of the interaction and low levels of student participation. A possible explanation has been that research hitherto has investigated mostly local EMI teachers who have been reported to lack the linguistic proficiency to engage in 'unscripted' interaction. To explore this we investigated the interaction patterns of 15 secondary science teachers in EMI high school programs in China, for whom English was their first and most proficient language in order to eliminate the teacher language proficiency issue. Our findings show that interaction was similarly teacher dominated and students' responses were of low linguistic complexity. Suggestions for further research to identify the reason for low student participation are given, together with some implications for EMI teacher professional development.

Keywords:

English Medium Instruction, classroom interaction; Science

1. Introduction

With English currently being the dominant international language of communication in many walks of life, education systems throughout the non-Anglophone world have been responding by introducing English as the medium of instruction (EMI). This gradual, but rapidly accelerating, change from teaching academic subjects through the medium of the first language (L1 Medium of Instruction; L1MOI) to EMI has occurred most noticeably in higher education (Coleman, 2006; Galloway, Numajiri, & Rees, 2020; Authors, XXXX). However, it is also increasingly to be found in secondary level education where in Europe it is typically referred to as Content and Language Integrated Learning (CLIL) and elsewhere (e.g. Asia and Africa) as EMI or Bilingual Education, but also on occasion as CLIL. Although the acronym CLIL and the term 'Bilingual Education' do not specify that English is the language of instruction, it is generally accepted and empirically proven that English is by far the L2 most often in question.

Research into these classrooms has focused on the interaction patterns between the teacher and her/his students for the important reason that both applied linguists and general educationalists (particularly in science education) believe that a significant amount of student learning takes place through classroom interaction (Littleton & Mercer, 2013; Long, 1996; Mortimer & Scott, 2003). However, the vast majority of EMI classrooms investigated in the literature so far are taught by teachers whose L1 is not English rather than by native English speaking teachers with a high English proficiency. It is the aim of this study to fill that gap by describing the interaction patterns occurring in a specific secondary school type in China.

1.1 Background

The theoretical and research background to which our current study perforce relates is wide-ranging and, in order to allow space for the interaction data we wish to include below, some of this background needs to be presented in condensed form. The background relates to:

- The comparative value of Native Speaker teachers (NSTs) and Non-Native Speaker Teachers (NNSTs).
- The contribution that classroom interaction makes to language learning
- The contribution that classroom interaction makes to content learning.

1.2 NNSTs, NSTs

In SLA, considerable commentary and empirical research has focused on the difference in the contribution that NSTs and NNSTs can make to learning an L2. The question has been addressed from at least two perspectives. The first of these is a sociolinguistic one. Since the term NST has almost always been applied to English NSTs (Llurda, 2005; Marr & English, 2019), and English is increasingly seen as encroaching on and/or threatening other languages and cultures (Kirkpatrick, 2011), the English NST has sometimes been considered as an interloper in non-Anglophone-settings, unjustifiably ranked higher than the NNST (Benke & Medgyes, 2005) and sometimes resulting in discriminatory hiring practices against NNSTs (Mahboob & Golden, 2013). The second is a pedagogical perspective. One of the main counterbalancing arguments to the linguistic superiority of the NST (i.e. her/his level of proficiency in English), has been that

the NNST can use the L1 of the students to assist them in understanding and learning English. While there is as yet little hard evidence (i.e. through highly controlled research designs with standardised tests as outcomes) as to who is worth more, the NST or NNST, as in Medgyes' (1992) original question, there is a wealth of evidence that NNSTs do indeed use the L1 in various degrees of frequency, and for various communicative functions. Evidence of L1 use is in English language learning settings (Jafari & Shokrpour, 2013; Lin, 2013; Authors, XXXX) and increasingly now also in EMI settings (Barnard & McLellan, 2013; De la Campa & Nassaji, 2009; Haroon, 2005; Tarnopolsky & Goodman, 2012).

The acronyms NST and NNST are however problematic, as discussed by Dewaele (2018) and Thomas & Osment (2019). Some of these problems include that some NNSTs can, to all intents and purposes, reach such levels of proficiency as to be able to claim parity with NSTs; not all NSTs necessarily possess a very high level of proficiency in all registers of the target language; NNSTs originating from countries where English is one of the official languages may also consider themselves native speakers of English. Thus, we would argue that a key factor in this field of EMI pedagogy research is the L2 proficiency level of EMI teachers thereby permitting confident use of the target language. The high English proficiency of the NSTs in our study presents a key differentiator from the NNSTs in most of the past classroom-based EMI studies where the teachers' own English proficiency level was often reported to inhibit confident use of classroom interaction (Sopia et.al., 2010; Tan, 2011; Yip et al., 2007). Indeed, for all the teachers English was their first language both in terms of 'the first one learnt' and the one they felt most confident to use in this classroom context. For this reason, we have retained the

acronyms NST and NNST whilst acknowledging that the categories should not, in principle, be considered as watertight.

