The Role of Language in Scaffolding Content & Language Integration in CLIL Science Classrooms

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Abstract

This commentary to the special issue "Teaching, Learning and Scaffolding in CLIL Science Classrooms" synthesizes the contributions from the authors by addressing two overarching questions. First, what is the role of language in mediating science teaching and learning in a CLIL science classroom? Second, to what extent can content and language be integrated or separated in CLIL instruction and assessment? In addressing the first question, I distil three major perspectives of how the authors conceive the role of language as a scaffolding tool. These roles are: (a) providing the discursive means and structure for classroom interaction to occur, (b) enabling students' construction of knowledge through cognitive and/or linguistic processes, and (c) providing the semantic relationships for science meaning-making. These three perspectives roughly correspond to the discursive, cognitive-linguistic, and semiotic roles of language respectively. In addition, two other roles – epistemic and affective, though not emphasized in this issue, are also discussed. In addressing the second question, I raise a dilemma concerning the integration of content and language. While there are clear political and theoretical arguments calling for an inseparable integration, there is also a common practice to separate content and language as distinct entities for various pedagogical and analytical purposes. In revolving this conundrum, I suggest a way forward is to consider the differences in the various roles of language (discursive/cognitive/linguistic vs. semiotic/epistemic/affective) or the levels of language involved (lexicogrammar vs. text/genre).

Keywords: Classroom discourse; Content Language Integrated Learning (CLIL); role of language; scientific language; scaffolding

1. Introduction

The role of language is an area of special interest for many researchers and teachers both in language education and science education. The attention to language issues spans across a wide range of research interests, including classroom discourse, disciplinary literacy, reading- and writing-to-learn approaches, scientific language and genre, translanguaging, and more recently, the use of multimodal representations (e.g., diagrams, equations, gestures). Pertinent to this special issue, the central focus revolves around the intersection of various home languages (e.g., English, Chinese, Japanese) and the language of science, within a political and pedagogical context of using a standardised medium of instruction. At the heart of this intersection is the drive toward a culturally relevant pedagogy that could cater to students' language proficiency and aspiration.

At the same time, the increasing prominence of Content and Language Integrated Learning (CLIL) in Europe and similar bilingual programs in other parts of the world has bought to attention the dual aspects of content-language teaching, which correspond to the goals of "learning language" and "learning through language" (Xu & Harfitt; this issue). Interesting, the idea of CLIL sparks an introspective reflection on what we typically mean by the terms "content" and "language" and how these two terms are related in the context of science teaching and learning. It also brings together two communities of people who have historically focused on one side of this duality – "content" for science educators and "language" for language educators (including L2 specialists). The timing of this special issue is therefore excellent in calling for a greater convergence between these two communities to examine the complexity and nuances of content-language integration.

Against this background, the six contributions in this special issue present novel classroom-based research that examines teachers' instructional practices and innovative pedagogies from a range of perspectives and foci, such as explicit language instruction or scaffold (An, Macaro & Childs, this issue; Lo, Lui, & Wong, this issue), teacher language awareness (Xu & Harfitt, this issue), Concept + Language Mapping (He & Lin, this issue), translanguaging with *kanji* (Turner, this issue), and concept sketches (Ho, Kwai & Rappa, this issue). Collectively, the authors in this special issue raised a number of insights that challenge and expand the central role of language in: (a) mediating science teaching and learning in general, and (b) its integration with content learning within CLIL classrooms more specifically.

In this commentary, I synthesize the contributions from the authors by exploring two overarching questions that span across their work. First, what is the role of language in mediating science teaching and learning in a CLIL science classroom? And second, to what extent can content and language be integrated or separated in CLIL instruction and assessment? The first question that will guide my commentary is more broad and theoretical as I examine the authors' underlying (and sometimes implicit) theories and perspectives that inform the way they frame their research in their classroom intervention and/or discourse analysis of data. The second question is more contextual as I examine the pedagogical (and sometimes political) rationale and practices that either reinforce or constraint the integration of content and language in a CLIL context.

