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Title: Doing Science through Translanguaging: A Study of Translanguaging Practices in Secondary English as a Medium of Instruction Science Laboratory Sessions

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Abstract

This study explores how students in a joint process of knowledge construction through the use of multilingual and multimodal resources in groups promotes the learning of scientific concepts in the context of laboratory work. Inductive qualitative discourse analysis was conducted to examine how students' translanguage in a group completing tasks in two Grade 10 secondary science labs (biology and chemistry) in a Hong Kong EMI secondary school and how such a joint process of knowledge construction promotes the learning of scientific concepts. Using translanguaging as a theoretical framework, the analysis shows that even though schools have imposed an English-only policy, students use their linguistic and semiotic resources to both co-construct their scientific knowledge and practise their science apprenticeship. Translanguaging plays a role in mediating the students' understanding of science, facilitating peer work and creating an enjoyable learning environment in the lab. The result implies that translanguaging as a pedagogical tool may create a space for content subject learning in Hong Kong EMI school setting.

Keywords: Translanguaging, classroom interaction, English-medium-instruction; science laboratory; space for content subject learning

Introduction

English-medium instruction (EMI) is an educational approach that has been increasingly implemented around the world (Author1, 2017; Author 1 and XXX; 2018; Author 1, 2019; Author and XXX, 2020; Dearden, 2015; Graddol, 2006; Macaro et al., 2018). As a form of immersion education, EMI shares some theoretical underpinnings with the content and language integrated learning (CLIL) approach (Dearden, 2015), which are found in European countries with its increased opportunities for English learning in content-subject areas, but EMI has its own characteristics. In Hong Kong, although English has official status and school-level language policy is clear, teachers and students may interact in their first language (L1), Cantonese, in classrooms and laboratory environments when engage in social conversation and when managing learning activities (Evans, 2000). Research has accounted for the natural use of the mother-tongue in EMI classrooms (Poon, 2013). One reason is that teachers and students using EMI in science classrooms have encountered many challenges, including science teachers' limited English skills, their lack of EMI training and their belief that teachers of science are not responsible for addressing students' inadequate English (Marsh et al., 2000; 2002; Othman and Saat, 2009; Yip, Tsang and Cheung, 2003). Similarly, according to Probyn (2001), science teachers in EMI science classrooms, such as South Africa, are generally resistant to being responsible for addressing student's language needs in science learning. Probyn (2006) interviews EMI science teachers in Africa. The science teachers in the study explained that they should not be expected to make science content more accessible to their students in English. Probyn's studies (2001; 2006; 2009; 2015) have shown that most EMI science teachers do not believe they have a role in teaching the language of

science. Science teachers' lack of language awareness has also led to poor teaching practices and limited classroom interaction (Hoare, 2003). As a result, the opportunities for students to learn English as a second language (L2) in the science classroom are limited. In Msimanga et al.'s (2017) recent review, dilemma is discovered among science teachers where they struggle with the choice of language usage. Home language is considered as a resource to help students engage with difficult concepts but it may also hinder science students' development of English proficiency.

EMI classrooms are predicated on the belief that they will provide greater L2 exposure. However, many students do not benefit from English-only instruction due to their poor English ability, thus raising the question of whether translanguaging can play a role in EMI teaching despite studies having reported its benefits (Lin, 2018; Lin and He, 2017). Here, translanguaging refers to the exploitation of multiple languages and semiotic resources in a multilingual repertoire. Translanguaging is potentially beneficial in EMI contexts in which content learning, rather than L2 acquisition, is the primary objective. Nevertheless, there is little research on translanguaging in EMI settings (Lin, 2018), and practical pedagogical suggestions for supporting students' language challenges appear inadequate (Chan, 2014; Poon et al., 2013).

Hence, there is a need to understand how plural languages and content learning interplay in EMI context. In addition, to the best of our knowledge, only a few studies have explored translanguaging in EMI science laboratory sessions. Studying laboratory sessions can potentially shed new light on content subject learning in EMI settings because laboratory sessions provide a space for students to develop their scientific knowledge by engaging in hands-on scientific experiments with their peers. Through investigating forms of interactional communication in a science laboratory setting, this study aims to understand how translanguaging create an interactional space for learning as a means of delivering the knowledge at EMI secondary level. Inductive qualitative discourse analysis was conducted to analyse this process in science experiment classrooms in Hong Kong.

