“*May I speak Cantonese?*”—Co-constructing a Scientific Proof in an EFL Junior Secondary Science Classroom

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Abstract

In this paper an excerpt of interaction between the teacher and her students in an EFL junior secondary science classroom in Hong Kong is analysed using the conversation analytic method of sequential analysis (Heap, 1985; Lin, 2007). The fine-grained analysis reveals that in the teacher’s effort to engage her students in the co-construction of a scientific proof, the students’ familiar everyday discourses need to be allowed to play a significant role.

Introduction: The Policy Context of L2 English Medium Education in Hong Kong

CLIL classrooms never exist in a sociopolitical vacuum but are always situated in the larger socioeconomic, sociopolitical, and language education policy contexts which assign different values to different linguistic varieties in society and in the classroom. The current language education policy dilemma in Hong Kong revolves around the question of how to ensure that students' proficiency in English can be improved without affecting their content leaning, while avoiding the social and educational costs of the previous policy of linguistic streaming (in 1998, schools were streamed into English medium or Chinese medium and there has since been the labeling effect of the Chinese medium schools as second-rate in society; see review of this policy in Lin & Man, 2009). Parental demand for access to English-medium schools is extremely strong and the imposition of restrictions of access to English-medium education through streaming is perceived as inequitable. Twelve years after the introduction of the 1998 streaming policy, the government is relaxing or destabilizing the strict boundary between the Chinese medium Instruction (CMI) schools and English medium instruction (EMI) schools. Starting from September 2010, former CMI secondary schools in Hong Kong are allowed to switch the medium of instruction (MOI) to English for some of their academic subjects or for some percentage of the lesson time of each of their academic subjects under the new 'fine-tuning MOI policy' of the Hong Kong Education Bureau in 2010. Many CMI schools have chosen to change the MOI of one or two of their academic subjects (usually Science or Mathematics) or some percentage of the lessons of each of their academic subjects from CMI to EMI (see Introduction to this Special Issue). It is against this background that the current classroom interaction analysis has been conducted. In the following sections the context of the analysis and Lemke (1990)'s key insights regarding interaction in the science classroom will be discussed and then an excerpt from the classroom interactions will be analysed to reveal the "point" of the lesson (Heap, 1985; Lin, 2007). This will then be discussed with reference to the question of what counts as doing science in the classroom and how students with basic L2 proficiency in the CLIL science classroom can be supported through what Lin (2012) conceptualizes as *the Rainbow Diagram* (see also Introduction to this Special Issue).

Context of the Analysis

The excerpt to be analysed was taken from a science class in school, which had been a CMI school for many years before switching its medium of instruction to English in all non-Chinese language related subjects (including science) starting from junior secondary one (Grade 7) in 2010 under the new fine-tuned MOI policy of the Hong Kong government. Four years after this switch, it was perceived by the school administration that some students seemed to need extra support in their learning of science. From March to May 2014, an extra tutorial class was thus set up on Saturday mornings for 10 weeks, and an additional science teacher was hired part-time to give extra lessons (each of 90 minutes) to 20 students pulled out from different Grade 7 classes. These students had all scored below average in their regular form tests in science. It is expected that the extra tutorial sessions will give extra support to these students to help boost their science learning and test results in the school.

The part-time teacher, Jenny (pseudonym), studied biology in English in a local university and is a fully certified science teacher with a Postgraduate Diploma in Education majoring in the teaching of science subjects. She has taught science in secondary schools in Hong Kong for 4 years before taking up her current full time job in an international school in Hong Kong. She is also about to complete her Master of Education (Science) part-time when our Language Across the Curriculum (LAC) project started (a project to offer LAC support to science teachers). Jenny is young, energetic, engaging, open to ideas and highly proficient in English. Upon knowing she will be teaching these tutorial classes part-time, she sought our support from March to May 2014. During this period of time, the second author of this paper regularly met with Jenny and did materials co-designing with her to help her build some language support into her science materials. However, the second author's input is not always incorporated due to the need to include exercises that help students to pass the school's science tests. The particular page of the lesson worksheet used in the episode we are going to analyze below was designed by the teacher. Appendix I shows the teacher's version of the first page of the lesson worksheet from *Lesson 6-Matter and Its Properties*, with the answer keys filled in.

The students, according to Jenny, are largely cooperative but seem to lack confidence in their science learning as they all have scored below average in their respective Grade 8 classes. The fact that they have been pulled out from their regular classes for this additional Saturday morning tutorial session also means that they are not familiar with many of the other students in this pull-out class, thus affecting the general classroom atmosphere. The second author of this paper, who has observed and videotaped some of these sessions, finds that the students largely listen passively to the teacher as she rushes through the lesson materials. This is, however, beyond the control of Jenny as before each session she is given by the school administration a list of topics and asked to cover all of them in the tutorial session. Oftentimes, Jenny is given very little time to prepare the lesson materials on these topics (e.g., she is given the topics just a few days before an upcoming session) and the second author of this paper has worked closely with Jenny to support her during this period of time. It is also important to note that the students have attended their regular science classes in which the same set of topics have been covered by their regular science teachers and Jenny's role is to re-teach or revise these topics using her own materials (different from the science textbook that is used in the school).