It should be mentioned that this commentary is written from the perspective of a science educator who has studied the use of language, literacy and discourse in more "mainstream" monolingual science classrooms, and has only some experiences in the CLIL research space. As such, the purpose of this commentary is not to provide critiques in the authors' theories and methodologies, but rather to highlight important ideas and issues that will foster further discussion and convergence among researchers working in multiple communities (e.g., applied linguistics, language education, bilingual education, science education) to move the field of CLIL forward.

2. Language in Discursive, Cognitive, Linguistic, Semiotic, Epistemic & Affective Roles

What is the role of language in mediating the learning of science in a CLIL science classroom? The common answer to this question tends to rely on a neo-Vygotskyan notion of scaffolding, as explained in the introduction of this special issue (Lo & Lin, this issue). Scaffolding is also a key construct that was foregrounded by several authors in their research design and analysis. For instance, "explicit language scaffold", "scaffolded interaction", and "designed vs. spontaneous scaffolding" are some constructs used by Lo et al. (this issue), Xu and Harfitt (this issue), and He and Lin (this issue) respectively. Although all the authors in this issue shared the same theoretical paradigm on scaffolding, there are some differences in the kinds of scaffolding they emphasized.

Reviewing across the six contributions, I distil three major aspects of how language was used as a scaffolding tool to support science teaching and learning in its various forms. The first aspect sees language as providing the discursive means and structure for classroom interaction to occur. The second aspect sees language as enabling students' construction of knowledge through cognitive and/or linguistic processes. The third aspect sees language as providing the semantic relationships for science meaning-making. These three aspects roughly correspond to the discursive, cognitive-linguistic, and semiotic roles of language respectively. In addition, I will discuss two other roles – epistemic and affective, which although were not emphasized in this issue, they are equally important in developing a holistic and balanced science education for all students.

2.1 Discursive Role to Scaffold Classroom Interaction

The first aspect of language as a discursive tool can be traced back to a long research tradition in classroom discourse. According to Cazden (1988, p. 3), "the study of classroom discourse is a kind of applied linguistics" to examine the language of teaching and learning.

With roots in conversational analysis and interactional ethnography, researchers view language as a form of social action that is accomplished through contingent and turn-taking events, and consequently examine how language was used to structure classroom activity in ways that would be recognized and counted as teaching or learning. Historically, research in this area has moved from the classic IRF (initiate, response, feedback) pattern first documented by Sinclair and Coulthard (1975) decades ago to contemporary identification or prescription of effective “scaffolding strategies” or “talk moves” that engage students in meaningful dialogue. Such scaffolding strategies or moves apply to first language students, and would arguably have more importance for bilingual learners as they tend to be shut off from classroom conversation that involves a second or foreign language.

This discursive and performative aspect of language is best illustrated in this issue by Xu and Harfitt (this issue) and Ho et al. (this issue) in their analysis of scaffolding based on the classroom transcripts. To some extent, it is also observed in He and Lin’s (this issue) analysis of the teachers’ spontaneous scaffolding during classroom interactions. In Xu and Harfitt’s study, they draw on Gibbons (2003) and Holton and Clarke (2006) to develop a set of “conceptual scaffolds” to understand how the teachers used language to co-construct knowledge with their students in the classroom. Such scaffolds include mediation, probing for expansion, translating, evoking discussion, encouraging self-scaffolding and withholding scaffolding. As for Ho et al.’s study, although they draw from a different framework by Chapin, O’Connor & Anderson’s (2013) focusing on questioning techniques, there are many overlaps with Xu and Harfitt’s coding scheme, such as revoicing, probing, and clarifying.