Translanguaging in EMI Classrooms

Translanguaging

The theoretical framework of translanguaging has recently attracted the attention of EMI/CLIL researchers due to the 'multilingual turn' in bilingual education (May, 2014) calling for a more nuanced ethnographic understanding of speakers' complex, multilingual and multimodal repertoires in their construction of meanings. This has encouraged EMI researchers to analyse the tension between the practice of using English as the only language of instruction and the reality of multilingual students speaking multiple languages (Macaro, 2018).

The term 'translanguaging' was first coined by Williams (1994) in the context of Welsh bilingual classrooms in reference to the deliberate alternation between languages for receptive or productive purposes, which is reflected in the practice of reading and discussing a topic in one language and then writing about it in another. Here, the alternation between languages is not spontaneous but rather strategic and deliberate, involving 'using one language to reinforce the other in order to increase understanding and in order to augment the pupil's ability in both languages' (Williams, 2002: 40). Translanguaging was originally intended to help learners develop a deeper understanding

of content scaffolded by one language with another (Williams, 2002). Scholars (e.g. He, Lai, and Lin 2016; Li Wei, 2018) further conceptualise the notion of translanguaging and they argued that translanguaging involves individuals to mobilize all of his/her communicative resources (both English and Cantonese words, co-ordinating gestures, facial expressions, sounds, visual images) to construct knowledge and experience in the dynamic flow of the meaning making process. As Li (2018: 22) argues, translanguaging reconceptualizes language as 'a multilingual, multisemiotic, multisensory, and multimodal resource for sense- and meaning-making, and the multilingual as someone who is aware of the existence of the political entities of named languages and has an ability to make use the structural features of some of them that they have acquired'. Recent studies on translanguaging literature have recognised the importance of deploying multiple linguistic resources in the process of scaffolding and identity affirmation (e.g. Li and Zhu, 2013; Mori and Sanuth, 2018).

For instance, Li and Zhu's (2013) study show that Chinese university students in London engage in translanguaging to construct new modes of communication in a new social environment and to develop their transnational identities. Translanguaging, therefore, 'signals a trans-semiotic system with many meaning-making signs, primarily linguistic ones that combine to make up a person's semiotic repertoire' (Garcia and Li, 2014: 42). It is a process of meaning-making in which speakers are both strategic and spontaneous when drawing on an integrated linguistic and semiotic repertoire, without a view of 'languages' as distinct and separate codes.

This study therefore views translanguaging as a space of knowledge construction in the form of social experience unfolding beyond different linguistic systems and modalities. Specifically, the act of translanguaging is seen as transformative in that it creates a space (Li, 2011) in which multilinguals utilise various multilingual and multimodal resources to create meaning during social interactions (Li, 2011; Li, 2018). This is a space created for not only translanguaging but also by translanguaging. In other words, the concept of translanguaging space emphasises dynamic multilingual communication and highlights the complexity and interconnectivity of the multimodal resources that are employed in everyday interaction. Translanguaging space is then a space where various resources, from multilingual to multimodal ones, interact and co-generate new meanings. It is important to note that the notion of code-switching differs from translanguaging in several ways. Code-switching refers to the alternation between languages in a communicative episode and such notion assume the existence of different languages as structural and cognitive entities. Code-switching analysis focuses on identifying the involved named languages. It will then conduct either a structural or a functional analysis regarding the process of switching from one language to another at a particular communicative episode. Nevertheless, translanguaging focuses on the process of meaning-making. The analytical focus is therefore on how individuals draw upon various linguistic, cognitive and multimodal resources to make meaning and make sense (Li, 2018).

Studies on translanguaging in EMI science classrooms

Research on translanguaging has recently focused on classroom interactions in science classrooms where content subjects are taught in English (e.g. Mazak and Herbas-Donoso, 2015; Poza, 2018; Lin and Lo, 2017). A recent ethnographic study by Lin and He (2017) investigate how an EMI science teacher use translanguaging as a pedagogical strategy to

motivate South Asian ethnic minorities to draw upon their multilingual repertoires in a year 9 HK EMI science classroom. The findings indicate that although the teacher and learners came from different linguistic and cultural backgrounds, their willingness to learn from each another create a space where learners are motivated to use the L2 and develop their linguistic repertoires. Lin and Wu's (2015) study investigate how learners use translanguaging to actively construct meaning and display understanding in a year 8 HK EMI science classroom. Based on their analysis of a five-minute interaction, the findings indicate that when the teacher grant permission to a low-proficiency learner to answer the teacher's response in Cantonese, this create an opportunity for the learner to elaborate at length in Cantonese, resolving her previous struggle to answer in English. Nikula and Moore (2016) present an exploratory study of translanguaging in various secondary CLIL classroom settings (biology in Finland, technology in Spain and history in Austria). Their analyses are similar to Lin and He's (2017) findings that teachers and students use translanguaging practices to fulfil different communicative intentions, including addressing pedagogical and interpersonal concerns and delivering classroom instruction.