Teaching Science *is* Apprenticing Students into Science Discourses

The seminal study, *Talking Science*, by Lemke (1990) is especially relevant in this context with his insights into the nature and functions of science classroom talk. Talking science does not simply mean talking *about* science but rather it means *doing* science *through the medium of language*. Talking science thus means "observing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching *in and through the language of science*" (Lemke, 1990, p. ix, italics added). Talking science in the classroom is in a sense analogous to engaging students in performing what Dalton-Puffer (2013) has recently called *cognitive discourse functions* (CDF). From Lemke (1990) to Dalton-Puffer (2013), there has been a growing recognition among education scholars that mastery of the content of a discipline is in large part mastery of the discipline's specific ways of using language, or discipline-specific discourses. Here, "discourse" is understood in the sense of not just ways of talking but also ways of thinking, reasoning, arguing, evaluating, etc. While CDFs are proposed as generic to different disciplines, the specific ways in which CDFs are performed in a discipline are shaped by the discipline-specific discourses. For instance, the ways a historian argues and reasons will not be the same as the ways a scientist argues and reasons although there can be some generic overlap (e.g., the use of generic logical, rhetorical structures such as syllogism).

Traditional science pedagogy, however, tends to privilege the notion of "concepts" and views mastery of science chiefly as mastery of science concepts. However, concepts are mediated by discourse and Lemke argues that the mentalism underlying the traditional science pedagogy is not helpful as it tends to ignore the role that language and thematic patterns play in the teaching and learning of science or any subject:

> I will argue… that for the most part "concepts" are just thematic items and their customary semantic relationships, that is, they are just bits of thematic patterns. We never use them one at a time; their usefulness comes from their connections to one another. So it is really the thematic patterns that we need and use. Purely "mental" notions of what a concept is tend to mystify how we talk and reason. They ignore the essential role of language and semantics in teaching and learning *any* subject. (Lemke, 1990, p. 91; italics original)

Lemke argues that what science teachers typically do in the classroom is in fact exposing students repeatedly to the thematic patterns of science. To illustrate this, let us look at an example from Lemke (1990, p. 88, italics original):

[March 19:]

Teacher: What happened was, more than likely is, the crust was pushed up. OK, and when we say the crust was pushed up, we say that it's *uplifted*. And that's why we find these marine fossils up on high mountaintops.

[March 20:]

Teacher: I'd like to go on with what we were talking about. And we were talking about *fossils,* that are used as *evidence*, that the earth's crust has been moved. Now what did we say about these fossils, how do they help us… *know* that, uh, the earth's crust has been moved?
Student: Like, if y' find, *fish* fossils on top of a mountain, you know that once there was water… up there, 'n the land *moved* or somethin'.
Teacher: OK, and what else besides. ...

In terms of science content, these two examples have only two words in common: *crust* and *fossils*. However, as Lemke delineates, the above two lesson excerpts have at least three more *thematic items* in common: MOVED (pushed up, uplifted, moved), MARINE (marine, fish), and HEIGHTS (high, mountaintops, top of a mountain), apart from CRUST (earth's crust, land) and FOSSILS. Among these five thematic items, the two lesson excerpts construct the same semantic relations:

CRUST—medium/process—MOVED

MARINE—classifier/thing—FOSSILS

FOSSILS—location—HEIGHTS

These individual semantic relationships are further joined to each other to make up a full thematic pattern in each of the two lesson excerpts:

[MARINE—classifier/thing—FOSSILS]—location—HEIGHTS

&

CRUST—medium/process—MOVED

The above two sets of thematic units are made to relate to each other in a specific way: *Evidence/Conclusion*. With this example and many others, Lemke (1990) shows that mastery of a subject entails mastery of the thematic items and their semantic relationships (i.e., thematic patterns) which constitute the discourses specific to the subject. While the teacher can make use of more or less monologic (e.g., teacher expositions/lecturing) or dialogic pedagogical strategies (e.g., student debates, student inquiry projects, pair/group work, teacher-student dialogue), teaching science ultimately entails enabling students to make meaning using these thematic items (e.g., subject-specific words, phrases made to relate to each other in a certain semantic relationship) in subject-specific thematic patterns (e.g., what counts as evidence to a certain conclusion).

Lemke's argument echoes the sociocultural turn in education starting from the 1970s with the growing influence of Vygotskian theories of language, thinking and learning (Vygotsky, 1978, 1986). In the field of language education and Content and Language Integrated Learning (CLIL), the sociocultural turn has led to keen insight into how one learns and constructs meaning (i.e., what is commonly called "ideas", "concepts") *through language*. This is captured in the notion of *languaging*; as Swain and Lapkin delineate:

> When one *languages*, one uses language, among other purposes, to focus attention, solve problems and create affect. What is crucial to understand here is that language is not merely a means of communicating what is in one person's head to another person. Rather, language serves to *construct the very idea* that one is hoping to convey. It is a means by which one comes to know what one does not know. (Swain and Lapkin, 2013, p. 105; italics added)
>
> … languaging, in the form of collaborative dialogue or private speech, constitutes part of the process of formulating the idea; it mediates the formulation of the idea. Indeed, it is when language is used to mediate conceptualization and problem-solving, whether that conceptualization or problem-solving is about language-related issues or science issues or mathematical ones, that languaging takes place. (Swain and Lapkin, 2013, pp. 106-7)

Much of what students are required to do in the classroom, however, might just involve mouthing or reciting/reproducing subject-specific wordings in worksheets or test/exam items without much languaging taking place. However, in a rare moment of dialogic inquiry impulse of the teacher, the whole situation can be made different. In the next section, we shall illustrate through our analysis of a 5-minute excerpt of interaction in Jenny's science classroom how the notion of thematic patterns (Lemke, 1990) and the notion of languaging (Swain, 2010; Swain and Lapkin, 2013) can help us understand what seems to be transpiring in the classroom and the role played by students' everyday discourses and familiar linguistic resources in making science learning a meaningful inquiry process.

Detailed Analysis of a Lesson Excerpt

In Jenny's science sessions, much of what she seems (to have been made by the school administration) to do is to go through the worksheets with students to show them what should count as model answers. Each tutorial session is structured similarly with the following stages: It begins with a review of the answers to the quiz the students did in the last lesson for about 15 minutes. Then students are given a new quiz of about 30 minutes to check their learning of the last lesson. After these procedures, Jenny will begin her teaching of a new lesson following the lesson materials and worksheets she has prepared.

