International Journal of Bilingual Education and Bilingualism

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rbeb20

Exploring content and language co-construction in CLIL with semantic waves

Yuen Yi Lo , Angel M. Y. Lin & Yiqi Liu

To cite this article: Yuen Yi Lo , Angel M. Y. Lin & Yiqi Liu (2020): Exploring content and language co-construction in CLIL with semantic waves, International Journal of Bilingual Education and Bilingualism, DOI: 10.1080/13670050.2020.1810203

To link to this article: https://doi.org/10.1080/13670050.2020.1810203

Published online: 30 Aug 2020.

INTERNATIONAL JOURNAL OF BILINGUAL EDUCATION AND BILINGUALISM
https://doi.org/10.1080/13670050.2020.1810203

Exploring content and language co-construction in CLIL with semantic waves

Yuen Yi Lo [a], Angel M. Y. Lin [b] and Yiqi Liu [c]

[a]Faculty of Education, The University of Hong Kong, Hong Kong SAR, China; [b]Faculty of Education, Simon Fraser University, Burnaby, Canada; [c]Department of English Language Education, The Education University of Hong Kong, Hong Kong SAR, China

ABSTRACT

In content and language integrated learning (CLIL) classrooms, it is assumed that non-language content subjects provide more authentic communicative contexts for students to learn a foreign/second/additional language (L2). However, learning abstract concepts and academic language in an L2 simultaneously is also challenging for CLIL students. It is thus important for CLIL teachers to unpack and repack both abstract concepts and academic discourse for the students. 'Semantic waves', which model classroom practices of both unpacking and repacking, is arguably a key to understanding cumulative knowledge-building. Applying the concepts of semantic profiles and semantic waves, this paper analyses the classroom discourse of two CLIL science lessons in Hong Kong. In one lesson, the semantic profile mainly consists of downward shifts. The teacher adopted various useful strategies to unpack science concepts, especially with multimodalities, everyday L2 and students' L1 resources. Yet, there was limited repacking. In contrast, some repacking was observed in another lesson, where the teacher provided explicit instruction on academic language and guided students through academic writing tasks. A semantic wave can thus be observed there. These findings on strategies for unpacking and repacking provide significant insights into knowledge building in CLIL contexts, and may hence illuminate CLIL pedagogical practices.

ARTICLE HISTORY
Received 15 January 2019
Accepted 17 July 2020

KEYWORDS
Bilingual education; content and language integrated learning (CLIL); classroom discourse

Introduction

In an increasingly popular set of bilingual education programmes broadly called content and language integrated learning (CLIL), students are learning non-language content subjects through their foreign/second/additional language (L2). In other words, students in CLIL are learning both abstract concepts and academic language in their (usually) less proficient language (i.e. L2). This inevitably poses double challenges to students, and CLIL teachers have been urged to provide more scaffolding through their classroom practices (Lo and Lin 2015). In existing CLIL research, teachers have been observed to employ multimodal and multilingual resources, including visuals, models, video clips, everyday L2 and students' L1 resources, to unpack content knowledge for students (e.g. Lin and Wu 2015; Nikula and Moore 2019). However, attempts to depict how CLIL teachers help students repack content knowledge in academic discourse remain scarce. It is pedagogically illuminating to examine how CLIL teachers guide students to shuttle between the various resources in their communicative repertoire through classroom talk and interaction (Lin 2012), so that students can express their content knowledge in L2 academic language. This paper seeks to theorise the

CONTACT Yuen Yi Lo yuenyilo@hku.hk

nature of teacher talk and classroom interaction during the unpacking and repacking processes in CLIL classroom discourse.

Legitimation code theory (LCT) and systemic functional linguistics (SFL) have been adopted as complementary frameworks in educational research to examine how teachers construe subject knowledge with students and have identified some effective pedagogical practices that facilitate 'cumulative' (rather than segmental) knowledge-building (Maton, 2013). While some concepts from LCT and SFL such as 'semantic gravity', 'semantic density', 'power words' and 'power grammar' may be difficult for teachers (and hence will be explained in detail in the next section), these concepts could help us understand what makes academic language difficult for students (e.g. the extent to which meanings depend on the context and the extent to which meanings are condensed within practices), and how teachers could mobilise their (and students') communicative resources to make academic language more accessible for students (Martin 2013; Martin and Maton 2017). The results of such analyses have yielded significant implications for pedagogical practices, in the sense that teachers can envisage how they can bridge the gap between high-stakes reading (i.e. reading academic texts) and high-stakes writing (i.e. the written tasks in assessment) through classroom practices. They not only unpack academic discourse by concretising abstract concepts and fleshing out the condensed meanings of technical terms, but also repack such meanings so that students can express them with academic discourse expected in high-stakes writing tasks (Maton, 2013). 'Semantic waves', which model classroom practices of both unpacking and repacking, is said to be the 'key to cumulative knowledge-building' (Maton, 2013, 8).

We would argue that such concept of cumulative knowledge building is equally, if not more, important in CLIL classrooms, considering the double challenges of content and L2 learning. Drawing on the useful conceptual tools of both LCT and SFL, this paper examines how teachers co-construct content and language (L2 academic language) with students in CLIL lessons. It also seeks to explore the usefulness of the concept of 'semantic waves' and 'semantic profiles' as an analytical tool of CLIL classroom discourse.

Literature review

Knowledge construction in CLIL

In recent years, CLIL has been used as an umbrella term encompassing different types of bilingual education programmes in different contexts, such as immersion, content-based instruction and English as medium of instruction (EMI) (Cenoz, Genesee, and Gorter 2014). Despite their differences in sociolinguistic context, curriculum goals, teacher and student profile, these programmes do share one underlying principle – content subjects provide more exposure to the target L2 in meaningful communicative contexts (Lyster and Ruiz de Zarobe 2018). That also partly explains why this kind of programme was coined content and language 'integrated' learning as it has the dual goal of content and language learning. However, such dual goal is not always guaranteed, in the sense that some CLIL students may sacrifice their academic achievement for L2 learning (e.g. Lo and Lo 2014). There could be several reasons for this, and some are related to the nature of the 'language' involved in CLIL (Llinares, Morton, and Whittaker 2012). First, the 'language' is usually teachers' and students' L2 (with English being the most common target language), and students may encounter difficulty when learning new academic knowledge in an L2. Second, the 'language' involves both everyday conversational language for classroom communication and interaction, as well as academic language or disciplinary literacy, which is essential for students to succeed in high-stakes assessment (Martin 2013). Thus, both CLIL teachers and students need to bridge the gap between the two registers of language in L2, and this poses tremendous challenges for them. It has been observed that CLIL teachers, most of whom have been trained as subject specialists (Mehisto 2008), tend to pay more attention to content teaching (Tan 2011; Walker 2011), leaving students to learn the L2 incidentally. However, the differences between the two registers of language and the special features of academic discourse imply that an incidental language learning approach is unlikely to succeed, and that more explicit instruction and guidance from teachers is necessary (Cammarata and Haley 2018).

To look into teacher-student interaction and the knowledge construction process in CLIL lessons, an increasing number of research studies have sought to examine the classroom discourse of CLIL lessons. Some studies have adopted Conversation Analysis (CA) to offer fine-grained analysis of how the teacher and students co-construct knowledge through their interaction. For example, in both Lin and Wu (2015) and Escobar Urmeneta and Walsh (2017), the CLIL science teachers in different educational contexts (Hong Kong and Catalonia) were observed to deploy multimodal and multilingual resources (e.g. gestures, blackboard work, visuals, students' L1) to co-construct the content knowledge in the target language with students. Such meaning making processes through language and other semiotic resources are also known as 'translanguaging' and 'trans-semiotising' practices, which are considered as essential for content and language learning in CLIL classrooms (Lin 2019; Liu 2020). Some other studies have integrated different theoretical and analytical approaches to investigate language use and interaction in CLIL classrooms. For instance, Llinares and Nikula (2016) combined Systemic Functional Linguistics (SFL) appraisal theory and the pragmatic analysis of teacher-student interaction to reveal the different patterns of teachers' and students' use of evaluative language resources in Science and Social Science lessons in Finland and Spain; Llinares and Morton (2017) focused on the SFL register variable of 'tenor' (the role relationship between interactants), and they adopted speech function analyses to examine how tenor was reflected and constructed by students during role plays and interviews.

These existing studies on CLIL classroom discourse provide interesting insights into teacher-student interaction, their language use and knowledge construction. However, there is still a need to capture a broader picture of classroom discourse or interaction, particularly in terms of the potential 'cumulative' effect of teacher-student interaction on student learning. Following some previous attempts and advocates for integration of theoretical approaches in CLIL research (Nikula, Llinares, and Dalton-Puffer 2013), this paper seeks to integrate concepts from LCT and SFL, which may be able to provide further useful tools for analysing CLIL classroom discourse.