Research has challenged the monolingual pedagogy of traditional bilingual classrooms such as EMI and CLIL and provided qualitative findings describing how translanguaging facilitates the meaning-making process (Lin and Wu, 2015; Nikula and Moore, 2016; Lin and He, 2017; Jakonen et al., 2018). Nevertheless, there has been limited fine-grained analysis of translanguaging in secondary-level EMI classroom interactions. Much of that research (e.g. Nikula and Moore, 2016; Poza, 2018; Lin and Lo, 2017; Jakonen et al., 2018) has conceptualised translanguaging as just a shift among linguistic repertoires.

The research on translanguaging includes a few studies on EMI (e.g. Lin and He, 2017) and numerous ones on bilingual classrooms (e.g. Moore and Vallejo, 2018). Both strands of research have used multimodal transcriptions to reveal translanguaging at work in different modalities. For example, Kääntä et al. (2018) conduct a multimodal conversation analysis of how physics teachers in CLIL classrooms in Finland explain a scientific theory (i.e. Hooke's law) by talking and drawing upon a range of embodied and material resources. They argue that the science teachers skilfully coordinat multilingual codes and engage with a wide range of multimodalities to define and contextualise abstract scientific phenomena. Those studies clearly demonstrate the usefulness of adopting a multimodal view to describe and analyse the complexity of translanguaging.

To the best of our knowledge, only a few studies have explored translanguaging in EMI science laboratory sessions. In order to fill in the research gap, our current study aims to analyse several laboratories in the EMI secondary setting and specifically in the HK context in which translanguaging draws on students' full linguistic repertoire (Cantonese and English) and various multimodal resources for knowledge construction.

The Methods

To address the research gaps mentioned above, this study conducts an in-depth qualitative discourse analysis to capture specific moments of interactional communication in EMI science laboratory sessions. In particular, this study aims to provide micro-level analyses of how science teachers and students use translanguaging practices (i.e. drawing on their

linguistic and multimodal resources) to get a grip on science learning. The data come from a large-scale study that observed classroom interactions in Grade 10-11 EMI science classrooms in Hong Kong. We conduct an inductive discourse analysis (Braun and Clarke, 2006) to examine how the different types of talk perform different pedagogical functions in EMI classrooms. We refer Lin's (2019) notion on the pedagogical functions of translanguaging to Hong Kong EMI science classrooms and extend to the context of lab class: 1) dialogic co-making of knowing which unfolds in the dynamic flow of action events involving translanguaging; 2) creating a space for students to develop their understanding of the target laboratory procedures; 3) spontaneous translanguaging for creating a fun and enjoyable learning environment in the laboratory sessions. This allow us to consider sequences of talk in interactional contexts and simultaneously explore, at the individual level, how students interact with their peers when performing group tasks.

Context and participants

The participants were teachers and students from Grade 10 EMI science classrooms (physics, chemistry and biology) from EMI secondary schools in Hong Kong. The students were 15 to 17 years old and they had completed six years of primary and three years of junior secondary compulsory education.

Under the government's language policy, which was revised in 2010, schools have been allowed to adopt EMI at the senior levels if the students' English proficiency reaches the threshold for learning in an English environment (Legislative Council, 2009). These EMI schools used Cantonese as the medium of instruction from Grades 7 to 9, and later switched to EMI for Grades 10 to 12, with English used for nearly all content subjects and for all public examinations. All the participants in this study are local students, and experienced similar period of English exposure before at primary and junior secondary level (before Grades 10).

Teachers' and students' backgrounds

The two science teachers teaching chemistry and biology hold a BSc degree in science and a postgraduate diploma in education. Although neither of the participating teachers have any formal qualifications in EMI, both of them had passed their English language subject before being admitted to a university, and they had an English proficiency equivalent to the score of 6 in the International English Language Testing System examination (IELTS Academic, 2012). All participating students indicated that they spoke Cantonese as their first language.