The lesson excerpt (see Appendix II) occurs in the middle of the sixth session (among 10 consecutive Saturday morning sessions from March to May 2014). In this session Jenny begins the new topic on *Matter and Its Properties* by asking the students to complete page one to three of the worksheets themselves. She then checks answers with them by projecting the worksheet onto the screen via a visualizer. The fill-in-the-blank exercise on page one of the worksheet (Appendix I) seems to aim at familiarizing students with the definition of "matter"—i.e., its two defining characteristics: "takes up space" and "has mass." Jenny has spent some time explaining to students what "take up space" means by showing to students some realia and what "mass" means by contrasting it with "weight". After this episode, Jenny moves on to check the answers of the exercise with the students just like what she has done prior to this episode, occasionally with some further explanations but mostly in a lecture format. In what follows, we shall do a turn-by-turn sequential analysis of this lesson excerpt. Further points of interest will also be discussed.

Appendix I shows the first page of the lesson worksheets (with model answers underlined) in the session focusing on matter. On the first page under the heading "What is matter" is a fill-in-the blank type of task: *Everything that* ___________ *and* _________ *is matter*. Students can just rote-memorize and reproduce the wordings without doing much languaging. Then the second task on the worksheet is for students to put an X next to items that do not qualify as matter. In the middle of going over this part (i.e., checking answers with students), in a rare moment of scientific inquiry impulse (against the institutional imperative to cover as many test/exam type items as possible in a session), Jenny starts off a series of Initiation-Response-Feedback (IRF) triadic dialogues (Sinclair and Coulthard, 1975; Mehan, 1979; Heap, 1985; Nassaji and Wells, 2000; Lin, 2007) to engage students in explaining how one can prove that "air takes up space and has mass."

In Turn 1 (in the excerpt; see Appendix II) we notice that the teacher makes the statements, "Gravity is an attractive force, acting on the object by the earth. So it does not take up space. Force does not take up space and does not have mass. You can't see it." At the end of Turn 1, the teacher initiates a question, "Well, can you see air?" This question seems to be asked with an implicit built-in contrast of "Air" to "Force" and "Gravity" (Force and gravity are not matter, while air is matter). Her question is responded to in Turn 2 by many students with a definite answer, "No." This implicit comparison between force and air (both we can't see) seems to necessitate some explanation on the part of the teacher before some model answer (e.g., air is matter) can be announced. In this split-second, in the interest of time, the teacher could have made the decision to do a monologic lecturing about how one can design an experiment to prove that air takes up space and has mass and thus one can conclude that it is matter. However, given the teacher's science pedagogical training, this option is likely to be frowned upon (by herself), and thus she "digresses" into a series of IRF triadic exchanges to engage students in explaining how one can prove that air takes up space and has mass.

Thus, in Turn 3 the teacher ask the class, "But it takes up space?" and again this question is responded to by the class with a definite "Yes." The logical connector "But" hints at some kind of logical contradiction emerging: We cannot see air (like force) but air takes up space (unlike force); how can one prove that air takes up space? Thus in Turn 5, the teacher ask the class, "How can you prove to me that air takes up space? Prove it. You can't see it. You can't feel it. How do you know it takes up space?" The teacher smiles invitingly to the students, like giving them a puzzle and encouraging them to solve it. This is responded to in Turn 6 by Ray (all names in the transcript are pseudonyms), a boy sitting at the back of the classroom with his candidate solution, "Because Mr. Lee tell us." (Mr. Lee is their science teacher at the school). As the tone does not sound sarcastic and there is no audible laughter from other classmates following this response, we cannot say that Ray is being cheeky or trying to poke fun. Quoting an authority as an explanation to the teacher is quite acceptable, at least in the culture of many Hong Kong classrooms. But the teacher seems to have entered into an inquiry-oriented pedagogical mood and insists on the students giving her an evidence that she can see; in Turn 7, she demands, "I want (.) an evidence that I can see." The short pause before "an evidence" might indicate that the teacher is taking some time to formulate her task to the students. Alice (a girl at the front) immediately responds with another candidate explanation, "Because there is (.)

air particle." Since the task (in Turn 7) has been formulated as giving an evidence that the teacher can see, Alice is thus implicitly held accountable to giving evidence that one can see, and this seems to have shaped the focus of the teacher's follow-up question (Turn 9), "Can you see air particles?" Alice is quick to answer "No, but (.) the motion" (Turn 10); the short pause might indicate her searching for an evidence that one can see, and she comes up with "motion" and waves her hand to gesture motion. Alice's candidate evidence (motion) is not taken up by the teacher, who then reformulates the question as "How can I observe air?" (Turn 11). Notice that the teacher now introduces a more formal, academic word, "observe", in the place of the more everyday word "see", which she has used four times in the preceding exchanges in this excerpt. As we shall see later, the word "observe" is a key thematic item in thematic patterns closely associated with the scientific method.