Unpacking LCT concepts of 'semantic profiles' & 'semantic waves'

Extending Bernstein's code theory (2000), LCT is 'a sociological framework for researching and changing practice' (Martin and Maton 2017, 29). It consists of five dimensions of conceptual tools, namely 'Specialization', 'Semantics', 'Autonomy', 'Temporality' and 'Density'. This study, similar to some previous research on educational practices, focused on 'Semantics'. This dimension construes social fields of practices as 'semantic structures', whose organising principles are 'semantic codes' comprising 'semantic gravity' and 'semantic density'. Each of these will be briefly explained to clarify the notions of semantic profiles and semantic waves.

Semantic gravity (SG) refers to the extent to which meaning relates to or depends on its context. The stronger the semantic gravity (SG+), the more meaning is dependent on its context. For example, the meaning of the name of a specific organ in biology (e.g. lung) embodies stronger semantic gravity than that of a process (e.g. respiration). Semantic gravity can change over time, and such processes can be captured as (i) *strengthening* semantic gravity (SG↑), when moving from abstract or generalised ideas towards concrete cases, and (ii) *weakening* semantic gravity (SG↓), when moving from concrete particulars of a case towards generalisations and abstractions whose meanings are less dependent on a specific context (Maton, 2013, 11).

Semantic density (SD) refers to the degree of condensation of meaning within practices. The stronger the semantic density (SD+), the more meanings are condensed within practices, or a meaning has a greater number of relations to other meanings (Martin and Maton 2017). It has to be noted that the strength of semantic density depends on the semantic structure within which a practice is located. For example, the semantic density of 'gold' used in the context of chemistry is likely to be stronger than when it is used in daily life, since 'gold' in chemistry is related to other concepts like 'atomic number, atomic weight, electronic configuration' (Martin and Maton 2017, 35). Semantic density can also change over time, with *strengthening* semantic density (SD↑) referring to moving from a simple symbol or term that represents a small number of meanings towards a more technical concept; and *weakening* semantic density (SD↓) taking place when the meanings condensed within a technical concept are explicitly unpacked and fleshed out.

Conceptualising the processes of strengthening and weakening semantic gravity and semantic density (SG↑↓, SD↑↓) generates the *semantic profile* of practices, and tracing the semantic profiles of practices over time enables us to analyse knowledge-building processes in lessons. For example, in content subject lessons like biology, the abstract scientific concepts are usually expressed with technical terms. These imply weak semantic gravity and strong semantic density (SG–, SD+). Teachers can then strengthen semantic gravity (SG↑) by using everyday language and examples, and cross-referencing students' previously learned concepts, while at the same time weakening semantic density (SD↓) by unpacking the term and delineating a limited number of its meanings (Maton, 2013). In addition, teachers can weaken semantic gravity (SG↓) and strengthen semantic density (SD↑) by repacking specific events and phenomenon into a specific technical concept. Maton (2013) argues that recurrent shifts between unpacking (downward shift in the semantic profile) and repacking (upward shift), which can be called 'semantic waves', are essential for knowledge building. It is then important for teachers to guide students through semantic waves, so that students can bridge the gap between high-stakes reading and high-stakes writing required for assessment. However, semantic waves are rarely observed in classrooms, since teachers mainly do unpacking, without attempts to repack (Maton, 2013), or teachers mainly unpack and repack knowledge orally, without guiding students to high-stakes writing (Martin 2013). This paper can hence address this research gap by examining how to increase teachers' awareness of the importance of having some kind of semantic waves in their teaching and how to support teachers to do so.

Systemic functional linguistics (SFL), complementary to LCT

SFL presents a functional model of language, which emphasises the role played by language in achieving communicative goals. The space in this paper does not allow a full account of SFL. Instead, it will focus on several key concepts which are useful when analysing features of academic discourse, thereby complementary to LCT framework (Martin and Maton 2017). First, 'power words' refer to technical terms conveying a number of meanings. In other words, these are words with strong semantic density (e.g. *keratin*, *deamination* in biology). Second, 'power grammar' is realised by grammatical metaphor, in which there is incongruent relationship between lexicogrammar and semantics (e.g. a noun typically represents a thing or a person, but in academic texts, a noun may perform the job of a verb, as in nominal phrases like 'the motion of particles'). Third, 'power composition' refers to the the rhetorical organisation which packages knowledge in texts (as genres) (Martin 2013). For instance, the genre 'factorial explanation' is often staged as 'Phenomenon' and 'Factors' (Rose and Martin 2012). Disciplines or content subjects tend to use a range of genres. Academic discourse deploys the 'power trio' to construe disciplinary knowledge, something which teachers have to help students to master (Martin 2013). Previous research has shown that CLIL teachers have tended to focus mainly on power words (i.e. subject-specific terms) when they are asked to incorporate language teaching into their lessons. They tend not to display awareness of other aspects (such as grammar and genres) of academic discourse (Cammarata and Haley 2018; Koopman, Skeet, and de Graaff 2014).

While the concepts of LCT are useful for understanding knowledge practices (e.g. teachers' pedagogical practices), ideas from SFL could be used to analyse the linguistic practices associated with those knowledge practices. In other words, while the LCT notion of semantic profiles can depict how teachers guide students through decontextualised vs. context-dependent meanings (i.e. SG) and simpler vs. more complex meanings (i.e. SD), SFL analysis reveals how the downward and upward shift along the semantic profiles is achieved through teachers' and students' use of linguistic resources such as the 'power trio' (Maton and Doran 2017). Seeing the potential of the two complementary frameworks, Matruglio, Maton, and Martin (2013) analysed how history teachers in Australia secondary schools unpacked content knowledge and academic language. With the concepts of semantic profiles and the analytical tools offered by SFL, the researchers identified specific strategies employed by the teachers to strengthen SG and weaken SD, including translating archaic language into contemporary language, reconstructing processes from nominal groups, and making use of present tense to position the students within the time of a particular historical event. However, similar to what others have observed, there was limited evidence of repacking and hence semantic waves were largely absent. The researchers concluded by calling for more research in classroom knowledge-building, using the notion of semantic waves. This paper seeks not only to continue this line of research, but also to extend it to the context of CLIL to investigate how complementary frameworks and concepts of LCT and SFL could be applied to reveal CLIL teachers' pedagogical strategies in de-constructing and co-constructing content and academic discourse in L2. This paper addresses the following questions: *How do teachers and students unpack and repack content and language in CLIL lessons? In particular, what strategies can be observed in CLIL lessons which result in some approximation to 'semantic waves'?*

Data sources and analysis

The classroom data analysed in this paper came from a small collection of content subject lessons (around 40 lessons in total) in Hong Kong. Hong Kong used to be a British colony and is now a special administrative region of China. Although the majority of population communicate in Chinese (spoken Cantonese and written Standard Chinese), parents and students have a strong preference for English as the medium of instruction (EMI) secondary schools (Grades 7–12, students aged between 12 and 18), believing that students in those schools can learn English more effectively (Li 2017). The latest medium of instruction policy (which started from 2010/11) provides secondary schools more flexibility in choosing their language of instruction for content subjects. As a result, most secondary schools are teaching at least some subjects through English. In other words, CLIL is being implemented in a large number of secondary schools in Hong Kong, which favours empirical research on CLIL.

The collection of content subject lessons was compiled from several research projects conducted between 2008 and 2013 (Lin and Lo 2017; Lo and Lin 2019). Those projects aimed to examine classroom language use and practices of CLIL content subject teachers. In view of this, the data were collected through non-participant classroom observations. At least one researcher was present in the classroom when the lessons were observed and video- and/or audio-recorded. This collection of lessons covered different content subjects (e.g. biology, geography, mathematics) and came from schools in different districts and with students of different characteristics. The teachers involved had different professional training and teaching experience. To conduct detailed analyses of classroom discourse with LCT and SFL frameworks, we selected two science lessons to focus on, mainly because the two lessons appeared to demonstrate different semantic profiles, which allows the authors to identify strategies that could facilitate semantic waves. The details of the school context, teachers and students will be presented in the respective excerpt in the results section, so as to better contextualise the lesson excerpts.

The observed lessons were first transcribed verbatim. Teachers' and students' actions as well as pauses longer than 3 s were indicated in the transcript, while short pauses were indicated with normal punctuation (see Appendix 1 for the transcription conventions). The transcribed material consists exclusively of teacher talk and teacher-student interactions, as there was no group-work in the two selected lesson episodes. This also matches the focus of this paper – how teachers co-constructed content and language with students. We then followed these steps to do the analysis: first, we read the lesson transcripts several times and identified the changes in semantic gravity (SG) and semantic density (SD) during the lesson. We then depicted the semantic profiles of the lessons. Second, we analysed the teachers' use of strategies and various resources associated with the changes in SG and SD, with reference to such SFL concepts of 'power words' and 'power grammar'.[1] These two strands of analysis were then combined to provide a more comprehensive picture of how teachers and students co-constructed content and language in the observed lessons. A comparison of the two lesson excerpts was made with respect to the overall patterns and strategies employed to identify any similarities and/or differences that might yield interesting implications for teaching and learning in CLIL lessons. The following sections present the two selected lesson excerpts, followed by annotation and analyses of the changes in SG and SD, as well as their semantic profiles.