The laboratory sessions were video-recorded. The first author was present in the classroom when the lessons were recorded. All of the recorded data were transcribed and translated from Cantonese to English by the first author using the *NVivo* software package for analysis. Two independent bilingual researchers performed a back translation, comparing that version against the original audio-recordings.

Analysis

1) Dialogic co-making of knowing which unfolds in the dynamic flow of action events involving translanguaging

In a Grade 10 biology lab lesson, the teacher first demonstrated the steps involved in analysing photosynthesis. As excerpt 1 shows, students worked in groups on a photosynthesis experiment and specifically the step of 'de-starching', which for this class involved depleting the starch reserves of a leaf. The process of de-starching examines starch and chlorophyll as the key factors in photosynthesis. The steps include: 1) heat the leaf in boiling water for 30 seconds (this halts its chemical reactions); 2) heat the leaf in boiling alcohol for a few minutes (this removes most of its colour); 3) wash it with water and spread it onto a white tile 4) add iodine solution from a dropping pipette.

[Excerpt 1 (Figure 1 to 6) here]

In line 1, the teacher offers a series of experimental instructions in English and expects the students to follow them accordingly. The teacher requires students to use the forceps to extract the leaf from the beaker. However, the teacher also provides safety instructions to the students by warning them not to touch the beaker. Next, the teacher advises the students to put the leaf into the test tube that contains alcohol.

Once the teacher utters the word 'now' in line 1, it becomes noticeable that the students in this particular group start to speak Cantonese with their peers to make sense of their teacher's experimental instruction. While S4 is picking up the leaf (figure 1), S1 follows the teacher's instructions by using Cantonese to advise S4 to take his time and slowly transfer the leaf to the test tube. However, when S4 tries to put the leaf inside the test tube (figure 2), his action is challenged by S1 (line 4). S2 and S3 subsequently request S4 to put the leaf into the beaker and S3 also emphasises this request by a using deictic gesture to continuously move his index finger from a high to low position (line 5). Simultaneously, S4 follows his peer's request by putting the leaf into the test tube (figure 3). In the next turn S4 initiates a question regarding the need to let the leaf cool down before putting it into alcohol (line 7), but S3 explains to S4 that it is not necessary for the leaf to cool down (line 9).

Hence, from lines 1-9, we can see that the whole process of experiment allowed the participants of the class to use their own dynamic linguistic and semiotic practices. However, the data of Excerpt 1 inclines toward more interactions among students rather than teacher-student interaction. The teacher's selection of English as medium of instruction conforms to the norm of the EMI setting, but at the same time, he/she didn't restrain students' use of L1 to externalise their understanding of the scientific procedures. It is actually a translanguaging process as a whole though there is no explicit multilingual interaction by the speakers.

The translanguaging engagement continued in science experience in the class. In line 10, the teacher uses English to initiate a question 'have you finished?' to the entire class to check progress. However, none of the students (S1-4) in the group respond to the teacher's question. Students continue to concentrate on the experiment and use Cantonese as a main linguistic tool for communication. As shown in line 11, S1 takes the forceps directly from S4 and challenges S4 by initiating a rhetorical question: 'can you poke it like this? By doing so, S1 dismisses S4's role in conducting the experiment and positions S4 as an observer to self-select himself as the student designated to act on behalf of the group. Although S2 attempts to ease the tension by uttering 'it doesn't matter' in Cantonese (line 12), S1 ignores S2's comment and rephrases the rhetorical question in line 13, which he previously constructed in line 11, to potentially draw his peer's attention

to how he inserts the leaf into the alcohol. While he is uttering, it can be seen that S1 uses the apparatus to insert the entire leaf into the test tube (figure 4). After a short 0.2-second pause, S1 initiates another rhetorical question to S4 by asking him whether he is crazy (line 13), which might be an attempt to humiliate S4 in front of his peers. Hence, from lines 4-13, the interaction can be categorised as disputational talk (Mercer, 1995; Mercer et al., 2004; 2009) because it turns into a conflict in which peer interaction focuses on the right or wrong way of putting the leaf into the test tube. There is a lack of negotiation space because the interaction ends without the group attempting to reach a common understanding of the specific procedures of the experiment.