Then immediately, Alex, a boy in the front, responds (Turn 12), "Use the *jam-tung*. To have some air." "Jam-tung" is a Cantonese word for syringe. The teacher responds encouragingly, "Ha ham" (Turn 13), seemingly wanting to hear more elaboration of this. Alex continues to elaborate (Turn 14), "Use to (.) Try to (.)" and just as Alex seems to be searching for words to complete his sentence, his utterance is continued by Ray (the boy at the back, who earlier in Turn 7 has quoted Mr. Lee the school science teacher as a response to the teacher's initiation) with the word, "compress"; however, this word is noticeably quieter than surrounding talk and might not have been heard by Alex in the front. Immediately the word "compress" is used by the teacher with her accompanying hand gesture of compressing (Turn 16) and immediately Alex uses the word "compress" to continue to finish his unfinished example, "compress it. And then if you can’t compress it out, because you use your finger to cover the mouth. And then (.) it takes up space.” (Turn 17). Notice that even though Alex seems to be struggling to *language* in English, he does seem to succeed in getting his idea across to the teacher. He also seems to be following the teacher’s implicit thematic pattern by ending his response (to the teacher’s earlier initiation of “how can you prove to me that air takes up space”) with the sentence, “And then (.) it takes up space.” The short pause before this seems to indicate his thinking/searching for the right words, and he hits upon the right thematic unit—“it takes up space,” which serves as a conclusion following his “evidence” (the syringe example).

Alex’s response is immediately affirmed, rephrased and elaborated by the teacher both in words and with accompanying blackboard drawings and gestures in Turn 18:

> “Right. One very good evidence, say if I use a syringe= [T draws on the blackboard as she speaks] =and I block it with my finger [Ss laugh, probably at her funny drawing]. And then I compress the syringe. You will find that finally you can’t compress it anymore. In other words, you can see the space cannot be further compressed because of the air inside. Or another example. When you blow a balloon= [T draws on the blackboard as she speaks]=you can see the balloon getting bigger. What do you blow into the balloon?”

We notice that apart from rephrasing and elaborating it in English, the teacher also draws a syringe and the associated hand/finger on the blackboard (see Figure 1), thus providing a visual image together with her words and gesture to illustrate fully the example contributed by Alex. We also notice that the teacher uses the word “block” (instead of the word “cover” which is used by Alex). In contrast to the student’s wording, “cover the mouth,” the teacher’s wording, “block the syringe,” seems to be a thematic unit that fits better into the thematic pattern of the implicit science experiment being discussed.

In the same turn the teacher introduces another example (the balloon example), drawing it on the blackboard, and makes another initiation, "What do you blow into the balloon?" To this many students respond, "Air." In Turn 22, the teacher provides the argument, "If it doesn't take up space, how can the balloon get bigger? So, you can see that air takes up space."

By now we can draft a tentative 3-part representation of the implicit thematic pattern that seems to be co-constructed and repeated throughout the teacher-led IRF interaction in this excerpt:

Aim (To prove that air takes up space)
Observable Evidence (Syringe example, balloon example)
Conclusion ("Air takes up space")

The above thematic pattern resembles a simplified version of the experimental report genre in school science, which typically consists of the following stages:

Aims of Experiment
Materials
Procedure
Observation
Discussion & Conclusion

Although a bit simplified, the oral thematic pattern that is being co-constructed in the above teacher-student exchanges has the 3 key stages of a scientific inquiry that illustrate the logic of the scientific method; i.e., To prove a *hypothesis*, one needs *observable evidence,* which then warrants a *conclusion*.

This thematic pattern is one of the many thematic patterns that constitute the discourses of science. Even though the word "experiment" is not mentioned explicitly in the above exchanges, the students are in fact being apprenticed into the logic and pattern of doing scientific experiments. For instance, one cannot just quote an authority to justify a conclusion (e.g., “Because Mr. Lee tells us.”) and an evidence counts as an evidence only when it is observable (“an evidence that I can see”). Only observable evidence can warrant a conclusion (“*So* you can see that air takes up space”). We notice that Alex has not used the explicit logical connector “So” and in its place he uses temporal sequencing words, “and then,” common in everyday storytelling. With engagement in more classroom exchanges like this (“repetition with variation”, see Lemke, 1990, p. 113), he might be able to pick up the explicit logical connectors (e.g., so, therefore) central in the science thematic patterns (discourses).

Figure 1. Picture of the teacher’s drawings on the blackboard (taken at the end of the excerpt)

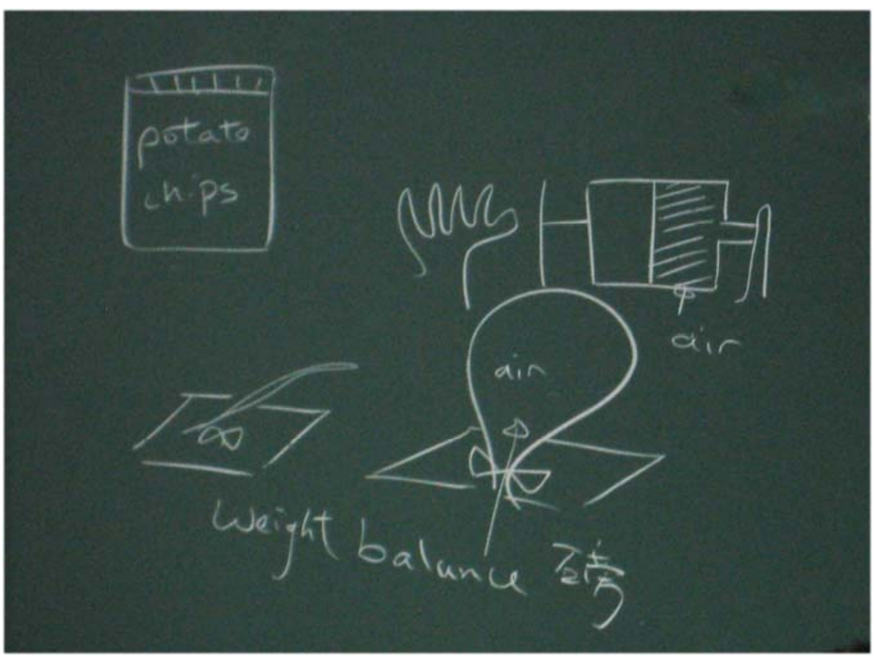


Fig.1 Picture of the blackboard drawing

In the rest of the lesson excerpt the teacher continues to engage students in IRF exchanges about how one can prove that air has mass (the second defining characteristic of matter). At the end of Turn 22, the teacher re-initiates, "How can you prove that air has mass?"