In particular, Xu and Harfitt raised an interesting observation regarding the implicit and explicit nature of “scaffolded interaction”, which I prefer to call discursive strategies. Discursive strategies are techniques that people use in a conversation (consciously or unconsciously) to achieve a particular purpose (Gumperz, 1982). IRF is a common discursive strategy used by teachers, many of whom are not even aware that they are using such technique to intuitively ask a narrow question with the aim of eliciting an expected answer. This is how many science teachers unknowingly or *implicitly* structure a conversation, particularly one that builds on a series of IRF patterns toward a specific content aligned with the official curriculum (Lemke, 1990). Xu and Harfitt suggest that some of the discursive strategies observed from the teachers were more conscious or *explicit* than other strategies. In my interpretation, a few strategies do indeed stand out in their explicitness to address the language challenges faced by the students. The first strategy is translating (episode 1, line 11), which interestingly is the only code that applies more specifically to bilingual students as compared to the rest of the codes that apply to all students. The second strategy is mediation (episode 2, line 5), which involves a comparison of terminologies used in scientific language as compared to vernacular language. The last one is withholding (episode 3), which shows a deliberate intention in holding back the answer.

This distinction between explicit and implicit scaffolding was also a major theme raised by other authors in this issue. However, instead of addressing the discursive role of language, what was being made explicit is quite different. In the next section, I will elaborate further, beginning with the cognitive-linguistic role of language.

2.2. Cognitive-Linguistic Role to Scaffold Construction of Knowledge

While the discursive role of language is necessary for organizing and accomplishing classroom interaction, it does not directly address the co-construction of knowledge that students are learning from the teachers. Xu and Harfitt (this issue) rightly expressed this particular role as follows: “Language is instrumental in the cognitive construction of knowledge and experience, not only because one disseminates knowledge by using a language, but also because language forms the way in which one construes an experience and internalises it as knowledge". In theorizing how language is used to scaffold the construction of knowledge, many authors in this issue draw from Vygotsky and Halliday to highlight the inseparable relationship between thought and language. Specifically, Halliday's systemic functional linguistics (SFL) provides a sophisticated framework to specify the linguistic structures that correspond to certain levels of knowledge construction. Due to this overlapping relation between thought and language, this is why I treat "cognitive-linguistic" as a unitary role of language, instead of separating them apart.

Lo et al. (this issue), An et al. (this issue), and Xu and Harfitt (this issue) provide good exemplars of this aspect of scaffolding that targets the cognitive and/or linguistic functions of language. In their articles, their primary focus in making this cognitive-linguistic connection was to examine what kind of "content" and "language" was foregrounded in their case studies, thus determining how much content and language was integrated in CLIL. This content-language integration is an issue I will address in a later section, but for now, I will comment on their perspectives regarding the role of language as a cognitive-linguistic scaffolding tool.

A good place to start is the coding scheme developed by Lo et al., which categorizes a classroom video episode into, first of all, either an instructional or regulative register. Lo et al.'s emphasis is on the instructional register, which they further divided into content and language, with each aspect having three levels. Content, in this case, is a Bloom's taxonomy type of cognitive level, consisting of recall, application, and analysis. Language, based on Lin's (2016) adaptation from SFL, is divided into lexico-grammar, sentence, and text. Through the categorization and analysis of these episodes, Lo et al. brought out two important findings. In the first finding, the majority of language teaching episodes was found to be focused on vocabulary and "embedded" (i.e., implicit) in content-oriented episodes. The implicit nature of such vocabulary teaching episodes is similarly found in An et al.'s (this issue) analysis of language-focused episodes (LFEs) in their study, as well as many other studies in both CLIL and science education literature.

The second finding from Lo et al., which is more interesting, shows how a teacher (Miss A) provided a kind of "*explicit* language scaffolding" that went beyond vocabulary to sentence pattern and text writing. The example provided was the step-by-step instruction to describe an experimental result in the form of a graph. Linguistically, this instruction involves unpacking the noun phrases, nominalization, and conjunctive relations in the sentence pattern. Based on this analysis, Lo et al. argued that Miss A's instruction provided a better scaffold that enabled her students to understand and express their scientific ideas more effectively. Similarly, in An et al.'s study (this issue), although they did not see this kind of explicit instruction in their data, they also argued that such language structures are distinctive to the register of science, and should therefore be "systematically and explicitly instructed" for all science students, particularly more so for bilingual students.