Throughout the excerpt, the translanguaging process can be identified when the teacher offers advice in English and when students use Cantonese to scaffold their understanding of the experimental procedures by accessing various multimodal resources (e.g. laboratory equipment and gestures). During the experiment, the teacher and students also switch between different modalities: speaking (teacher), conducting the experiment (students) and sharing information (students). In the peer interaction, the students assume the different discourse identities of being observers, announcers and those representatives designated to conduct the experiment and manage participation. However, their peer interaction does not lead to exploratory talk with students jointly negotiating procedures in a way that improve their understanding of the experiment.

2) Creating a space for students to develop their understanding of the target laboratory procedures

What excerpt 2 shows below is another dialogue among participants in the same observational setting.

[Excerpt 2 (Figure 7 to 15) here]

As shown in excerpt 2 and from line 1 to 18, the four students in the group self-motivate to discuss their member's manner of de-starching and question his adherence to safety guidelines. S2 is the person to carry out the de-starching. When the S2 takes the leaf out of boiling alcohol for a few minutes, his group members S1, S3 and S4 offer commentary about the quality of his performance. As in lines 1-4, S1 and S3 act as facilitators, issuing commands to S2 to carry out the steps of picking up the leaf. As shown from lines 1-6, the students are engaging in cumulative talk because in their utterances there are more commands than questions or answers. As in line 3, S4 acts as an instructor by providing a number of negations to remind S2 not to damage the leaf. In line 6, S1 challenges S2 over what he was doing. S4 then challenges S2 in line 8 about why he feels nervous and instructs S2 to finish up the procedure in line 9. In line 10, S3 continues his role as a facilitator by verbalising each single step of the procedures and directing S2 to finish the task.

In line 11, the teacher announces that the group can conduct the iodine test on the leaf. They need to transfer the leaf from the alcohol back into hot water, add a few drops of iodine solution onto the leaf and then write down its observed changes in colour. S2 resumes the task by applying a few drops of iodine solution to the surface of the boiled leaf, one without a cell wall. From lines 12-18, the four students discuss their observations of the colour of the leaf. S2 carries out the entire process of de-starching and makes the first comment. S2 explains that the leaf's colour looks like that of hot tea. S3 continues

his role as an instructor, directing S2 to apply a few more drops of iodine solution. In line 14, S2 makes the first challenging move and ignores S3's instruction by saying 'enough enough'. In line 15, S3 provides a justification giving the rationale for why it is necessary to have more drops of iodine solution. S3 questions S2 as to why the leaf turns green rather than brown like the iodine solution. In line 16, S4 wants to participate in S2 and S3s' discussion of the changes of the colour of the leaf by supporting what S3 said about the leaf turning green by using the discourse maker 'right, because⋯'). In line 17, S1 acts as an instructor but wants to dismiss the discussion because he believes that the colour of the leaf is not important in the experiment. S1 says 'forget it never mind' to urge the rest of the group to continue with the experiment. Finally, in line 18, the discussion ends with S2 saying that it is acceptable not to pursue the topic.

From lines 1-18, we can see some opportunities for the four students to actively negotiate the meanings of their own observations, the ways to carry out the lab procedure and discussion of the physical changes of the leaf in their L1. We can observe that this process actually rather close to the original pedagogical practise of 'translanguaging' explained by Cen Williams, according to him, ''translanguaging means that you receive information through the medium of one language (e.g., English) and use it yourself through the medium of the other language. Before you can use that information successfully, you must have fully understood it'' (Williams, 1996, p. 64). Students stick to their first language while talking about the lab task, without forcing themselves to speak English to undertake the experiment guided by teacher. More specifically, the four students use Cantonese to: 1) present the experimental procedure; 2) provide enough detail to accomplish the tasks; 3) describe procedures; and 4) justify procedures. As shown in the excerpt, the students are engaging in cumulative talk as suggested by their focus on the 'what' and 'how' of laboratory procedures. Students seldom ask one another follow-up questions to gain a deeper understanding of the scientific phenomenon.

The four students construct a flow of interactions involving multiple linguistic resources and multiple modes (e.g., spoken, written, writing, gestures, facial expressions and eye gaze). This echoes with Multimodalities/Extextualization Cycle (MEC) which outlines stages that teachers can provide systematic scaffolding to facilitate students' expansion of their repertoire by planning spaces for translanguaging (Lin, 2015). Through translanguaging, the MEC allows students for uninterrupted flow of meaning construction and ultimately provides them with space to practise orienting their meaning making towards the target science discourse.