1.3 The Contribution of Interaction to Language Learning

Interaction in L2 classrooms has sought to demonstrate that student learning can take place without necessarily having to compare the language being taught with the L1 of the students (Ellis & He, 1999; Gass, 2018; Swain, 1995). In brief, this can be done by: making L2 input comprehensible through a variety of modification techniques (e.g. avoiding complex structures, paraphrasing, slowing the speech rate), established in Krashen's (1982) Input hypothesis; taking part in meaning negotiation (e.g. checking student comprehension, encouraging requests for clarification, looking for signs that confirm student comprehension), explained in Long's (1996) Interaction Hypothesis; by requiring students to say something they may not be sure is correct (known as 'pushed output') thus allowing them to 'try out' their knowledge of the L2, explained in Swain's (1995) Output hypothesis, and also enabling possible corrective feedback. Long's (1996) Interaction Hypothesis summarizes that all these processes are essential mechanisms that interaction provides to facilitate effective L2 development. Extending the work on the role of interaction in SLA, Authors (XXXX) further highlighted substantial student turns as a principle of high-quality interaction for second language learning in language classrooms.

1.4 The Contribution of Interaction to Content Learning

With regard to content learning (i.e. the learning of academic subjects other than the L2 itself), teacher- student(s) interaction has also been the subject of increasing research particularly in pre-university education. This research can find its roots in the theoretical perspectives on pedagogy articulated with regard to Science classrooms in L1 contexts (Alexander, 2004; Mortimer & Scott, 2003; Prawat, 1992) where the underlying theory of learning is a constructivist one. Here, through teacher-student interaction, the student arrives at a new or more developed understanding of scientific phenomena, replacing where necessary misconceptions about scientific processes and relationships, or what Yip (2004) calls 'conceptual change'. The constructivist approach is contrasted with what is sometimes called a 'transmission approach', where teachers 'transmit' science knowledge through monologues, as in a uni-directional lecture.

Various focuses and methodologies have been adopted in studying EMI/CLIL classroom interaction. Some has adopted a conversation analysis (CA) framework where the on-going classroom interaction process itself is the main focus rather than the scientific concepts being learned. For example, Evnitskaya & Morton (2011) combined CA with the notion of Communities of Practice (Wenger et al., 2002) to shine a spotlight on learning and identity-formation occurring in CLIL science classrooms in Spain. Some have used the systemic functional linguistics framework (Halliday, 1978, 1994) to analyse language use in CLIL classes (Dalton-Puffer, 2007;Lo & Jeong, 2018). Others has identified and extracted certain aspects of classroom interaction to describe and/or measure these and compare them among teachers. For example, Chin (2007) carried out research on teacher questioning techniques and explored

how the various types of constructivist teacher questioning and feedback can "open up the space for further inquiry and learning" (p.1334, see also Yip 2004). Last but not least, quantitative measures of aspects of classroom interaction have also been taken, for example comparing the *amount* of teacher talk with that of student talk, as conducted in Authors' (XXXX) study and more recently by Authors (XXXX) in a study of EMI teacher professional development. In EMI settings this approach is theoretically justified both in terms of content learning and language learning. As already mentioned, learners are hypothesised to not only acquire more language by being involved in interaction rather than listening to monologic teacher talk (Gass, 2018) but also to acquire a more in-depth understanding of (in our case) scientific concepts (Alexander, 2004). Higher quantities of student talk reflect more student participation in classroom interaction, and can thus indicate more opportunities for language learning and science learning.

In terms of university EMI student *perceptions* of interaction when comparing NSTs or NNSTs, Qiu and Fang (2019) found that science students reported NSTs adopting higher levels of interaction but had less intercultural competence compared with NNSTs who were able to identify students' learning difficulties more. These authors also reported a comparison of one NST and one NNST, which showed that the latter "spent 98.21% of his time lecturing" (p.9) whilst the former used 59.62% of instructional time in lecture mode.