Lesson 1: a semantic profile with mainly downward shifts

Excerpt 1 was taken from the first part [03:56–08:40] of a Grade 10 (15–16 years old) Biology lesson, taught by T1, who had been teaching the subject through English in the school for over 20 years.[2] The topic of the unit being taught was 'food substances', and the teacher and students were discussing 'protein', in particular its structure and functions. Prior to this lesson, two other food substances, fats and carbohydrates, had been discussed. The school where T1 worked in was a high-banding school, which admitted the top one-third of primary school leavers. In the school, most content subjects were taught in English at all grade levels. In other words, the Grade 10 students in the lesson observed had a few years of CLIL experience.

Excerpt 1

T1: [after talking about the chemical structure of proteins] Well, why do we need protein? Why? (pause) Why? Why do we need protein?

S: Body building

T1: Louder

S: Body building

T1: Yes, for body building. Okay? So which part of your body, okay, well, body building. [pause; writing on the blackboard] Can you tell me which parts of your body are made up of protein?

S: Bones

T1: Well, okay. Part of bones, right? I would like to say bones, bones also contain a lot of minerals. Okay? So part of bones. Anything else?

S: Hair (pause)

T1: Air?

S: Hair.

T1: Hair, okay, yes. Hair. And ______?

S: 手指甲 (*nails*)

T1: 手指甲 (*nails*). Okay, actually hair, the nail. Anything else? (pause) How about animals? Animals have ______?

S: Horn

T1: Horns, yes, horns. Actually they belong to the same class of proteins called keratin. 角，角，角，叫角質層呀 (*Horns, horns, horns, [they are] called keratin*). Okay? And also our skin, you know, skin. They all contain the same type of protein. So next time when you 食鹿茸 (*eat antlers*) [antlers as expressed in the term of Chinese medicine], you know, 鹿茸 (*antlers*), when you don't have the money to buy 鹿茸(*antlers*), what can you do? (pause) You bite your nail. Okay? Just bite your nail. It's the same protein. Okay? [Ss laugh] (pause) So anything else?

S: Enzymes

T1: Yes?

S: Enzymes

T1: Sorry? I can't hear.

Ss: Enzymes, enzymes

T1: Enzymes. Okay. We don't call it body building for enzymes because for body building, you mean building up your body structure. We want, I want something structural, structure.

S: Muscles

T1: Muscles, exactly, muscles. So people who want to build their body, they actually have to take in extra protein, like kind of, er, like milk powder. 有無見過呀? (*Have you seen that?*) 嗰啲，嗰啲，食嗰啲補充劑. (*Those, those, eat those supplements.*) 有無呀? (*Have you?*) (…) (a student's name), you have the potential. [Ss laugh] Can you show us your muscles?

S: 我無呀 (*I don't* [have any muscle]) (…)

T1: Yes. They have to take in extra protein supplement. See? This is what it means by body building. And I heard (a student's name) said something very important. Besides body building, they are also important in our, in our, well, functioning. It's extremely important in our body function because protein is needed for making enzymes. Remember? Okay? And enzyme is the, is the, well, (…) for all our, our meta, metabolism, for our metabolic reactions. Okay? So protein is very important for, well, body building and help our body functions. Okay? (pause) Okay? Or Let me show you a few pictures? I think probably some of your, some of your, you have seen these pictures earlier, right? In form three, I showed it to my form three students. Okay? It shows you what happen if you have good protein, well, good source of protein.

[Ss laugh]

T1: (…) When you don't get enough protein, you become so thin. Okay? Because protein is important for body building, okay? So generally, for growth and repair. I forget one thing, you know, protein also gives energy, you know that? Okay? Carbo, very often we say carbohydrates and fats are for body, or for what? For energy. But in fact, protein is also a very important energy source. Okay? (pause) Well, one problem with protein is, we, our body doesn't store protein, it doesn't store it. When we have excess protein, we will break it down into amino acids. And then we can't store amino acids. And we have to break it down by a process called deamination. We will talk about it later, okay? That's we remove excess protein and we pass it out as urea. You know what's urea?

Ss: 尿 (*urine*)

T1: Urea, 尿素 (*urea*) And, and some as ammonia. Ammonia has a familiar smell at the toilet, right? Okay? Ammonia and urea …

The question in lines 1–2 '*Why do we need protein?*' marked a shift in the focus of interaction, from the chemical structure of protein to the functions of protein. In this excerpt, T1 and students were discussing three main functions, namely '*body building*' (lines 3–36 & 40–46), '*body functioning*' (lines 36–40), and '*giving energy*' (lines 46–54). When these three functions were first introduced, they were decontextualised concepts condensing a few connected ideas (SG−, SD+). These functions were often expressed in nominal groups used in grammatical metaphor (i.e. 'power grammar'). For example, in response to T1's question, one student responded with the nominal group '*body building*' (line 3), which was accepted and elaborated by T1 '*Yes, for body building*' (line 6). Here, the process that 'protein helps to build our body' was nominalised to an entity 'body building', which was used in the sentence '*protein is important for body building*'. Similarly, T1 introduced the second function by saying '*they (protein) are also important in our … functioning … in our body function*' (lines 37–38), where 'protein helps our body to function' was nominalised. For the third function, T1 introduced it with a rather accessible sentence '*protein also gives energy*' (line 46), but he then paraphrased it as '*protein is also a very important energy source*' (line 48), perhaps to make the structure more parallel with the other two functions mentioned. It also shifted from an action verb sentence (*X gives Y*) to a relational sentence, which construes the ways of being and having and relates an entity to another entity (*X is a source of Y*), which is a frequent sentence pattern in academic registers in contrast to everyday registers. The relational sentence pattern makes it possible to construe additional layers of knowledge (e.g. X is a *very important* source of Y). Relational sentences play an important role in knowledge construction and are characterised by increasing *lexical density* (i.e. enhancing the density of information by packing activity sentences into nominal groups or grammatical metaphors and expressing relations among different processes in a simple clause rather than connecting strings of simple clauses in a clause complex) but decreasing *grammatical intricacy* (or clausal complexity) (Halliday 2004). For example, the following clause complex connecting two simple clauses '*protein also gives energy and it is very important*' can be otherwise construed with a more succinct simple relational sentence '*protein is also a very important energy source*'. We can see that T1 readily shifted between everyday language and 'power grammar' to help students to grasp these patterns. When T1 shifted from an everyday sentence to an academic sentence, SG decreases and SD increases. In addition to these three main functions (often expressed in nominal groups), some other moments with SG− and SD+ were those when T1 used the technical terms (i.e. 'power words'), which were highly decontextualised and condensed in meanings. Examples include '*keratin*' (line 18), '*deamination*' (line 50), '*urea*' (line 51) and '*ammonia*' (line 53).

Our analysis of Excerpt 1 shows that T1 adopted three strategies to unpack the decontextualised and condensed concepts, as well as academic language. These three strategies include paraphrasing nominal groups, fleshing out abstract ideas with more specific concepts and unpacking knowledge and language with students' prior knowledge and visual aids. First, T1 paraphrased the nominal groups to make them more comprehensible for students. For example, after mentioning the first function of '*body building*' (line 6), T1 elaborated on the concept by asking a more straightforward question '*Can you tell me which parts of your body are made up of protein?*' (line 7), which unpacked the nominal group 'body building'. In a similar vein, after T1 introduced the second function '*body functioning … body function*' (lines 37–38), he paraphrased the nominal group by saying '*protein … help our body functions*' (line 40).

Second, T1 fleshed out abstract and condensed ideas with more specific concepts or contexts. This is especially obvious for the first function 'body building', which is a rather general concept. With the question '*which parts of your body are made up of protein*?', T1 then engaged students in providing some concrete examples to contextualise how protein helps to build our body. These body parts included '*bones*' (line 8), '*hair*' (line 11), '*nails'* (line 15), '*horn*' (line 17), and '*muscles*' (line 30). It may be worth noting that one student mentioned '*enzymes*' (line 25), but T1 did not accept the answer by explaining that '*for body building, you mean building up body structure*' (lines 28–29). This further concretised the meaning of 'body building'. Another type of concrete example is provided through instances from daily life, which students were familiar with and could easily relate to. When elaborating such daily life examples, T1 often inserted some L1 terms or phrases, probably to further engage the students and to make the examples more effective. For instance, to unpack the technical term '*keratin*' and its related concepts (line 18), T1 made use of something students were familiar with in their daily life, which is鹿茸 (*antlers*) (line 20), a very expensive Chinese medicine. And with the joke that if we could not afford to consume antlers, we could bite our nails, T1 helped the students link up the concept of keratin and its manifestations such as horns and nails. Next, to elaborate how protein helps to build muscles, T1 mentioned the example that some people needed to take in extra milk powder to build up muscles (lines 31–37). He used some L1 when doing the elaboration (e.g. 有無見過呀? [*Have you seen that?*] 嗰啲，嗰啲，食嗰啲補充劑 [*Those, those, eat those supplements*]). Towards the end of Excerpt 1, T1 attempted to explain the technical term '*urea*' with the L1 equivalent, which may have been prompted by the mistranslation provided by the students ('尿 (*urine*)' in line 52). When explaining '*ammonia*', T1 linked it up with the '*smell at the toilet*' (line 53), something that the students will have encountered in their daily life.