Alice (notice that she has previously responded in Turns 8, 10, with candidate answers that are not affirmed by the teacher) attempts again to respond, "Eh (5) You (.) you (.) you (.) May I speak Cantonese?" (Turn 23). The long 5-second pause after "Eh" and the three consecutive short pauses after "You" gives us evidence that she seems to be struggling hard to *language* in English (i.e., to construct her ideas in English) before finally bursting out into a request to the teacher to allow her to speak Cantonese. Remember earlier another student, Alex, has just used a Cantonese word (jam-tung) in the middle of his utterance (Turn 12) without first asking for permission to use a Cantonese word. Alice, in contrast, seems to be oriented towards the institutional norm (and the government policy) that only English should be used in EMI classes. Interestingly, we see Alex immediately says, "Yes, I can use Cantonese." (Turn 24). Alex starts his turn with "Yes," as if answering Alice. We can thus see that even under the same institutional English-only policy, there can be diverse takes on this policy, as evidenced by the different orientations of Alex and Alice. In Turn 25, the teacher says, "Yes, go ahead." With this permission, Alice immediately comes up with an extended utterance in Cantonese (Turn26), which is in sharp contrast to her struggling effort to *language* (to construct meaning) in English only (Turn 23).

Alice's example seems to be drawn from her everyday observation (possibly on a TV documentary) of a diver carrying a tank of compressed air. Notice that even in Cantonese, she does not have the field-specific vocabulary of "oxygen tank": she calls it air instead of oxygen, and she does not seem to know the Cantonese word for oxygen tank. However, she does employ the Cantonese word for "compress", which is not an everyday Cantonese word, but a formal Cantonese word. We can see that Alice seems to be languaging across languages (i.e., translanguaging): she picks up the English word, "compress" from the on-going discussion and finds the Cantonese equivalent word for compress. As the words "oxygen tanks" do not get into the conversation and both the English and Chinese versions of this do not seem to exist in Alice's vocabulary, she seems to be expressing the example with a mixture of both everyday words and field-specific words (e.g., compress) which exist in both her L1 (Cantonese) and L2 (English). She is drawing on all her existing and evolving linguistic resources (both Cantonese and English, both everyday and academic wordings), to actively construct meaning (i.e., to *language* about how the diver carries compressed air which is heavier after compressing) to show to the teacher her own understanding of how she can observe that air has mass. We see that if allowed to do *translanguging,* to draw on one's existing multiple linguistic resources (Creese and Blackledge, 2010), a student even with basic, fledging L2 resources can construct an extended and meaningful response to the teacher's initiation drawing on her L1 resources (in contrast to producing only one or two words in her L2 if she is not allowed to use her existing resources). Notice that although Alice constructs her response in Cantonese, her Cantonese response has words that are direct translations of the academic English words (e.g., compress) which have been used in the on-going lesson conversation between the teacher and other students and are picked up by Alice in her response; that is, her L1 response has been shaped by her attentiveness, and also shows her responsiveness, to the preceding L2 exchanges in the unfolding classroom discussion between the teacher and the students (e.g., they have been talking about compressing a syringe). Thus, one can make the argument that allowing students to translanguage in the CLIL classroom does not necessarily lead to students closing their ears to exchanges in the target language (L2).

Immediately after Alice's Cantonese response, the teacher continues to speak in English to give feedback (Turn 27), "You are talk (.) okay, how do I know it is heaver? What do you use to measure?" The teacher's midway pause seems to show her taking some time to think of how to repair her feedback, and her subsequent re-formulation of her feedback into a new initiation, asking how one knows that it is heavier shows us that she is leading her students to think like a scientist. A scientist cannot just say something is heavier; a scientist has to show what kind of reliable instrument is used to measure and to give the measurement as an evidence. She is thus apprenticing her students into the scientist's way of talking/thinking/acting/reasoning (i.e., apprenticing them into science discourses).

To the teacher's initiation, Alex responds, "Use Micro (.)" (Turn 28) but while he is pausing (probably searching for the right word), his speaking turn is interrupted by another boy, Ray, who speaks noticeably much more loudly (probably in order to gain a speaking turn from where he is sitting—at the back of the classroom) (Turn 29):

> "For example ↑ , er (.) potato chips has many air. Then (.) But when we open it, it just has steam. It just has very few potato chips. The (.) the (.) But it is very hea: vy when we have not (.) em (.) em (.) opened it."

Ray might be making some grammatical mistakes (e.g., "many air") and have multiple hesitations (short pauses, indicating that he might be searching for the right words) but he is languaging in English (constructing his example totally in English) and managing not only to gain a speaking turn (by raising his voice and using the signaling words, “For example,” to interrupt a fellow student’s speaking turn) but also to hold an extended speaking turn with an utterance completely in English (following the institutional norm of using only English and also showing his ability to participate in discussion in English). Notice that he is not responding to the teacher’s immediately preceding question (i.e., how one can measure the compressed air); he is instead responding to the teacher’s earlier question of how one can prove that air has mass. While Alice has responded with her “diver and compressed air” example, Ray seems to be eager to grab a chance to respond with his own different candidate example. And he seems to have constructed this example from his everyday experience and observation of what happens when one opens a packet of potato chips: it is heavier before one opens it. We notice that instead of relying on an authority (see Turn 6 when he says, “Because Mr. Lee tell us”), Ray seems to have now become an active thinker trying to come up with his own way of proving that air has mass. It shows that he might be trying to think like a scientist, and this seems to be what the teacher is trying to get the students to do through her way of formulating her feedback to her students’ responses in this unfolding series of IRF triadic dialogue.