Such translanguaging involves multimodal practices that simultaneously integrate both spoken words and physical actions (i.e. performing lab tasks) into tightly linked chain of meaning: 'spoken Cantonese-English teacher instruction – physical actions of doing lab'. It shows students' understanding and annotation of the target laboratory procedure, which is de-starching.

3) Spontaneous translanguaging for creating a fun and enjoyable learning environment in the laboratory sessions

In excerpt 3, the teacher requires the students to remove the test tube from the beaker, pick the leaf up and wash away the alcohol. By doing so, this prepares the students to add iodine solution from a dropping pipette and test the leaf for the presence of starch.

[Excerpt 3 (Figure 16) here]

In line 1, the teacher first uses English to draw the students' attention by asking them to 'listen carefully'. He then offers explicit instructions for using their bare hands to extract boiling tube from the beaker and put it back into the test tube rack. After a short 0.3-second pause, the teacher switches to Cantonese and reminds the students to hold the test tube tightly to avoid dropping it onto the bench.

Despite the teacher's explicit instructions, S1 fails to follow the teacher's instructions because he uses a test tube holder to pick up the test tube (line 2). This motivates S3 to clarify the correct procedures to S1 in Cantonese so that S1 can correct the mistake. By doing so, this illustrates that S3 understands the teacher's English instructions because he is able to explain the appropriate instructions to his classmates.

In line 3, the teacher continues to mix English and Cantonese when offering explicit instructions. This time, the teacher invites students to touch the test tube to feel its temperature and informs them that the test tube is not very hot. S1 follows the teacher's instruction by picking up the test tube. Concurrently, he opens his mouth widely and enunciates 'ah' in a high intonation to pretend that he is burned by touching the test tube at a high temperature (line 4, figure 16). By adapting an informal and bantering register, S1 playfully treats the task as enjoyable and non-serious. This transforms the serious atmosphere of a laboratory into a more pleasant learning environment (Bell, 2005).

The following excerpt 4 is extracted from a chemistry laboratory session in another EMI secondary school. In this Grade 10 Chemistry lab lesson, the teacher first demonstrates the steps needed to compare the relative strength of acids. The students are expected to measure the electrical conductivity between a weak and strong acid with a digital ammeter. The students need to set up the apparatus (see below figure 21) with a power supply connected to a digital ammeter whose graphite (carbon) electrode rod holder is placed over a beaker of acid.

Figure 17: Equipment for measuring electrical conductivity

[Figure 17 here]

As excerpt 4 shows, the teacher and his students discuss important procedures in measuring electrical current of the acids through lively but systematically structured interactions. Prior to excerpt 4, the students used the ammeter to estimate conductivity in a water sample and they had trouble obtaining results. Subsequently, they asked the teacher for assistance.

[Excerpt 4 (Figure 18 to 37) here]

In line 1, S2 uses Cantonese to announce that the group is suffering from technical issues and the teacher will be handling the situation. S2 then initiates a question by asking the teacher what 0.00 means in Cantonese (line 3). S2 repeats his announcement in line 4 by introducing the arrival of the teacher as the 'expert' and his role in solving the technical failure for the group. Then the teacher initiates a clarification request in Cantonese by asking S2 to explain what he means by 0.00 (line 5). S2 responds to the teacher's question by pointing at the voltmeter (line 5) and S3 also performs the same deictic gesture in line

6. Despite the students' responses to the teacher's questions, the teacher initiates another clarification request. He first points at the beaker and asks about its contents in Cantonese. As no one responds during the 0.5-second pause, he looks at the voltmeter and asks whether 'ammonia solution' is inside the beaker, 'ammonia solution 呀?' (line 7). Here, we can see that the teacher is combining the English scientific term, 'ammonia solution', and the Cantonese modal particle, 呀, in his clarification request. S2 repairs the teacher's clarification by uttering 'sodium hydroxide' in English (line 8). The teacher then acknowledges S2's repair by repeating 'sodium hydroxide' and looking between the voltmeter and the beaker (figure 23) to understand the experiment's technical failure.