Third, T1 unpacked knowledge and language with students' prior knowledge and visuals. When he talked about the second function 'for body functioning', he drew on students' prior knowledge of 'enzymes' and 'metabolism' (lines 38–39). He first explained why protein is important for body functioning with the explicit causal connective 'because', saying '*because protein is needed for making enzymes*' (line 38). With the checking question '*Remember?*' (line 39), T1 was relating the new knowledge to students' prior knowledge about enzymes and metabolism. T1 was also seen to do unpacking with visuals (e.g. pictures of muscular people in lines 41–44).

To summarise, the general approach adopted by T1 was that he started with some key, condensed concepts (e.g. the three functions of protein) and technical terms, and then he employed various semiotic resources (including linguistic and visual ones) to unpack those concepts and terms. However, there were very brief moments when T1 tried to repack, and he did this very quickly and mainly orally. For instance, after quite a few exchanges about different body parts that are made up of protein, T1 summarised the discussion by making a general statement '*this is what it means by body building*' (line 36). After briefly introducing the second function (i.e. for body functioning), T1 summarised the functions again by saying '*So protein is very important for, well, body building and help our body functions*' (line 40) and later he reiterated that '*protein is important for body building … for growth and repair*' (lines 45–46). He also paraphrased '*protein also gives energy*' (line 46) to '*protein is also a very important energy source*' (line 48). These could be regarded as upward shifts in the semantic profile, as the concrete examples were summarised into generalised, decontextualised statements, and some processes (e.g. building our body, growing, repairing) were also changed to nominal groups (i.e. power grammar).

The above analysis is illustrated in Figure 1, which is the semantic profile of Excerpt 1. The Y-axis of the figure presents the strength of SG and SD of the classroom discourse,[3] and the X-axis is the lesson time (from beginning to the end of the lesson). The figure roughly presents the changes in SG and SD as the lesson proceeds. In Figure 1, we observe several downward semantic shifts, in the sense that T1 moved from highly lexically condensed and decontextualised ideas (i.e. removed from everyday contexts) (SG–, SD+) towards lexically less condensed, more concrete, everyday contextualised understandings (SG+, SD–). While doing such repeated unpacking, T1 actually deployed quite a few strategies, including daily life examples and everyday L2 (highlighted in red in the figure), visuals (highlighted in yellow), and L1 (highlighted in blue). However, there was only very limited repacking (highlighted in green) which was mainly done through oral summaries of previous discussions. A potential issue with such a semantic profile is that some students might be able to 'pick up' the

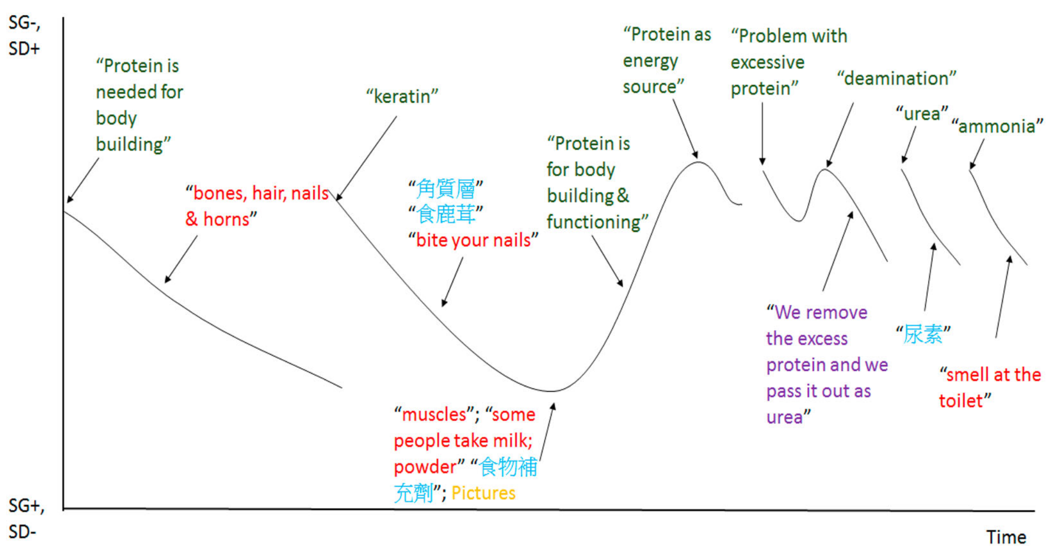

Figure 1. The semantic profile of Excerpt 1.

academic language while some might not, resulting in inequitable access to 'power' words, grammar and text (Maton, 2013).

Lesson 2: the presence of 'semantic waves'

Excerpt 2 represents the first half [03:30–25:44] of a Grade 7 (12–13 years old) Science lesson taught by T2, who had been teaching in the school for 2 years when the lessons were observed. Despite her relatively short teaching experience, she was aware of the difficulties in learning Science through English and she had attended some workshops on using English as the medium of instruction and language across the curriculum. The topic of the unit was 'matter as particles' and the lesson observed focused on Brownian motion, which proposes that when larger particles are hit by smaller particles, the larger ones change direction and move in a zigzag path. Before this lesson, the students had learned about the characteristics of particles, the particles theory and the teacher had briefly presented Brownian motion. This lesson took place in an average secondary school, in which some content subjects (e.g. mathematics and integrated science) were taught in English in junior forms (grades 7–9). Given the fact that most primary schools in Hong Kong adopt Chinese as the medium of instruction, the students in the observed lesson had just started CLIL experience. Since the whole excerpt is quite long, it will be broken down into several parts.

Excerpt 2, Part 1 [03:30–07:55]: Downward shift 1: Using mobile app, L1 & everyday L2

T2: So, today, what we are going to do today is to learn about the Brownian motion. We have discussed the Brownian motion. Remember that, the app that I used in your classroom?

Ss: Yeah

T2: Oh, yeah, yes. Really?

Ss: Yes

T2: Yes. This one [connecting the iPad to the projector], remember that?

Ss: Yeah.

T2: So, what do you see now? What are they? They are balls?

Ss: Particles!

T2: Yes, they are particles. That's right. Now if I, here, maybe they are some particles. Are they moving in a fast speed?

Ss: No.

T2: No, they are slow, right? So if I increase the temperature, I am increasing the temperature. So what are the changes?

Ss: Faster!

T2: They move faster. Okay, let me increase the temperature. [pause; increasing the temperature in the app] Now they are moving. So are they moving in a straight line or, in a circular path?

S: No. Circle

T2: In a circle? Or straight line?

Ss: Straight line.

T2: They will make a straight line. Okay. Now if I add some particles, with blue in colour. So is there any difference between the blue colour balls and the purple, purple balls? Compare. How about the size? Are they the same size?

Ss: No.

T2: No. They are different size. Which one is bigger?

Ss: The purple

T2: Purple balls is bigger. Now I want all of you to observe, to see how the purple particles moving. What are their path? What's their path? Is it the circular or straight line? Now still in a straight line? No, they are not moving in a straight line. In a circle? Yes?

Ss: No.

T2: No. So do you still remember our three choices. The first one straight line. Second, zigzag path. And then the third one in a circular path.

Ss: Zigzag path.

T2: So, zigzag path. What is the meaning of a zigzag path?

Ss: Z 字型 *(The shape of the letter Z)*

T2: Can you use an English letter to represent Z 字型 *(the shape of the letter Z)?*

S: A Chinese word like 'z'.

T2: Yes, it's like a 'z'. That's why it's called a zigzag. [pause; writing on the blackboard] They are moving in a zigzag path. Why? Why they are not moving in a straight line, but a zigzag path? Can you tell me why? Observe how they are moving in a zigzag path. Initially they are moving in a straight line, right? Without the blue small particles, they are moving in a straight line, the purple one. But after adding the blue small particles, now the purple particles are moving in a zigzag path. Why? (pause) Give me a reason.

S: 撞 (*hit)*

T2: 撞 (*hit)*. Hit. So which hit which?