By now we can predict what the teacher is going to say as feedback: she will be insisting on getting the students to say just how one can measure that it is heavier. Indeed in Turn 30, the teacher says, “How can you prove it is heavier? What device do you use to measure it? Heavier, lighter, what do we use to measure it? What apparatus do we use?” Notice that the teacher has now introduced more field-specific words: device, apparatus. These words are highly frequent in experimental reports (e.g., in the procedure stage of this genre). Now, we can predict what a student’s response might be—the name of a measuring device/apparatus. Indeed we see that Alice comes up with the name, "Balance," (Turn 31). To this the teacher affirms and elaborates ("Exactly. Use a weight balance") while simultaneously drawing the device on the blackboard (Figure 1) and continues with her feedback, "Say you talk about a pack of potato chips. Or I talk about a balloon. Put it on the weight balance, before, and after. Say if you talk about a pack of potato chips, before I open it (.) [T points to the balloon drawing] Shh(.) Say(.) [T draws a pack of potato chips and points to it]" In the early part of this speaking turn, there seem to be some students not paying attention to her or making some off-task noise (the teacher needs to say "Shh" to indicate to the students to keep quiet) and we see her sliding to and fro between the student's example (potato chips) and her own model example (balloon) in both her words and her hand gestures (pointing at the potato chips drawing and then at the balloon drawing). We also notice that the teacher immediately follows her feedback with another initiation using the potato chips example, "Do you expect, the potato chips [packet], have a higher or lower mass before I open it?"(Turn 32; "packet" added). Alice responds, "Higher." (Turn33). The teacher affirms it and follows this affirmation with an elaborate exposition, which starts off with Ray's potato chips example and ending with her own model example of the balloon (Turn 34):

> "Right, because of the air inside that makes the pack heavier. But when I open it, the air escapes and the mass should be slightly lower. If you (.) you are not convinced, go to another example that is exactly the same. Before the balloon is being blown, put it on the weight balance. Blow some air, tie it and measure it again. You will see (.) [T draws a ribbon] Of course you have to have a ribbon on the same weight balance to compare the mass of the two. Would you expect before or after blowing to be heavier?"

We can see that by interweaving the students' words (balance, potato chips) and her own words (weight balance, balloon) into her speaking turns, the teacher seems to be leading her students towards, and trying to focus her students' attention on, her ultimate model example (the balloon example: blowing air into it, tying it with a ribbon, measuring it on a weight balance before and after blowing, both with the ribbon). In an informal chat after the lesson, the teacher told the second author of this paper that she had wanted to stay with the student's potation chip example but she thought the balloon example is more neat as there are fewer intervening variables (just the balloon and air, without the potato chips). We might agree with the teacher that the balloon is a better example from the scientist's perspective, while the potato chips packet example is a more everyday life example (from the student's perspective) and the teacher is trying to "move" students from their everyday examples (everyday perspectives/thematic patterns) to the scientist's examples (scientific perspectives/thematic patterns) through her guidance in the unfolding interaction. She has not preplanned these exchanges with her students but she seems to be offering timely guidance to her students (about how to speak/reason/prove like a scientist) through grasping the teachable moments emerging in the unfolding teacher-student(s) dialogue. She seems to be accomplishing this mainly by constructing her feedback in certain particular ways, which include affirming, repeating, rephrasing, completing, translating, elaborating her students' everyday (both L1 and L2) wordings/examples and interweaving these with her own science field-specific (L2) wordings/examples. The point of this series of IRF exchanges seems to be that of "moving" her students from their everyday discourses into the science discourses.

"Guidance Through Interaction in the Context of Shared Experience": Translanguaging and Trans-semiotizing in the CLIL Classroom

In the above analysis we see that the teacher seems to have been successful in engaging students in co-constructing an exposition (epitomized in her final exposition in Turns 33 and 35) on how one can prove that air takes up space and has mass. She has done this through the use of the IRF *discourse format* (Heap, 1985; Lin, 1999; 2007) and by selecting, modifying, and interweaving some of the students' contributions/wordings in their Response (R) into her own Feedback (F) and (re-)Initiation (I). She has not, however, facilitated students in expressing this exposition flexibly themselves; as Lemke puts it:

> … there need to be ways for teachers to help students abstract from any one particular wording of the relations of a thematic pattern to the pattern itself. Only in this way can they become free of parroting back fixed wordings and begin to use thematic *meanings* flexibly to answer questions, talk their way through problems, and so on. (Lemke, 1990, p. 113)

The fundamental way to help students to do this, according to Lemke, is the use of "Repetition with Variation" (Lemke, 1990, p. 113; Lin, forthcoming a). This can be illustrated with an example quoted from Painter's (1999) analysis of a family interaction (the father, mother and child are travelling in a rented car instead of their own family car):

Father: This car can't go as fast as ours.

Child: I thought--I thought all cars could--all cars could go the same--all cars could go the same (.) fast…

Mother: The same speed.

Child: Yes, same speed.