Concerned with the possible disadvantages of EMI, researchers have investigated teacher/student amounts of talk by asking whether these measures differ in EMI classrooms as compared to L1 Medium of Instruction (L1MOI) classrooms. A great deal of this research has been carried out in Hong Kong (Lin, 2006; Yip et al., 2007; Authors, XXXX) with local EMI

teachers, who are typically NNSTs. For example, Yip et al. (2007) found that Cantonese MOI junior secondary science teachers were more interactive than their EMI counterparts. Authors (XXXX) approached the issue by comparing 60 classes in MOI-changing schools and EMI schools with varying degrees of L2 use as the MOI. They found that more L2 use was associated with more teacher talk and less student talk. In the school with the most L2 use in their study, i.e., 79.2% L2 use, teacher talk took 96.0% of the interaction time with student talk occupying only 4.4%, and the average teacher turn length was 36.4 seconds with the average student turn length being only 2.6 seconds. Similar findings were also found in Authors' (XXXX) study situated in EMI classrooms where students produced more talk when the teachers resorted to the use of the L1.

The research findings above suggest that it may be the use of the L2 that is leading to more monologic teaching. This is also reinforced by Dalton-Puffer's (2007) overview of CLIL classes in Europe. In many studies the EMI teachers' own English proficiency was indeed called into question and identified as an obstacle for opening up classroom interaction (Sopia et.al., 2010; Tan, 2011; Yip et al., 2007). Yet Wannagat (2007) found, when comparing EMI history lessons (designated CLIL lessons) in Germany with EMI science in Hong Kong, the former were considerably more interactive, raising the possibility of other factors coming into play, such as subject discipline.

We hypothesised therefore that *at least* the following variables could affect classroom interaction in EMI classrooms: (1) the language proficiency of the teacher; (2) whether the teacher could switch to the students' L1; (3) the discipline being taught. In this study we aimed to eliminate the factor of the teachers' English language proficiency by studying the interaction

of NSTs in China, a cohort, as we have said, hitherto under-investigated in EMI settings. Thus, we believed we would be eliminating a potential reluctance for teachers to involve themselves in high levels of interaction which might result in 'unexpected demands on their proficiency'. We would then be able to compare theirs with the interaction patterns of NNSTs reported in previous research in EMI secondary contexts. We also sought to eliminate a potential subject variable by investigating only EMI science classrooms. A potential fourth variable, teachers' pedagogical content knowledge, could not be controlled for as we did not have access to this variable in previous research publications, and could only obtain self-reported teacher pre-service education in the current study.

To summarise, previous EMI research (both at secondary and tertiary level) has suggested that NNSTs are less interactive than they would be if they were teaching in an LIMOI setting. At least one study at the tertiary level comparing NSTs and NNSTs has suggested that that the latter are less interactive. No study to our knowledge has investigated the features of interaction of a large cohort of science teachers who were NSTs in a secondary education setting. This led us to our research question.

1.5 Research question

What are the features of teacher-whole class interaction in EMI science classes taught by NSTs in foreign high school programs in China?

2. Materials and methods

2.1 Research context

The research setting was the international departments of high schools and independent private high schools (Grade 10-12) in China which had adopted English as the medium of instruction to teach (often) an Anglophone curriculum, and had employed native speakers of English science teachers from the US, UK, Canada etc. The student body is typically homogenous local Chinese students who plan to transition to tertiary education overseas. Examples of the curricula taught include Canadian provincial high school curricula, e.g. British Columbia, Alberta, IB (The International Baccalaureate), UK IGCSE (General Certificate of Secondary Education) and A-level (Advanced level) curriculum, and American AP (Advanced Placement) curriculum.

2.2 Sample

Seven schools in five cities from three provinces in north, central and south China were recruited, involving 15 foreign native speakers of English science teachers and 308 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 of 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, demonstrating that the schools were in different provinces in China and a variety of curricula were included. Although each program administered their entrance exam individually and there was no standardized

exam applied to these foreign high school programs in the country, they were all situated in schools that were regarded as top tier secondary schools in their respective cities, given their students' good academic results in the Chinese medium instruction program. To understand more the level of students' academic attainment and English proficiency, the teachers were consulted. While there was a spread, the majority of students were described as being at an intermediate English level, and possessing relatively strong academic ability. In addition, the estimations from the teachers at the same school were cross-checked and they were similar, indicating a level of reliability of their estimations.

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, thus confirming their NST status. All teachers had less than five years of EMI science teaching experience, most of which was gained in China. Table 1 below shows a summary of the teachers' professional background. All teachers were represented by a number, e.g., T1, to maintain anonymity.

A distinctive feature of the teacher sample is their TESOL experience. Ten out of the 15 teachers had either past teaching experience in TESOL or had training in TESOL, or both. This contrasts with the characteristics of bilingual EMI teachers where they are found to typically not have TESOL teaching or training experience (Barwell, 2005; Lo, 2017). None of the teachers reported having had any training on EMI.

Eleven of the 15 teachers had a Bachelor's degree in Sciences while four held a bachelor's degree not in Sciences but a Bachelor's degree in Education.