It is noticeable that the teacher and students are jointly negotiating the reasons for why the experiment failed. S2 displays his understanding of the functions of sodium hydroxide by using Cantonese '我知㗎' to express his understanding and then to explain the functions of sodium hydroxide (line 10). The teacher acknowledges S2's explanation in English by uttering 'oh I know' and elaborates on the nature of sodium hydroxide by explaining that 'sodium hydroxide has silver ion' (line 11). The teacher uses English in this instance, in contrast to his prior statements in lines 5 and 7, possibly because he is conforming to the English-only norm of the EMI setting. After S2 acknowledges the teacher's elaboration by uttering a token of acknowledgement with 'yup' in line 12, the teacher is 'doing' the experiment in lines 12-13 (figures 26 and 27) to test the voltmeter. It is observed that the teacher turns the switch on and off and fixes the wires continuously from lines 12-18. The other students observe the teacher's actions and make comments. Several students express their confusion (line 14), making statements about the phenomenon (line 15), describing the position of the wire (line 16) and expressing concern (line 17). In line 19, S2 notices that there is a change of voltage on the voltmeter screen and he initiates a question in Cantonese by asking why the voltage changed. S2 and another student also ask the teacher to explain the phenomenon (lines 20-21). So far, it is noticeable that from lines 10-21, the teacher and students are engaging in exploratory talk. This is depicted in moments when the students ask many questions to know why they cannot get an accurate reading from the voltmeter. Curiosity dominates the talk, encouraging students to reflect on their prior knowledge (e.g. S2 in line 10) and question their teacher's findings (e.g. lines 14-15, line 19).

In the subsequent interaction, the teacher and students engage in playful talk that turns the classroom atmosphere into one with a more informal learning environment (Tai and Li, 2020a). In line 22, the teacher explains why he gets a different result compared with that of the students. He explains in English that 'the graphite electrode rod is broken' and simultaneously points at the beaker. S2 acknowledges the teacher's explanation by uttering 'oh' in Cantonese and clapping his hands to indicate the teacher's success in identifying the problem. Here, we can see that the teacher is using English to engage with the students, and then the student responds the teacher in Cantonese, which is not the target language in an EMI setting. Concurrently, the teacher takes apart the graphite electrode rods (line 23, figure 33), enunciates 'yeah' in the next line and shows the rods to the students (lines 24). By using both verbal and non-verbal resources, he depicts his removal of the graphite electrode rods as a victory worthy of celebration. The other students in the group echo the teacher's response by verbally responding 'yeah' in line 25. Several students switch between verbal and multimodal communication modes by clapping their hands (lines 25 and 26) and verbally praising the teacher as a 'genius' (line 26) to recognise the teacher's skilful ability in solving the problem. The teacher takes the next turn to celebrate his success by uttering 'yeah', followed by laughter (line 27). So

far, we can see that the teacher and students are engaging in translanguaging practices (switching between verbal and non-verbal communication modes, with the teachers using L2 English and the students using L1 Cantonese and some English jargon) to produce the playful talk. It is also noticeable that the exploratory talk is co-constructed by the teacher and students. While the students initiate questions and share relevant scientific information to consider the scientific phenomenon, the teacher offers an alternative view in line 22 and actively proves the reliability of the proposed view to his students (i.e. graphite electrode rod is broken) by removing them from the experiment (line 24). Both the teacher and students engage in constructing knowledge via exploratory talk.

In both excerpts, the classroom participants engage in translanguaging practices that co-construct an enjoyable learning environment in the laboratory sessions. By displaying a different orientation to the normative nature of language choice in the science laboratory context, S1 in excerpt 3 and the teacher and students in excerpt 4 can be seen as translanguaging in that they draw on their full linguistic and multimodal resources to construct the playful talk. This is demonstrated by playfully exaggerating the consequences of following an instruction (excerpt 3), importing an informal register (excerpts 3 and 4), exploiting an unconventional phrase to commend the teacher's action (excerpt 4) and switching between verbal and non-verbal communication modes together with the use of multimodal resources (excerpts 3 and 4). These translanguaging practices appear to play a role in constructing the playful talk and in creating an interactional space in which EMI science lab talk becomes more conversational and playful (Tai and Li, 2020a).

Discussion and Conclusion

Based on the analysis in this study, we believe that translanguaging practices in EMI science lab class offers space for students' learning in an active way. The pedagogical advantages of translanguaging in the observed Hong Kong EMI science lab classrooms shed light on its function as: 1) dialogic co-making of knowing which unfolds in the dynamic flow of action events involving translanguaging; 2) creating a space for students to develop their understanding of the target laboratory procedures; 3) spontaneous translanguaging for creating a fun and enjoyable learning environment in the laboratory sessions.