S: The blue

T2: The blue particles hit the ____?

Ss: Purple

T2: Purple particles. And then after the hitting, what happen to the purple particles?

S: Go to another side.

T2: Go to another side, right? It change the ____? It change something. Something is changed.

S: Way

T2: Direction

T2: Yes, change the direction. That's why the purple particles are moving in a zigzag path. So this kind of motion, we call it (pause) Brownian motion, Brownian motion.

Part 1 of Excerpt 2 represents the start of the lesson. T2 clearly stated that the lesson was about 'Brownian motion', which is a discipline-specific term representing a generalised theory (i.e. 'power word'), and has weak SG and strong SD. She then unpacked the theory with a mobile app where one can observe the movement of particles when the temperature changes or when new particles are added. The mobile app provided a simulated context for T2 and students to discuss and explain the movement of particles of different sizes, thereby strengthening SG and weakening SD. At the beginning of the discussion, T2 first asked whether what students saw in the app were '*balls*', an everyday term familiar to students (line 8). When students answered '*particles*', a science key term (line 9) and T2 recast students' contribution in a complete clause '*they are particles*' (line 10), T2 consolidated students' existing knowledge of a power word relevant to Brownian motion, thus strengthening SD (i.e. SG+, SD↑). With the animation of the mobile app, T2 shifted to largely everyday language again to check whether students still remembered some key terms and concepts (i.e. SG+, SD-) in lines 13–16. T2 then asked students to observe the moving path of the particles (lines 26–38). Such concrete observations then laid the foundation for the explanation of the Brownian motion (lines 38–53). During the process, T2 engaged students in co-making an oral sequential explanation by explaining what happened step by step – '*Initially they are moving in a straight line … the purple one*' (lines 39–40). '*But after adding the blue small particles …* ' (line 40), '*the blue particles hit the purple particles*' (lines 45–47). '*And then after the hitting … (the purple particles) change the direction*' (lines 47–52). '*That's why the purple particles are moving in a zigzag path*' (line 52). T2's use of temporal and causal connectives (underlined in the quotes) helped explain Brownian motion clearly. Another interesting point to note in this part of Excerpt 2 is that T2 not only helped translate students' L1 utterances to L2 ('撞' to '*hit*' [line 43]), but also increased SD of students' and her joint contributions by substituting concrete activity verbs with nominal groups, i.e. using nominalisation and grammatical metaphor, a defining feature of scientific English (Halliday 1989) and also an important form of power grammar. Figure 2 shows the transitivity analysis (i.e. part of the analysis on field) of students' and T2's utterances from lines 46–53 converging into the conceptualisation of Brownian motion. Specifically, under T2's solicitation, students described the observed phenomenon with concrete activity verbs of *hitting* and *going*. T2 first paraphrased everyday L2 lexical items to more academic lexis ('*go to another side*' [line 48] to '*change the direction*' [line 52] and to '*moving in a zigzag path*' [line 52]) and then turned the material process into an identifying relational process, substituting three verbs ('*hit*' and '*go to another side*' or '*change the direction*') with one noun ('*this kind of motion*') and replacing '*moving in a zigzag path*' with two nominal groups or participants (i.e. '*this kind of motion*' and '*Brownian motion*'). Hence, this part of the lesson can be regarded as downward shift 1, where the unpacking and explanation of the key concept (and power words) Brownian motion took place. But this downward shift also involved some minor fluctuations: (1) lines 2–8 recalling the mobile app after mentioning 'Brownian motion': SG↑, SD↓; (2) lines 9–10 when mentioning 'particles': SG+, SD↑; (3) lines 10–52 when discussing movement of the particles: SG+, SD↓; (4) line 53 when mentioning 'Brownian motion': SG+, SD↑. At the same time, in this part of the lesson, T2 was preparing students for the upcoming upward shift through paraphrasing students' L1 and everyday L2 responses to L2 academic language.

Excerpt 2, Part 2 [07:55–12:18]: Upward shift 1: Oral 'repacking' & written summary (students' note taking)

T2: Now refer to your textbook. (pause) Brownian motion. Refer to your textbook. So, you have observed the Brownian motion through my apps. Can anyone, can anyone describe what is Brownian motion again? You have pieces of information. But can someone do a summary for us? First one, they are moving in a zigzag path, about the Brownian motion, right? And then second, I asked you why. So someone gave me the answer. Someone gave me the reason why. Do you still remember that? I remember that is (pause) 邊個講呀 (*who said so*)? (a student's name)? So, who tell me why they are moving in zigzag path?

S: Hit.

T2: Hit. So which one hit?

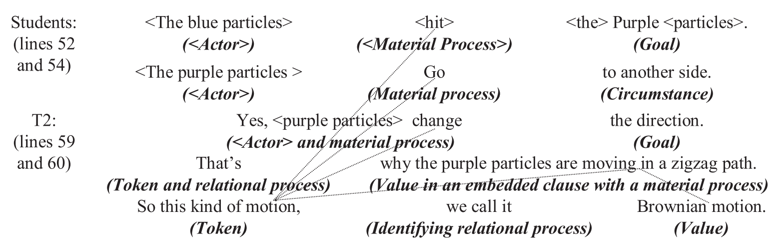

Figure 2. Nominalising material processes to increase semantic density.

Ss: The blue …

T2: The blue one, the blue particles hit the purple. So that is the smaller particles, right? [pause; writing on the blackboard] The smaller particles hit the larger particles. [pause; writing on the blackboard] And then what happened to the larger particles?

S: They change

T2: They change the ____?

S: Direction.

T2: Direction. [pause; writing on the blackboard] Okay, so here are the key points for the Brownian motion. First, you observe that the bigger, the larger particles move in a zigzag path. And then why? Because the smaller particles will hit the larger particles. And then the larger particles will change the direction of motion. Therefore, rather than moving in a straight line, they are moving in a zigzag path. Right? Like the English letter 'z'. Or you may say in Chinese, Z 字型 (*The shape of the letter Z)*. So this is Brownian motion, we are calling. Why your pen stop moving? Stop writing? You should [be] writing down something now into your handout, your journal or your textbook.

[Ss jotted down notes]

T2: So hurry up, students. Otherwise, we don't have time for the experiment today. We will have the experiment if you behave well. (pause) Okay?

[… some lines about lowering the curtain omitted]

T2: Oh, I forgot the first one. What is the first point?

Ss: Zigzag. Zigzag path.

T2: Zigzag path. And then how about the second point?

Ss: Smaller particles.

T2: Smaller particles will hit ____

Ss: Larger particles

T2: What?

S: Just hit.

T2: Just hit? The larger particles. And then the last one is?

Ss: Change the direction.

T2: Change the direction. [pause; writing on the blackboard] Okay, very good. Did you all copy them down, the key points?

Ss: Yes

After exploring Brownian motion with the mobile app, T2 prompted the students to describe the key concept again ('*Can anyone describe what is Brownian motion again?*' [line 2]). After several question-and-answer exchanges (lines 5–16), T2 concluded with several '*key points*' (lines 16–20). Here, it should be noted that T2 employed similar clause patterns as those in Excerpt 1 (e.g. *X hits Y and Y changes the direction*) but replaced the participants of clauses (i.e. '*blue and purple particles*') with more discipline-specific lexis (i.e. small and large '*particles*'), as stated in Brownian motion, thus increasing the writtenness or formality of the classroom talk with power words and power grammar. She also slightly expanded the sentence '*they (the larger particles) change the direction*' (lines 11–16) to '*the larger particles will change the direction of motion*' (line 18), thereby linking the motion of the concrete, observed, coloured 'particles' (which are not actually the submicroscopic 'particles') to the technical term 'Brownian motion'. Such oral repacking summarised students' concrete observations into something abstract (or submicroscopic) and generalisable, thereby weakening the SG. In addition, T2 expected the students to jot down some notes in their handout. Hence, T2 and the students revisited the key points of Brownian motion again in lines 27–39. This part forms upward shift 1, where T2 decontextualised some concrete observations into the theory with the students.

Excerpt 2, Part 3 [12:18–15:33]: Downward shift 2: Reading the story of Robert Brown, with the example of pollen grains and water

T2: Yes, very good. Now, please go back to your textbook, on page 149. Here are some descriptions of the Brownian motion. You may refer to your textbook if you cannot see it [text projected onto the screen] clearly. So the first one, the first guy observed the Brownian motion is called, here's the name, Robert Brown. So that's why this motion named after him. We call it Brownian motion because the first one observed this kind of motion is called Brown. In the year of 1827. So what did he do? He observed some pollen grains. Do you know what's the meaning of pollen grains? S: 花粉 (*pollen grains*)

Ss: Flower

T2: Flower _____?

S: Grains

T2: [laughed] So what's the meaning of pollen grains?