Background of the 15 teachers							
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 Teachers' background

2.3 Data collection

Non-participant naturalistic observation (Rose et al., 2020) was carried out by the first author with a camera at the back of the classrooms, taking an unobtrusive role. This data collection method was taken to capture directly the naturally occurring EMI science classes taught in the target school programs, without intervention from the researcher. Although there could be a Hawthorne Effect (Borkowska, 2011), potentially found in observation studies, the teacher and students from each lesson observation commented in separate post-lesson interviews that the classroom interaction behaviour in the lesson observed could represent normal interaction behaviour in their EMI science classes. Lack of space does not permit us to include data from interviews.

Before the observations, the teacher and students were debriefed on the project and given participant information sheets, where they were ensured the privacy of the data and the purpose of the observation was not to evaluate them. Two lesson observations were conducted for each of the 15 teachers, making 30 lessons in total. All lessons were video recorded with participants' consent. The lessons were typically between 45 minutes to one hour, making 1520

minutes of lessons observed and recorded. A wide range of topics were taught from plant structure, biome types, acidic and basic solution, to sound waves.

2.4 Data analysis

All video-recordings of the 30 lessons were imported to NVivo 11, and the teacher-whole class interaction in the lessons was transcribed verbatim. Non-content related talk (e.g., administrative talk) was also not transcribed as our focus was on the interplay between language and content.

Based on the lesson transcripts, discourse analysis (Borkowska, 2011) was performed first through deductive and inductive coding in NVivo to identify the target behaviors for analysis, and then quantitative analysis of the time proportion and frequency of the target behaviors as well as qualitative analysis.

Guided by the literature on the role of interaction in SLA, e.g., Long's (1996) Interaction Hypothesis, and the role of interaction in science education, e.g., the constructivist approach (Alexander, 2004; Mortimer & Scott, 2003; Prawat, 1992), this study has consulted previous research which described classroom interaction and adopted five parameters as target behaviors for analysis to understand the classroom interaction in the 30 lessons.

1). time percentage of teacher talk and student talk

2). the turn-taking behavior between the teacher and students, i.e., the number of teacher turns and student turns, and their respective turn length

3). the noun verb ratio of student talk

4). frequency of IRF sequences

5). time proportion, length and frequency of teacher monologue

Parameter 1) provides an overall level of interaction by showing the time percentage of all teacher talk and all student talk. Parameter 2) examined the frequency of exchanges between the teacher and students, i.e., how often the teacher and students took turns, and the length of their talk each time they spoke. These two parameters were used in Authors' (XXXX) description of classroom interaction behaviors in secondary EMI classes in Hong Kong and Authors' (XXXX) study of EMI in HE in China. The results for these two parameters were obtained following the coding of 'teacher talk' and 'student talk' in each lesson in NVivo, which then allowed NVivo to automatically produce the time proportion and number of occurrences of teacher talk and student talk in each lesson. The time proportions directly provided results for Parameter 1) and the number of occurences provided results on the number of teacher turns and student turns for Parameter 2). The teacher and student turn lengths were produced by dividing the overall time length of teacher talk and student talk by the number of teacher or student turns in each lesson.

Parameter 3) explores the level of lingusitic complexity of student talk because verb use generally requires whole sentences (or at least verb-phrases), unlike nouns and adjectives. The more full sentences were used, the more likely the students produced linguistically sophisticated output, which indicates more experimenting with their interlanguage, thus helpful for L2 development (Swain, 1985). This may also indicate more in-depth elaborations of

their science understandings as science explanations most often involve processes, described by verbs. This parameter was also used in Authors' (XXXX), Authors' (XXXX) and Authors' (XXXX) studies. The result was produced by counting the nouns and verbs in student talk manually in the lesson transcripts, based on number of types rather than tokens.

Parameter 4) was based on the long-established IRF (initiation-response-feedback) structure to understand classroom discourse (Sinclair & Coulthard, 1975), where extended IRF sequences have been argued to reflect more interaction and to be more beneficial to learning (Hall, 1997; Mortimer & Scott, 2003; Wells, 1993). This can indicate how understandings of concepts were developed as the interaction proceeded in the EMI science classes. This parameter was also used in Authors' (XXXX) study. The number of occurrences of IRF sequences of various length, e.g, single cycled IRFs, two-cycled IRFs, were produced in NVivo following coding these sequences.

Parameter 5) emerged from the data through inductive analysis as a common type of teacher talk in this study. They were defined as the parts of a teacher's talk to the whole class where no questions were asked and no student output was invited. Thus, teacher monologues typically entailed delivery of knowledge without checking students' comprehension or inviting students to speculate. Usage of teacher monologues can further reveal the degree of teacher dominance. The results were obtained by coding teacher monologues in NVivo, which enabled production of the time proportion, length and number of occurrences of teacher monologues in each lesson.