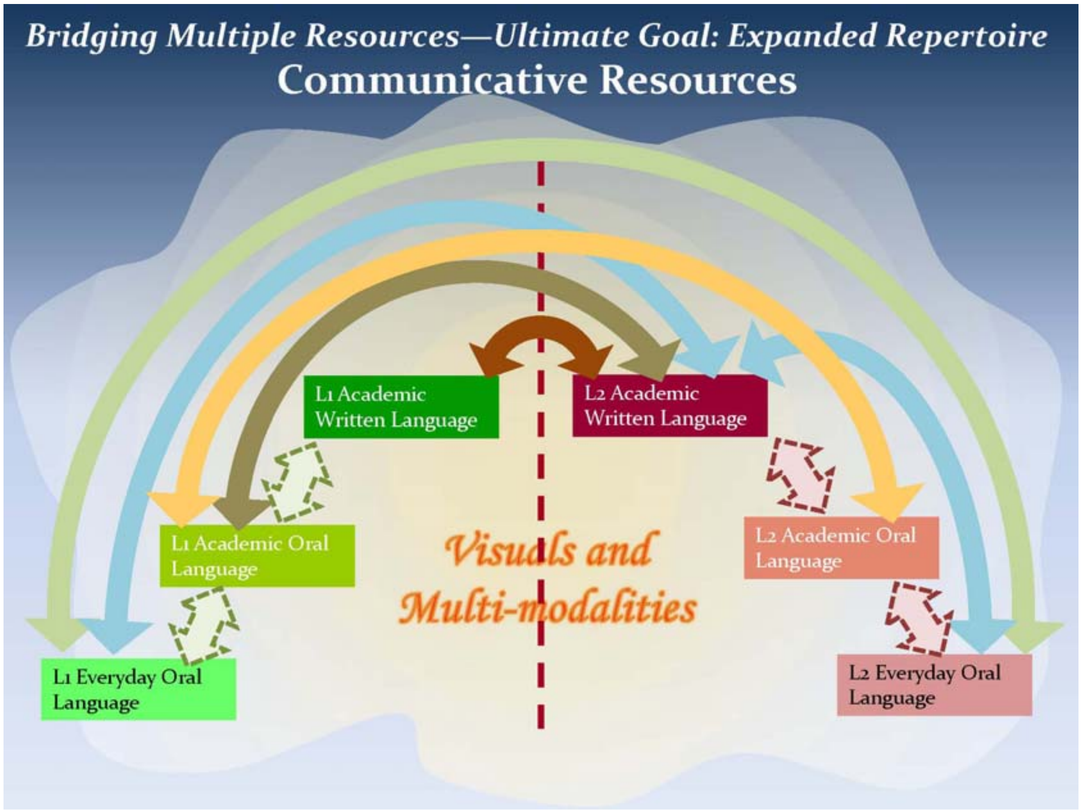
(Painter, 1990, p. 121, qtd. in Rose and Martin, 2012, p. 80)

In the above example the child is guided through the mother-child interaction in the context of shared experience (both sharing the here-and-now context) to develop mastery of the linguistic contrast between "fast" and "speed" within the linguistic system of lexico-grammar (i.e., the contrast between an adjective and a noun). At the same time, the child is also immersed in the shared social context of interaction (i.e., engaging in co-constructing the unfolding conversation text). Prior to the mother's provision of the right word ("speed"), the child seems to be struggling to find the appropriate thematic item (from his fledging language system) to express his meaning, hence the pause before his coming up with the word "fast", which has got the semantic meaning right but *not* the lexico-grammatical contrast (permitted by the language system) right (i.e., it is an adjective instead of a noun). This struggling effort seems to be reflected in his shifting extra conscious effort to find the right linguistic structure from the linguistic system (e.g., of English) in order to instantiate a meaning that he is struggling to contribute to the on-going conversation or argument (that all cars can go the same speed—that the father's statement needs to be corrected or qualified).

We see that L2 learners (e.g., Jenny's students in her science class), likewise, have this experience of struggling to find the right linguistic structure or contrast (from their fledging mastery of the L2 English system) to construe a meaning which is often important in the context of on-going interaction (e.g., syringe, compress; see analysis above); i.e., they are struggling to *language* (Swain, 2010) in English (their L2). At this point, if they are allowed to *translanguage*, they can draw on their familiar linguistic resources (e.g., L1) to construct their meanings. Notice that the mother's linguistic scaffolding (provision of the right linguistic structure) is *just in time* and *just in need* (Gee, 2003). The teacher in our science classroom could have also provided more linguistic scaffolding. For instance, in Turn 13, instead of just giving an encouraging "Ha ham," to acknowledge Alex's contribution (Turn 12, "Use the *jam-tung*…"), she can also say, "Yes, use a syringe to…", like the mother helping the child who is struggling to express himself. Drawing on Halliday (1975, 1993) and Painter (1986, 1991, 1996, 1999)'s work, Rose and Martin propose that successful language learning depends on "guidance through interaction in the context of shared experience' (2012, p. 58). In the same vein, the following remark of Lemke (1990) is also useful in our CLIL contexts: “Of course, just listening to the teacher do this is not enough; they need practice at doing it themselves, at putting things into ‘their own’ or ‘different’ words.” (p. 113). In other words, students need to be provided with ample opportunities to practice *languaging* in the L2 science discourses.

In conclusion, we propose that successful CLIL depends on guidance through interaction in the context of shared experience, with the additional principle that (struggling) learners should be allowed to translanguge and *trans-semiotize* (Lin, forthcoming b) by drawing on whatever familiar semiotic resources at their disposal: e.g., L1/L2 everyday wordings, L1/L2 academic wordings, as well as visuals, drawings, gestures, etc. (i.e., multimodalities) (see the Rainbow Diagram in Fig. 2). While Rose and Martin (2012) do not focus on translanguaging per se, their principle is compatible with our proposal in the context of L2 CLIL classrooms. We see that Jenny our science teacher seems to be successful in allowing her students to translanguage in encouraging them to express their meanings (by drawing on their familiar linguistic resources) and in providing drawings on the blackboard and using accompanying gestures to help her students to access the L2 science discourses (e.g., wordings, thematic patterns), and she could have been further assisted to give more language support in her CLIL classroom. How to do this seamlessly in the unfolding lesson dialogues without interrupting the flow of the discussion will require further design intervention research in CLIL classrooms instead of just naturalistic observation research.