S: 花粉 (*pollen grains*)

T2: Yes, something related to the flowers. [pause; writing the Chinese translation] You should put down the meaning on your handout. (pause) On your handout. Remember we have the tables here. Yes, pollen grains. (pause) So it is花粉 (*pollen grains*).

[Ss wrote in their handout]

T2: Okay, what happened to Brown? He observed that the pollen grains move in a zigzag path. And then he asked himself. Do you remember the steps of scientific investigation?

S: Asking question.

T2: Yes, asking question. So Brown asked a question. He observed that the pollen grains in water are moving in a zigzag path. So he asked himself a question. Why did the pollen grains move in a zigzag path? And then he had a suggested answer. What do we call a suggested answer in Science? Start with 'h', the word. Hypo_____?

Ss: Hypothesis.

T2: Hypothesis. That's right. So here is the hypothesis. The hypothesis is that the pollen grains is something large compared with water, right? 花粉係大過水 (*pollen grains are bigger than water [particles]*). So pollen grains is larger than water, okay? So pollen grains will hit the water particles. And then what happen to the pollen grains? The third point. Change the _____

Ss: Direction.

T2: Direction. That's right. Change the direction, okay?

In part 3 of the excerpt, T2 drew students' attention to the story of Brown's discovery process in the textbook. This biographic storytelling not only constructs more social closeness in terms of tenor but also adds more spokenness in terms of mode. She first described the scientist as a '*guy*' (line 3) and then explained the name of the theory by saying '*We call it Brownian motion because the first one observed this kind of motion is called Brown*' (lines 4–5). This literally unpacked the technical term 'Brownian motion' to some everyday term like 'Brown's motion', which would help students remember it more easily. T2 then guided students to read the story with some explanation or elaboration in clauses that expressed everyday processes (e.g. 'He *observed* some pollen grains' [line 5]) and connected different processes by conjunctions (e.g. '*And then* he asked himself.' [lines 16–17]), which is typical of everyday conversation registers focusing on the congruent representations of everyday experiences, thus reducing technicality of discourse (Halliday 1989). During this storytelling, T2 also illustrated Brownian motion again with the original examples of pollen grains and water (instead of the generalised concepts of smaller and larger particles). Hence, this part can be regarded as downward shift 2, as the teacher contextualised the abstract submicroscopic concepts with concrete, observable objects. In this excerpt, it may also be interesting to note that when T2 was explaining Brown's story, she reminded students of '*the steps of scientific investigation*' (line 17), including '*asking a question*' (line 18) and making a '*hypothesis*' (line 23). These previously learned concepts may help the students better understand the steps in the scientific inquiry process leading to the conceptualisation of the power word, Brownian motion.

Excerpt 2, Part 4 [15:33–16:58]: Upward shift 2: Oral summary & reading the hypothesis from the textbook

T2: You can refer to here [pointing to the screen]. That's page 151. Am I correct?

Ss: Yes

T2: Yes.

[… some lines about the clarity of words shown on the screen are omitted]

T2: Maybe we just underline the word. And then I will draw it for you. Don't worry, okay? So what is his hypothesis is that the small particles will move in a random direction. And then they hit the large particles randomly. Do you still remember the meaning of random?

S: 隨機 *(random)*

T2: Yes, 隨機 *(random)*. And causes the larger particles to change the direction of motion frequently. That's why it move in a zigzag path.

Excerpt 2, Part 5 [16:58–18:32]: Downward shift 3: Reiterating key points with another example

T2: So here in this passage, smoke grains represent (pause) represent the large particles. (pause) And then, how about the air particles? What does it represent? Large or small?

Ss: Small.

T2: Small. That's right. [pause; writing on the blackboard] Air particles represent the small particles. And then smoke grains represent the large particles. Okay? So did you underline? And these sentence or the descriptions about the Brownian motion appear again the key points. So you may also memorise the key points here. Just the same, but it change the subject only. The Brownian motion are of very small grains. It's caused by the water particles or air particles hitting the grains randomly from different direction. It appears again in the key points. So do you all now understand what is Brownian motion?

Ss: Yes

T2: Maybe, yes?

Ss: Yes.

After reading the origin of Brownian motion, T2 attempted to summarise the hypothesis in part 4 of the excerpt. T2 asked the students to read the hypothesis in their textbook (line 1) and underlined some key words (line 5). By reiterating the hypothesis (lines 5–10), T2 introduced a few more discipline-specific terms or phrases, such as '*move in random direction*' (line 6) and '*change the direction of motion*' (line 9), instead of the more everyday L2 that the students had been using. These weakened SG and strengthened SD, and so part 4 can be regarded as another upward shift in the semantic profile. This part is then followed by another short episode (part 5) where T2 illustrated Brownian motion again with the examples of 'smoke gains' and 'air particles' in the textbook passage. There seemed to be a SG+ and SD+ moment where T2 said '*It's caused by the water particles or air particles hitting the grains randomly from different direction(s)*' (lines 7–8). In this part, the teacher was explaining a complex term (or power word) with concrete, contextual examples of water/air particles hitting grains. The Brownian motion is about the random movement of microscopic particles, not only about grains. The teacher's utterance in lines 7–9 is a summary of concrete examples of Brownian motion. Hence, it is technical but still contextual, making it SG+ and SD+ (Mouton and Archer 2019). In this sentence, there was a passive structure ('*caused by*') and an embedded clause ('*the water particles or air particles hitting the grains randomly from different direction(s)*') as the participant of the clause, both of which increase the writtenness of T2's utterance, another example of power grammar. Despite this, part 5 can be generally regarded as another downward shift.

Excerpt 2, Part 6 [18:32–23:45]: Upward shift 3: Repacking in written form; 'joint construction'

T2: Now we have a practice. Don't close your textbook. At the same time, open your notes or handout to page 3. Page 3. (pause) In page 3, look at the questions under Brownian motion, the box. (pause) Imagine, you are going to observe the movement of some metal beans and some balls. So which one is lager? Beans or balls?

Ss: Beans

T2: Hah?

S: Balls.

T2: Balls should be larger than beans, I suppose. The metal beans is smaller, right? Okay, so metal beans is smaller. [pause; writing on the blackboard] So how about the balls? It's bigger. [pause; writing on the blackboard] Now when they are put together, what would happen to the balls, which is larger than beans? What would happen to the balls? Describe, how would it be? The motion, the path. It will move in a ______

Ss: Z

T2: Zigzag path. Yes, Brownian motion again. So do you know how to write down the description or the explanations of the Brownian motion of the bigger ball? You should know how to write them down, right?

S: Yes

T2: Yes. Can you do it by yourself?

Ss: No.

T2: No? So maybe we do it together. Now first of all, the metal beans should be moving, according to the particles theory. First one, you have to describe, here, the direction of the metal beans' move. So what is the direction?

S: 方向 *(Direction)*

T2: Yes, so what is the direction of the metal beans' motion?

S: Random

T2: Random. Or we may say in _______? In random ______?

Ss: -ly

T2: In randomly direction? Can you use a simpler word to represent random?

S: All direction

T2: Yes, very good. In all direction. [pause; writing on the blackboard] And then what happen when they meet the ball? (pause) They will ____? Forget already? (pause) Small beans, what will happen?

S: Hit the

T2: Yes, they will hit the ball. They hit the ball randomly and then, so the second sentence, you may refer to what's the interaction between the balls and the beans. They will hit the balls randomly from, which directions?

S: Different

T2: Different directions, yes. [pause; writing on the blackboard] And then, so what is result of the hitting? The hit may cause the balls to change its ____? (pause)

Ss: Direction.

T2: Direction. [pause; writing on the blackboard] So the ball now are moving in a, what kind of path? (pause) The zig ____?

S: Zigzag.

T2: Zigzag path. [pause; writing on the blackboard] (a student's name), can you follow? Yes.

[Ss completed the writing practice]

Excerpt 2, Part 7 [23:45–25:44]: Upward shift 4: Repacking in written form; independent construction

T2: Okay, that's good. So we used some examples to help you how to write down the description about the Brownian motion. First of all, we use the balls with different colours. Remember the blue particles and the purple? And then we do it again using the pollen grains and water. Now we've just done about the metal beans and the balls. And then finally, what are we required to do is that you have to write down the description about the Brownian motion, by using small particles and large particles. So how can you do that? You may refer to the passage above. Okay? You may use these sentence structures again. But are we going to use the words metal beans and the foam balls again?

Ss: No.

T2: No. So what are going to replace these two words? Smaller particles and ____?

Ss: Larger particles.

T2: Larger particles. So which one is smaller particles?

Ss: Beans

T2: Mental beans. And which one is larger particles?

Ss: Balls.

T2: The balls, okay. So can you rewrite the sentence again and then fill in the blanks below the word 'Brownian motion'? Do you know what to do?