While the results for the five parameters were produced for each of the 30 lessons, averages were calculated by adding the results of all lessons and dividing it by 30.

While the quantitative measures provided an overall picture of classroom interaction in a large number of lessons, qualitative analysis was also performed through examining the lesson transcripts to understand the context and content of the target behaviors. This allowed an understanding of the fine detail of interactions that may not have been revealed by the quantitative analysis (Borkowska, 2011; Tsui, 1995; Wragg, 2012). Example excerpts are provided to demonstrate how the target behaviors typically took place and give a more in-depth picture of what was really happening in the classrooms. The students were numbered according to the order of when they spoke to maintain anonymity and are reported as such (e.g., S1, S2) in the lesson excerpts in the results section.

10% of the lessons (i.e., 3 lessons) were randomly selected to be coded again by another researcher. This resulted in an inter-rater reliability of 0.80, indicating a reasonable level of reliability of the coding in this study (Robson, 2002).

3. Results

3.1 Time percentage of teacher-talk and student-talk

Teacher talk took 85.6% and student talk took 11.6% of the teacher-whole class interaction time. Thus, on average, teacher talk took up the vast majority of the interaction time. The percentages were of the teacher-whole class interaction time rather than the whole lesson time.

This way the results reflect the weight of teacher talk and student talk in relation to each other without the impact of other lesson activities.

3.2 Teacher-student turn-taking behavior

On average the teachers took 96.6 turns in a lesson and each turn lasted for an average of 20.5 seconds. The students as a whole on average took 52.2 turns in a lesson and each turn lasted for 3.5 seconds. The ratio of teacher to student turns is roughly 2:1. This matches the long-established IRF (initiation-response-feedback) pattern of classroom discourse (Sinclair & Coulthard, 1975), where the teacher asks a question, followed by a student's answer and then the teacher provides feedback. The considerably short average student turn length, 3.5 seconds, indicates that the students in general did not sustain lengthy explanations of their ideas. Together with the results on total talk, the turn-taking behavior also indicates a pattern of teacher dominance.

Excerpt 1 below is a typical example of the turn-taking behavior, taken from T13's second Biology lesson on sea floor spreading.

Excerpt 1

Turn	Timespan	Content	Speaker
28	3:00-3:12	Now [T drawing], while the uh rocks are being pushed away from the ridge, what's going to happen next? The magma is going to	T

29	3:12-3:13	To cool.	Ss
30	3:13-3:24	Yeah, so magma um cools down, hardens and becomes what? [T writing "magma cools down/ harden"]	T
31	3:24-3:26	Rocks.	S2
32	3:27-3:42	It becomes, before it becomes into a, which contains lots and lots of iron? Ah, ah Lucy?	T
33	3:42-3:45	Magnetic.	S3
34	3:46-3:53	Yes, it will become, the state will become magnetic which is what? It's called--uh Patrick?	T
35	3:54-3:56	Molten basalt.	S4
36	3:56-4:10	Exactly. It will become um molten basalt [T writing "molten basalt"], ok?	T

In the example above, the student turns were short (between one to three seconds) and featured single words or phrases, which are the terminology used in key science concepts in this lesson, such as *magnetic* and *molten basalt*. It could be argued that this was also a result of the way the teacher asked her questions, which left certain key words and phrases for the students to fill in.

Another example is provided in Excerpt 2 to demonstrate another common behavior of turn-taking, where the teacher asked an open-ended question which required a full explanation, but the teacher accepted the student's answer of only a key word without requiring the students to produce a full sentence to explain the whole idea. Excerpt 2 is from T6's first Chemistry class on acids and bases.

Excerpt 2

Turn	Timespan	Content	Speaker
11	02:45-02:47	What would be a Bronsted base then using the same logic?	T
12	02:48-02:49	Accepts.	S3
13	02:49-02:51	Yes, anything that accepts a proton, okay?	T

In Excerpt 2 above, the student's turn was only one second, consisting of one word 'accepts', rather than a complete sentence to describe the whole idea including a process, e.g., 'a Bronsted base would be anything that accepts a proton', a lengthier answer with a more

complicated linguistic structure. The teacher then provided the full explanation himself, based on his interpretation of the meaning of the student's answer, without requiring the student to provide a complete sentence. This was done despite the student possibly knowing the concept, suggested by the key word given, 'accepts', or vaguely remembering that the concept of Bronsted base is related to accepting something.

3.3 Teacher monologue

39.2% of the classroom interaction time was teacher monologues, where no student output was invited. This means that within the teacher talk, 45.6% (i.e., 39.2%/86%) was teacher monologues. Teacher talk that was directly involved in dialogues with students, e.g., teacher questions and feedback, was only 54.4% of the total teacher talk.