Fig. 2. Bridging Multiple Resources -- Ultimate Goal: Expanded Repertoire (From Lin, 2012, p. 93)



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Appendix I. Lesson Worksheet

S1 Integrated Science

Name: ______________________ (   )   Class: ______   Date: ___________

Lesson 6   Unit 17 Matter and its properties

A. Definition of matter
B. Three states of matter
C. The changes of state
D. Measuring the melting point and boiling point &
Determining the states of matter from the melting and boiling points

A. What is matter?

Everything that takes up space and has mass is matter.

Put a "X" in the box next to the items of NON-MATTER.

	Smoke		Air
	Rainbow	X	Light
X	Heat		Water
X	Sound	X	Microwave
X	Force	X	Gravity(地心引力)

Why are some of the items above NON-MATTER?

This is because they do not take up space and do not have mass.

Appendix II. Lesson Excerpt

1	T:	*[T crosses out the last item of the exercise on the worksheet "Gravity", indicating it is not a matter]* Gravity is an attractive force, acting on the object by the earth. So it does not take up space. *[T moves from the projected worksheet to the blackboard]* Force does not take up space and does not have mass. You can't see it. It doesn't (.)Well, can you see air?
2	Ss:	No.
3	T:	But does it take up space?
4	Ss:	Yes.
5	T:	How can you prove to me that air takes up space?(.)Prove it. You can't see it. You can't feel it. How do you know it takes up space?*[T smiles to challenge Ss]*
6	Ray (boy at the back):	Because Mr. Lee *[their science T at the school]* tell us.
7	T:	I want(.) an evidence that I can see↑.
8	Alice (girl at the front):	Because there is (.) air particle.
9	T:	Can you see air particles?
10	Alice (girl at the front):	No, but(.) the motion*[Alice moves hands]*.
11	T:	How can I observe air?
12	Alex (boy at the front):	Use the 針筒 *((trans: syringe))*. To have some air.
13	T:	Ha ham
14	Alex (boy at the front):	Use to(.) Try to (.)=
15	Ray (boy at the back):	=°Compress° *[seems not heard by Alex at the front]*
16	T:	=Compress *[gesturing the action of compress]*
17	Alex (boy at the front):	=compress it. And then if you can't compress it out, because you use your finger to cover the mouth. And then(.) it takes up space.
18	T:	Right. One very good evidence, say if I use a syringe= *[T draws on the blackboard as she speaks]*
19	T:	=and I block it with my finger*[Ss laugh]*. And then I compress the syringe. You will find that finally you can't compress it anymore. In other words, you can see the space cannot be further compressed because of the air inside. Or another example. When you blow a balloon= *[T draws on the blackboard as she speaks]*
20	T:	=you can see the balloon getting bigger. What do you blow into the balloon?
21	Ss:	Air.
22	T:	If it doesn't take up space, how can the balloon get bigger? So you can see that air takes up space. How can I prove that air has mass? How can I prove that? (.) You can't even see it, feel it. How can you prove that air has mass?
23	Alice (girl at the front):	Eh (5) You (.) you(.) you(.) May I speak Cantonese?
24	Alex (boy at the front):	Yes, I can use Cantonese.

25	T:	Yes, go ahead.
26	Alice (girl at the front):	好似果 D 潛水員帶果 D, 將果 D 空氣壓縮左噶嘛，但系重左噶嘛，本來毋野，但壓縮左之後就重左噶嘛 ((trans. Like what the diver carries. The air is compressed, but it is heavier. Initially here there is nothing, but it is heavier after compression))
27	T:	You are talk(.) OK, how do I know it is heavier? What do you use to measure?
28	Alex (boy at the front):	Use micro(.)=
29	Ray (boy at the back):	=For example↑, er(.)potato chips has many air.Then(.)But when we open it, it just has steam. It just has very few potato chips. The(.) the(.)But it is very hea: vy when we have not (.) em(.) em(.) opened it.
30	T:	How can you prove it is heavier? What device do you use to measure it? Heavier, lighter, what do we use to measure it? What apparatus do we use?
31	Alice (girl at the front):	Balance.
32	T:	Exactly. Use a weight balance *[T draws on the blackboard]*.Say you talk about a pack of potato chips. Or I talk about a balloon. Put it on the weight balance, before, and after. Say if you talk about a pack of potato chips, before I open it(.)*[T points to the balloon drawing]*Shh(.)Say(.)*[T draws a pack of potato chips and points to it]*Do you expect, the potato chips, have a higher or lower mass before I open it?
33	Alice (girl at the front):	Higher.
34	T:	Right, because of the air inside that makes the pack heavier. But when I open it, the air escapes and the mass should be slightly lower. If you (.) you are not convinced, go to another example that is exactly the same. Before the balloon is being blown, put it on the weight balance. Blow some air, tie it and measure it again. You will see (.) *[T draws a ribbon]* Of course you have to have a ribbon on the same weight balance to compare the mass of the two. Would you expect before or after blowing to be heavier?
35	Ss:	After.
36	T:	After blowing, because there is some air inside. So I can prove that air takes up space and has mass.

Transcription Conventions

=	(a) Turn continues below, at the next identical symbol**;** (b) If inserted at the end of one speaker's turn and at the beginning of the next speaker's adjacent turn, indicates there is no gap at all between the two turns
↑	Rising intonation
(3)	Interval between utterances (in seconds)
(.)	Very short untimed pause
e:r the: : :	Lengthening of the preceding sound
°°	Utterances between degree signs are noticeably quieter than surrounding talk
[T writes]	Nonverbal actions or author's comments
針筒 ((tr.: syringe.))	Non-English words are italicized and are followed by an English translation in double parentheses
T:	Teacher

S/Ss: Unidentified student/several or all students simultaneously