Ss: Yes

T: Yes? 重寫上面的段落，但我們用什麼字? (*Rewrite the above paragraph. But which words should we use?*)

Ss: Smaller

T2: Smaller particles and larger particles, okay? So you will have two minutes. After two minutes, I will ask someone to read them out.

Both parts 6 and 7 are upward moving parts of the semantic profile. After reading the textbook, T2 asked students to do a practice in their handout (attached in Appendix 2). The written practice asked students to observe and describe the movement of metal beans and foam balls, using the concept of Brownian motion, the power word of the lesson. As some students said they didn't know how to do the practice (line 16), T2 decided to '*do it together*' (line 17) with the students. From lines 17–38, T2 interacted with the students and provided sentence-to-sentence guidance for them. During the interaction, T2 again highlighted some key phrases, including '*in all direction*' (line 26), '*hit the balls randomly*' (line 29), '*change its direction*' (lines 33–35) and '*move in a zigzag path*' (lines 35–38). Hence, upward shift 3 in part 6 can be regarded as the 'joint-construction' part of the lesson, where the teacher provided scaffolding, particularly in terms of academic language, so that students could later do the repacking themselves.

That is exactly what the students were asked to do in part 7 of the excerpt – they '*have to write down the description about the Brownian motion by using small particles and large particles*' (lines

4–5). In other words, they had to explain Brownian motion with the appropriate academic language. In the practice (Appendix 2), no language support was provided for this question. However, in the lesson, T2 made it very clear that students only needed to '*rewrite the sentence again*' (line 14). Instead of using concrete objects like mental beans and foam balls, students had to use generalised terms such as '*larger particles*' and '*smaller particles*' (line 19) to present the abstract theory. Thus, part 7 of the excerpt represents upward shift 4 of the lesson, which is the 'independent construction' stage, during which students were expected to attempt academic writing with the support they had been receiving. In other words, they were apprenticed into producing disciplinary language (Martin 2013).

The above detailed analysis of Excerpt 2 aims to illustrate how teachers can unpack difficult content knowledge *and* academic discourse along the semantic wave, which has not been very frequently observed in actual classrooms (Martin 2013). Roughly plotting the various parts of Excerpt 2 in a semantic profile (see Figure 3), one can see the recurrent unpacking and repacking moves, both in spoken and written form. Similar to T1, T2 made good use of the resources of students' communicative repertoire, such as visuals/ animation (the mobile application), everyday life examples, everyday L2 and L1. Apart from repacking through oral summary, T2 put some efforts into writing by asking students to jot down some notes, attempt the writing practice with language support and finally the independent writing task. Going through the semantic wave, students were scaffolded to tackle the high-stakes writing task.

It may be noticed that in Excerpt 2 (and also Excerpt 1), students' responses tended to be rather short, often limited to single-word answer or short phrases (e.g. '*larger/smaller particles*', '*zigzag path*', '*all direction*'). One may wonder whether the semantic waves observed could actually help students understand the concepts and complete the writing task. We did not collect students' sample work from the lesson, but their performance could be reflected in the answer checking phase after the two-minute individual work (Excerpt 3).

Excerpt 3 [27:46–29:50]: Students' performance on the writing task

T2: [the timer beeping] Okay, students, that means time's up, pens down. [pause; stopping the timer] So shall we have the lucky draw again?

Ss: No

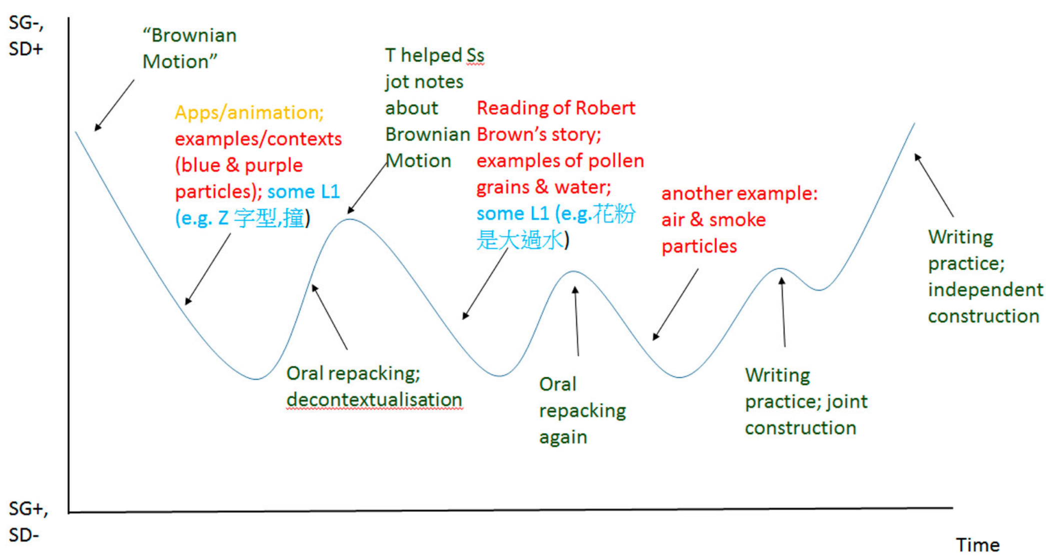

Figure 3. The semantic profile of Excerpt 2.

T2: Yes. [pause; doing the lucky draw] Number 9.

S1: The smaller particles move in all direction.

T2: Okay, stop. The first sentence, the smaller particles move in all direction. Very good. Okay, so who is the next one? [pause; doing the lucky draw] 19. [Ss laughing] Random, random number.

S2: They hit the (…) [S2 mumbling]

T2: They hit the (…) [imitating S2's mumbling] I can't hear you.

S2: They hit the (…)

T2: They hit the larger ____?

S2: Larger particles.

T2: Larger particles. Very good. In which direction?

S2: They come from different

T2: From different ____?

S2: Direction

T2: Directions. Okay, second sentence, they hit the larger particles from different direction. Okay, and then the last one. [pause; doing the lucky draw] 21.

S3: So the larger particles move in zigzag path.

T2: So the larger particles change its directions and then move in a zigzag path, right? …

In Excerpt 3, T2 randomly picked students with their class number, but it could be seen that all the nominated students, especially number 9 and 21, could describe the key steps of Brownian motion in complete sentences. This shows the potential effect of the 'cumulative' knowledge building process from Excerpt 2. Probably owing to their low English proficiency, students did not say much during teacher-student interaction. Yet, they were likely to be engaged throughout the process, since they could demonstrate their understanding after repeated cycles of unpacking, scaffolding, and repacking.

Conclusions

Through the detailed analysis of two lesson excerpts, this paper applies the concepts of 'semantic profiles' to analyse the unpacking and repacking processes in CLIL classrooms, and to examine the linguistic and other semiotic resources deployed by teachers during such processes. Our analyses show that teachers often start with abstract and lexically condensed and layered concepts, usually expressed through technical terms (i.e. power words) and nominalisation with grammatical metaphor and passivisation (i.e. power grammar). They then employ different strategies and make use of students' various communicative resources, such as L1, L2 everyday registers, daily life examples and multimodalities, to unpack the concepts and academic language. However, unpacking alone may not help students to express their content knowledge in appropriate academic language in L2, and repacking is essential. Our analysis of Excerpt 2 in this paper demonstrates how teachers could do repacking in both oral and written form, through oral summary, note-taking, repetition with variation (e.g. illustrating the same theory with different examples) and scaffolded written practice. Such repeated unpacking and repacking will result in semantic waves, which are argued to be the key to cumulative knowledge-building (Maton, 2013). In addition to these useful unpacking and repacking strategies, we believe that the notion of semantic profiles can be used as a meta-language and visualisation tool to engage CLIL teachers in critical reflection on CLIL classroom strategies, thereby facilitating CLIL teacher professional development.

Notes

1. We did not include 'power composition' (the remaining part of the 'power trio') in our analysis, mainly because it was not observed in our existing collection of CLIL lessons. This may be due to two reasons. First, over 70% of our lessons were observed at the junior secondary level. As Excerpt 2 reveals, junior secondary students are often required to write short paragraphs, instead of essays. Second, teachers in our observed lessons (and also in other educational contexts) did not pay too much attention to helping their students write subject-specific genres. They tend to focus on subject-specific vocabulary (Cammarata and Haley 2018; Koopman, Skeet, and de Graaff 2014).
2. The lesson excerpt has been analysed in Lin and Lo (2017), focusing on how the teacher co-constructed language and content with students, with reference to the notions of translanguaging and thematic patterns.
3. In Figures 1 and 3, there are fixed combinations between SG− and SD+, as well as between SG+ and SD−. These represent what often happens in classrooms and what was observed in the two excerpts in this paper. However, it should be noted that it is possible to have other combinations of SG and SD.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Yuen Yi Lo is an Associate Professor in the Faculty of Education, the University of Hong Kong. Her research interests include Medium of Instruction policy, code-switching, CLIL, language across the curriculum and teacher collaboration. She has published her work in *Review of Educational Research*, *International Journal of Bilingual Education and Bilingualism*, and *Language and Education*.