Teacher monologues on average took place 13.1 times in a lesson and the average time length of one teacher monologue was 49.6 seconds. Although the average length may not appear long, the teachers used monologues quite frequently, i.e., 13.1 times in a lesson, thus resulting in considerable overall usage of it, further demonstrating teacher dominance where a sizable proportion of teacher talk was uni-directional, leaving limited space for student contributions.

3.4 Noun and verb ratio of student talk

The average ratio of nouns to verbs in student talk was 4.9:1, meaning that for almost every five nouns in student talk there was one verb, thus revealing a strong noun-orientated nature of the student output.

An examination of the lesson transcripts shows that in many cases the student output was not in the form of complete sentences or clauses but often featured a single noun or noun phrase. Excerpt 3 below provides an example, taken from T13's first Biology lesson about continental drift theory. This excerpt took place after a group discussion where students reviewed the four pieces of evidence that Alfred Wegener proposed for continental drift theory, i.e., jigsaw puzzle fit, matching geological structures and rocks, matching fossils and paleoglaciation, which had been covered in the previous lessons. Here the teacher was asking individual students to say what each piece of evidence was.

Excerpt 3

Turn	Timespan	Contents	Speaker
20	13:47-13:48	Fredrick.	T
21	13:49-13:51	Uh...the paleoglaciation.	S1
22	13:52-13:54	Paleoglaciation. Please explain.	T

23	13:54-14:02	Um, glacier...Uh.	S1
24	14:03-14:18	That's ok. So, we have ancient glaciers, right? And the ancient glaciers they what? They, they move, they retreat, they advance, right? [T using gestures to show "move, retreat and advance"]. ….	T

In Turn 21, the student gave one correct piece of evidence, paleoglaciation, and the teacher asked a follow-up question to elicit an elaboration of this evidence. However, in Turn 23, the student only gave a key word, 'glacier', which is a noun, without producing a full explanation of what the glacier did to provide support to the continental drift theory, where the presence of verbs would be necessary. The teacher, in Turn 24, accepted the single-noun answer and then provided the full explanation herself using several verbs to describe the movement of ancient glaciers, which were 'move', 'retreat' and 'advance'. She did not ask the student to try to produce verbs to form a full description even though this was a review. We can speculate that the reason the student only produced a single-noun answer might be that he was not able to identify the appropriate verbs to describe the movements of ancient glaciers, or that he did not remember this scientific knowledge introduced in the previous lessons. However, this is a typical example of students' use of only a noun or a noun phrase in their answers without

composing a complete sentence with verbs to fully explain their ideas, and the teacher did not push the students to do so.

The overall noun-oriented nature of the student talk indicates that the students might not have been sufficiently developing their verb system in English and might not have sufficiently experimented with expressing science ideas in their L2 as science often involves processes (e.g., motion, energy transfers), requiring use of verbs.

3.5 IRF sequences

On average there were 31.6 IRF sequences in a lesson with 13.8 of them being single-cycled IRF sequences, where no follow-up teacher questions were asked. Thus, single-cycled IRFs made up 43.7%, i.e., almost half of, all IRF sequences. The next most frequently used IRFs was two-cycled ones, where a follow-up teacher question was asked based upon the student's response in the first cycle, on average 4.3 times per lesson. The longer IRF sequences were therefore rare, taking place only once per lesson on average.

While examining IRF sequences, it was found that in the limited number of multi-cycled IRF sequences some cycles were in fact made up by teachers' repetitions and reformulations of a previous question. These restatements of questions were usually the result of receiving no responses from students, student responses indicating difficulties in comprehending the question, or incorrect responses from the students. On average in a lesson there were 4.8 repetitions or reformulations of the same question. These extended IRF cycles differ from the type of extended IRF sequences promoted in the literature where follow-up questions are

asked to invite students to further explain their ideas (e.g., Littleton & Mercer, 2013). Considering the already low number of extended IRF sequences in the lessons of this study, this finding means that the actual extended chains of IRFs promoted in the literature were even rarer.

Excerpt 4 demonstrates the typical repetitions or reformulations of a previous question in extended IRF sequences. Excerpt 4 is from T4's second Biology lesson on Biomolecules.