Teachers and students in an EMI classroom with diversified English levels can utilise translanguaging as a useful mechanism/driving force for students with limited English proficiency to externalise their understanding via interactive communication in science enquiry. This process may broaden the possibility for developing their competence in scientific talks, which aims to further strengthen their abilities in disputation, cumulative and exploratory talk (Mercer, 1995).

With reference to research on 'translanguaging', our analysis of the Grade 10 Hong Kong EMI science laboratory lessons shows how students select and deploy linguistic and semiotic repertoires in peer groups in order to communicate for a scientific enquiry. Although there is a school-based EMI policy, the students followed the teacher's English lab instructions and they themselves choose to use Cantonese to interact with their peers and follow the lab procedures. Such a joint process allowed them constructing the science knowledge in a relatively more effective way without being restrained by the language they were not quite familiar with.

On one hand, students in the lab experiment navigated a wide range of modalities (e.g. from speaking to text, from text to diagram and from diagram to hands-on experience), utilising their existing linguistic and semiotic resources to co-construct scientific knowledge and practise their science apprenticeship. On the other hand, in excerpt 2, the students in the peer group actively negotiated carrying out the lab procedures of de-starching and participated in discussions about the physical changes in the leaf. We can see moments of meaningful negotiations observed in the students' translanguaging practices, where they are self-motivated to discuss cognitive abstract concepts and lab methods. Translanguaging offers students an opportunity to actively engage in scientific enquiry and develop their identity as they transition from novice to expert scientists who can present arguments and counter-arguments.

Furthermore, translanguaging is also used for other purposes, including creating an enjoyable learning atmosphere. This is illustrated in excerpts 3 and 4, in which students draw on their full multilingual and multimodal repertoires to playfully exaggerate the consequences of touching a warm test tube (excerpt 3) and praise the teacher's ability to resolve an issue (excerpt 4). By engaging in humour and playful talk, translanguaging practices can potentially contribute to promoting an enjoyable environment related to their active classroom participation and interaction (Tai and Li, 2020a). In addition, it provides teachers and students the opportunity to 'do conversation', which is the foundation of meaningful communication (van Lier 1996).

This study has pedagogical implications for both EMI science teachers and students. The results imply that translanguaging as a pedagogical tool can create a space for content subject learning in Hong Kong EMI school settings. This echoes with a growing number of studies in exploring pedagogical uses of translanguaging in EMI contexts (see more Paulsrud, Tian and Toth, 2021; Lin & Lo, 2017; Tai and Li, 2020a; 2020b; 2020c). The use of translanguaging opens a space for the students to build on others' responses when presenting their own views. As seen in the analysis, science students in the observed lessons co-construct their science experience through translanguaging which reflects in a series of dynamic flow of action events in their laboratory experiment. This is observed in Tai and Li's study (2020b) where they find that translanguaging facilitates the creation of a safe space for co-learning between EMI teacher and students, which emphasises equity in knowledge construction and challenges the hierarchical relationship between the teacher and the learner. Additionally, because students can draw on their full linguistic and multimodal resources to construct the playful talk, it is evidenced that students engage in these translanguaging practices which allows them to co-construct an enjoyable learning environment in the laboratory sessions. Such interactional phenomenon is also reflected in Tai and Li's (2020a) study as they argue that translanguaging appears to be a critical resource in constructing playful talk to achieve a wide range of pedagogical goals such as rapport building, content explanation and meaningful communication between EMI teacher and students. Furthermore, as shown in the analysis, it is demonstrated that student's translanguaging practices provides them with an interactional space which enables them to develop their understanding of the scientific procedures of doing experiment through the utilisation of various linguistic and multimodal means.

EMI as a practice has raised important concerns regarding the complicated interrelationships between language use and knowledge output. Throughout the analysis

section, we have demonstrated that the EMI science laboratory session can potentially act as a translanguaging space (Li, 2011; Li, 2018) because it provides an interactional space for teachers and students to draw on their full multilingual and multimodal resources to construct science knowledge and develop their competence in 'doing' science.

This study showcases an example that illustrates the dynamic conceptual framework of EMI in multilingual setting. It moves away from the traditional view to EMI instruction in which teachers and students use fixed language codes to function as a tool for teaching and learning disciplinary knowledge (Dafouz & Smit, 2014). The translanguaging practices observed in this study allow multilingual teachers and students to engage in knowledge construction by drawing on their diverse language resources. This demonstrates that EMI can in fact encapsulate discursive practices for teaching and learning.

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