Angel M. Y. Lin received her doctoral degree from the Ontario Institute for Studies in Education, University of Toronto in 1996. Her research and teaching have focused on critical discourse analysis, critical literacies, bilingual and multilingual education. She has published six research books and over 100 research articles and book chapters, and serves on the editorial boards of leading international research journals. She was a full professor in the Faculty of Education, University of Hong Kong before moving in 2018 to Simon Fraser University to take up the position of Canada Research Chair (Tier 1) in Plurilingual and Intercultural Education.

Yiqi Liu is an Assistant Professor in the Department of English Language Education, The Education University of Hong Kong. Hermain research interests include discourse analysis, sociolinguistics, and bilingual education. Her publications have appeared in *Discourse and Communication*, *Language and Education*, *Chinese Journal of Communication, Assessment andEvaluation in Higher Education* and *International Journal of Bilingual Education and Bilingualism*.

ORCID

Yuen Yi Lo http://orcid.org/0000-0002-0850-5447
Angel M. Y. Lin http://orcid.org/0000-0002-6204-8021
Yiqi Liu http://orcid.org/0000-0003-0637-636X

References

Bernstein, B. 2000. *Pedagogy, Symbolic Control and Identity: Theory, Research, Critique*. London: Rowman & Littlefield.

Cammarata, L., and C. Haley. 2018. "Integrated Content, Language, and Literacy Instruction in a Canadian French Immersion Context: A Professional Development Journey." *International Journal of Bilingual Education and Bilingualism* 21 (3): 332–348.

Cenoz, J., F. Genesee, and D. Gorter. 2014. "Critical Analysis of CLIL: Taking Stock and Looking Forward." *Applied Linguistics* 35 (3): 243–262.

Escobar Urmeneta, C., and S. Walsh. 2017. "Classroom Interactional Competence in Content and Language Integrated Learning." In *Applied Linguistics Perspectives on CLIL*, edited by A. Llinares and T. Morton, 183–200. Amsterdam: John Benjamins.

Halliday, M. A. 1989. "Some Grammatical Problems in Scientific English." *Australian Review of Applied Linguistics. Series S* 6 (1): 13–37.

Halliday, M. A. 2004. *The Language of Science: Collected Works of M. A. K. Halliday*, edited by Jonathan J. Webster. Vol. 5. London: Continuum Books.

Koopman, G. J., J. Skeet, and R. de Graaff. 2014. "Exploring Content Teachers' Knowledge of Language Pedagogy: A Report on a Small-Scale Research Project in a Dutch CLIL Context." *The Language Learning Journal* 42 (2): 123–136.

Li, D. C. S. 2017. *Multilingual Hong Kong: Languages, Literacies and Identities*. Switzerland: Springer.

Lin, A. M. Y. 2012. "Multilingual and Multimodal Resources in Genre-Based Pedagogical Approaches to L2 English Content Classrooms." In *English – A Changing Medium for Education*, edited by C. Leung, and B. V. Street, 79–103. Bristol, UK: Multilingual Matters.

Lin, A. M. Y. 2019. "Theories of Trans/Languaging and Trans-Semiotizing: Implications for Content-Based Education Classrooms." *International Journal of Bilingual Education and Bilingualism* 22 (1): 5–16.

Lin, A. M. Y., and Y. Y. Lo. 2017. "Trans/Languaging and the Triadic Dialogue in Content and Language Integrated Learning (CLIL) Classrooms." *Language and Education* 31 (1): 26–45.

Lin, A. M. Y., and Y. Wu. 2015. "'May I Speak Cantonese?' – Co-Constructing a Scientific Proof in an EFL Junior Secondary Science Classroom." *International Journal of Bilingual Education and Bilingualism* 18 (3): 289–305.

Liu, Y. 2020. "Translanguaging and Trans-Semiotizing as Planned Systematic Scaffolding: Examining Feeling-Meaning in CLIL Classrooms." *English Teaching & Learning* 44: 149–173.

Llinares, A., and T. Morton. 2017. "Speech Function Analysis to Explore CLIL Students' Spoken Language for Knowledge Construction." In *Applied Linguistics Perspectives on CLIL*, edited by A. Llinares and T. Morton, 125–144. Amsterdam: John Benjamins.

Llinares, A., T. Morton, and R. Whittaker. 2012. *The Roles of Language in CLIL*. Cambridge: Cambridge University Press.

Llinares, A., and T. Nikula. 2016. "Evaluative Language use by Teachers and Students in CLIL Across Contexts: Integrating SFL and Pragmatic Approaches." In *Conceptualising Integration in CLIL and Multinlinugal Education*, edited by T. Nikula, E. Dafouz Milne, P. Moore, and U. Smit, 189–210. Bristol: Multilingual Matters.

Lo, Y. Y., and A. M. Y. Lin. 2015. "Special Issue: Designing Multilingual and Multimodal CLIL Frameworks for EFL Students." *International Journal of Bilingual Education and Bilingualism* 18 (3): 261–269.

Lo, Y. Y., and A. M. Y. Lin. 2019. "Curriculum Genres and Task Structure as Frameworks to Analyse Teachers' use of L1 in CBI Classrooms." *International Journal of Bilingual Education and Bilingualism* 22 (1): 78–90.

Lo, Y. Y., and E. S. C. Lo. 2014. "A Meta-Analysis of the Effectiveness of English-Medium Education in Hong Kong." *Review of Educational Research* 84 (1): 47–73.

Lyster, R., and Y. Ruiz de Zarobe. 2018. "Introduction: Instructional Practices and Teacher Development in CLIL and Immersion School Settings." *International Journal of Bilingual Education and Bilingualism* 21 (3): 273–274.

Martin, J. R. 2013. "Embedded Literacy: Knowledge as Meaning." *Linguistics and Education* 24 (1): 23–37.

Martin, J. R., and K. Maton. 2017. "Systemic Functional Linguistics and Legitimation Code Theory on Education: Rethinking Field and Knowledge Structure." *Onomázein* 35: 12–45.

Maton, K. 2013. "*Making Semantic Waves: A Key to Cumulative Knowledge Building*." *Linguistics and Education* 24 (1): 8–22.

Maton, K., and Y. J. Doran. 2017. "SFL and Code Theory." In *The Routledge Systemic Functional Linguistic Handbook*, edited by T. Bartlett and G. O'Grady, 605–618. London: Routledge.

Matruglio, E., K. Maton, and J. Martin. 2013. "Time Travel: The Role of Temporality in Enabling Semantic Waves in Secondary School Teaching." *Linguistics and Education* 24 (1): 38–49.

Mehisto, P. 2008. "CLIL Counterweights: Recognising and Decreasing Disjuncture in CLIL." *International CLIL Research Journal* 1 (1): 93–119.

Mouton, M., and E. Archer. 2019. "Legitimation Code Theory to Facilitate Transition From High School to First-Year Biology." *Journal of Biological Education* 53 (1): 2–20.

Nikula, T., A. Llinares, and C. Dalton-Puffer. 2013. "European Research on CLIL Classroom Discourse." *Journal of Immersion and Content-Based Language Education* 1 (1): 70–100.

Nikula, T., and P. Moore. 2019. "Exploring Translanguaging in CLIL." *International Journal of Bilingual Education and Bilingualism* 22 (2): 237–249.

Rose, D., and J. R. Martin. 2012. *Learning to Write/Reading to Learn: Genre, Knowledge and Pedagogy in the Sydney School*. London: Equinox.

Tan, M. 2011. "Mathematics and Science Teachers' Beliefs and Practices Regarding the Teaching of Language in Content Learning." *Language Teaching Research* 15 (3): 325–342.

Walker, E. 2011. "How 'Language-Aware' are Lesson Studies in an East Asian High School Context?" *Language and Education* 25 (3): 187–202.

Appendices

Appendix 1. Transcription conventions

T = Teacher
S = single student
Ss = more than one student
(…) = inaudible utterances
(*italics*) = Translation of Chinese utterances
[ ] = nonverbal actions or author's comments
____ (at the end of questions) = short pauses indicating blank filling questions
… = some lines deleted

Appendix 2. The handout and writing practice used in Excerpt 2

Brownian motion (Book 1B, p.149)

Demonstration:
Tasks:
1. Observe the movement of the smoke particles. (the directions of movement)

Explain what you see:

The metal beans move in ____________________.

They __________ the foam ball randomly from ____________________________. The hits cause the foam ball change its _____________________ __________________. So the foam balls move in ____________________.

Guiding questions:
1. Describe the direction of the metal beans move
2. What is the interaction between metal beans and foam ball
3. How do the foam balls move?

The Brownian motion:

____

____

____