Excerpt 4

Turn	Timespan	Content	Speaker
13	2:08- 2:26	Ok, so what's the difference? There are 22 amino acids. What's the only thing that is different? Lucy, what's the only thing that is different about amino acid?	T
14	2:27- 2:30	Um...different?	S1
15	2:30 - 2:34	What's the difference? So, so these parts [T pointing at the drawing about the structure of amino acids on the blackboard.]	T
16	2:35 -2:36	Ah, the nitrogen?	S1
17	2:37 - 2:39	The nitrogen is different? [T pointing at the drawing about the structure of amino acids on the blackboard.]	T

18	2:39 - 2:41	Maybe?	Lucy
19	2:41 - 2:42	What's the difference?	T
20	2:42 - 2:43	Different?	Lucy
21	2:43 - 2:46	There are 22 amino acids, right?	T
22	2:46 - 2:47	Yeah.	Ss
23	2:47 - 2:54	What's different about, what makes these 22 amino acids different, if everything here is the same [T pointing to the drawing]?	T
24	2:54 - 2:58	Oh! The different order of... [Ss looking down at the textbook]. The R group.	Ss
25	2:58 - 2:59	What?	T
26	2:59 - 3:00	The R group.	Ss

27	3:00 - 4:20	The R group, the R group on the side chain. …	T

Excerpt 4 shows that the teacher repeated and reformulated the question 'what's the only thing that is different about amino acid?' three times in Turns 15, 19 and 23 in this incident of negotiation of meaning (Long, 1996), which started from the student's signal of a clarification request 'Um...different?' in Line 14. The difficulty could have been caused by the language used in the teacher's question, or the students' lack of understanding of the science concept. If this is a language issue, the linguistic structure that could have caused students' problems with comprehension may be the phrase 'different about' or the relative clause 'that is different about amino acid' to describe the noun phrase 'the only thing'. This case of negotiation of meaning was not resolved until the teacher paragraphed the question into 'what makes these 22 amino acids different, if everything here is the same?' These processes mean the exchange of ideas between teachers and students can take significantly longer than in the L1 classrooms, even when the teacher is highly proficient in English. The prevalence of restatements of questions also suggests that pedagogically beneficial extended IRF sequences are rarer than the quantitative result shows.

4. Discussion and Conclusions

Given the value attributed to interaction for both science learning and language learning, this study investigated classroom interaction in 30 science lessons in EMI high school programs in China. The unique NST population with high English proficiency provides a rare EMI scenario in which to observe whether the elimination of the commonly identified challenge in the past EMI literature, teachers' own limited English proficiency (Cho, 2012; Sopia et al., 2010; Tan, 2011; Zacharias, 2013), would lead to more classroom interaction.

The results suggest that, although the teachers had a very high English proficiency level, the classroom interaction remained extensively teacher dominated with student participation limited both in terms of quantity and quality. The general low level of interaction resembles that described in previous studies with local NNSTs in EMI/CLIL/immersion classrooms (e.g., Dalton-Puffer, 2007; Harley et al., 1990; Lin, 2006; Authors, XXXX; Yip et al., 2007). In particular, the heavy time proportion of teacher talk and short student turn length also echo with Authors' (XXXX) finding where teacher talk took 96.0% of the interaction time with the average student turn length being 2.6 seconds.

Limited classroom interaction implies limited opportunities for science learning and English learning in this emerging EMI context as in other EMI contexts. The speaking time proportion and turn-taking behavior data analysis provides a general picture of a lack of substantial output from students. This is further demonstrated by the number of teacher turns being approximately twice those of students reflecting the triadic IRF pattern of interaction, thus

offering few opportunities for negotiation of meaning, whether this be the meaning of a linguistic item or the understanding of a science concept.

It is true that the IRF structure and high levels of teacher talk are also commonly found in L1 subject classrooms (Atkins, 2001; Sunderland, 2001). However, one might posit that in EMI classes there would be even greater need for negotiation of meaning, perhaps involving more student initiations for clarification, or more extended IRFRF sequences where teachers request students to modify their previous output in order to demonstrate understanding. This is especially so when we consider that EMI negotiation of meaning often involves not only negotiation of the meaning of a word (as in EFL classrooms) but also 'negotiation' of a scientific concept. We should note that the same finding of a triadic conversation structure was also found in Dalton-Puffer's (2007) work with CLIL teachers in secondary schools in Austria.

While previous EMI studies have qualitatively reported the prevalent use of single-cycled IRF sequences in EMI classes and the lack of extended IRFs (Authors, XXXX, XXXX), this study provides both quantitative and qualitative evidence on IRF sequences. In addition, the common use of repetitions and reformulations of questions by teachers in the already low number of multi-cycled IRFs indicates the even rarer incidents of what some consider desirable extended IRFs with follow-up questions (e.g., Littleton & Mercer, 2013). This reveals the difficulty in EMI classes of moving conversations forward and the long process of modifying a question repeatedly to elicit answers. This may explain why there were still limited extended IRF sequences even when the teachers had high levels of English proficiency and were unlikely to

close down the conversation due to their lack of confidence with spontaneous (perhaps unplanned) English.

The analysis of our data which found a predominance of teacher monologues (as defined earlier) further underscores a tendency for direct lecturing. Although at times uni-directional sequences of teacher talk may be necessary in order to outline concepts (Mortimer & Scott, 2003), the overall significant proportion of it in this study still reveals a pattern of knowledge transmission, making scaffolding, which is key to the interaction-oriented constructivist view of teaching science (Mansour, 2009; Prawat, 1992), a secondary consideration. Once again, we would posit, the need for careful scaffolding is even greater in an EMI context than in an L1MOI one.

While the previous parameters reveal the low quantity of student output, the strong noun-oriented nature of student output reflects a limited level of linguistic complexity in student output (Authors, XXXX). In other words, we found limited student contributions not only in terms of quantity but also in terms of quality. With limited experimentation through the use of verbs and complete sentence structures (or at least verb phrases), students had reduced opportunities to notice the gap between their interlanguage and the target language forms, which are key to language development (Swain, 1995). The low percentage of verbs used may consequently indicate that, as science ideas and concepts often involve processes and explanations, typically requiring the use of verbs, this low use of verbs by students may offer reduced opportunities for students to elaborate their conceptualisations of science.

Although the classes in our study were not designated or promoted by the school as 'CLIL classes', they were nevertheless operating in a context where both content and language were an issue: content, because teachers were trying to increase the students' knowledge and understanding of scientific concepts; language, because the students could not have the same level of English proficiency as students in an L1MOI class. Although in our study we have eliminated the teacher English proficiency factor, we have found similar patterns of interaction to that in classes where the English proficiency of the teacher was considered a potential limiting factor (Qiang et al., 2011; Sopia et al., 2010; Tan, 2011; Yip et al., 2007). This study shows that the teachers' high English proficiency alone is insufficient to promote students' participation.

Our study had several limitations. One limitation is that space does not allow a further qualitative analysis of each of the lessons. Although the goal of this study was not to understand the subtle and nuanced role relations and context that certainly are in play in the classroom interaction behaviours, more studies that take a conversation analysis approach to understand such dynamics in this new EMI context would be helpful. Given the teachers in this study all had limited EMI teaching experience, we also acknowledge that this may have contributed to the teacher dominance in the classes, as research has shown novice teachers tend to teach in a more teacher-centred manner (Confait, 2015; Hogan et al., 2003). However, Authors (XXXX) found that, with two very experienced EMI teachers, greater student-centred interaction could not be attributed to their experience but to a willingness to consider a change in their pedagogy. Nevertheless, although the EMI setting of the current study is a relatively new phenomenon, it would be profitable to examine classes taught by NSTs with more EMI

experience to examine if their classes are less teacher centred. Another limitation is that we were not able to compare directly EMI classes taught by NSTs and EMI classes taught by NNSTs in the same setting and we have been obliged to compare our data to data provided by other studies with NNSTs teaching in other EMI settings. There thus remains an empirical question to be further explored: what threshold level of student English proficiency enables classroom interaction? In other words, future EMI research would need to control for student language proficiency and then compare three classroom settings in which similar science topics were being taught:

1. Classrooms where both the teacher and students were interacting through their L1 (non-EMI classrooms)
2. Classrooms where the teacher was operating through her/his L1 but the students were operating through their L2 (as in our study)
3. Classrooms where both the teacher and the students were interacting through their L2 (as in Authors, XXXX).

Comparing Setting 1, where both students and teachers have high proficiency in the MOI, and Setting 2, where only teachers have high proficiency in the MOI but the students are still learning the MOI, can provide answers to whether the low classroom interaction is a feature for EMI classes with the students' own English proficiency level being a main factor. More comparisons between Settings 2 and 3 can add further evidence regarding whether the teachers' own English proficiency makes a difference in the level of classroom interaction or whether the interaction level is mostly constrained by the students' English proficiency level.

An implication for teacher professional development is that this study showed EMI training should go well beyond enhancing teachers' English proficiency level and include classroom interaction strategies which scaffold students to produce lengthier output with more sophisticated linguistic structures. For example, teachers should more often require students to provide full sentence answers, rather than quickly accepting single-noun answers. Due to the frequent need to reformulate and restate questions, extended IRF sequences which do elicit more evidence of students' understandings could take more cycles of IRF, thus needing more awareness and persistence from the teacher to keep opening up and continuing conversations. EMI teachers may also need to be aware that IRF sequences in EMI classes need not be rigid, following three-act cycles, and should be encouraged to incorporate more negotiation of meaning, where they request student modifications of output or check students' comprehension and modify their own input.

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5.Declaration of interest statement

None.

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