2.3 Semiotic Role to Scaffold Science Meaning-Making

The last aspect of scaffolding that I distil in this issue involves the semiotic role of language in providing the semantic relationships for science meaning-making. This perspective is influenced by the theory of social semiotics. With its roots from Halliday's meaning-oriented theory of language, social semiotics has developed into a general theory of how people make meanings using various semiotic modes, of which verbal language is just one mode among a range of multimodalities (Lemke, 1990). Social semiotics has often been used to analyze any text (broadly defined) by examining the semantic relationships made by every word, symbol, visual sketch, and body movement (e.g., Tang, 2011). Pedagogically, semantic relationships are also important as a scaffolding tool, and this is best illustrated by He and Lin (this issue).

He and Lin make use of Lemke's (1990) notion of thematic pattern, which is defined as "a pattern of semantic relationships", to expand a common strategy used in content-area teaching – concept mapping. As they rightly pointed out, although concept mapping provides a suitable "big picture" view of a science topic (consisting of multiple so-called "concepts"), it obstructs the fact that a concept itself is actually a shared and institutionalized thematic pattern that is repeated over and over again in multiple instances (e.g., teachers' talk, textbooks, written examinations). With this limitation of concept mapping, He and Lin developed what they called "concept + language mapping" in order to "emphasize the role of language in concept instruction in CLIL lessons". While thematic pattern has been used by researchers in text analysis, what is bold and unique in He and Lin's work is they have taken thematic pattern further to develop into a pedagogy. This will be useful for science teachers and students to become cognizant of the customary semantic relationships that are necessary to learn a particular scientific concept.

In Turner's (this issue) article, although she did not foreground semantic relationships or the meaning-making role of language, social semiotics provides an interesting interpretation to her key finding. Turner found from her study that the meanings of some scientific concepts were easier for the students to access in *kanji* than in English. From a social semiotics perspective, *kanji* is a unique semiotic system that was historically adopted from the Chinese writing scripts and later developed, along with the development of *hiragana* and *katakana*, to write parts of the Japanese language focusing on content words. As a character-based writing system, similar to written Chinese, the meaning of many words in *kanji* is realized through the semantic relationship of two or more characters. Taking an example from Turner's article, the meaning of "solid" in *kanji* is inferred from the semantic relationship of "hard", which is an ATTRIBUTE and "body", which is a MEDIUM (see Lemke, 1990 for a list semantic relationships). By providing information on the semantic relationships of a word from within the word itself, this was how *kanji* could be used as an additional resource for translanguaging between the students' L1 and L2. In this sense, the use of *kanji* as a scaffolding tool draws on the semiotic affordance of this written mode.

The example from *kanji* provides an interesting insight on how we learn vocabulary: the meaning of a new word can only be learned in relation to other existing words, or to be more exact, through their semantic relationships. This applies whether we learn a word from a dictionary or through a teacher's oral definition. Many CLIL teachers, as reported by An et al. and Lo et al. (this issue) usually stress on vocabulary instruction in their language-focused teaching at a word level. This can sometimes be problematic as bilingual students are led to rely on rote memorization and therefore mistake familiarity with scientific keywords for knowledge of the related concepts. Instead, learning a new scientific term (and its associated concept) often depends on learning the web of semantic relationships (or thematic pattern) that are used with the term. As such, the teaching of new technical vocabulary must not merely focus at a lexicogrammatical level (e.g., through repetition, synonym, paraphrasing), but also at a thematic-pattern level comprising several semantic relationships. This focus will involve a different instructional approach that makes explicit the underlying semantic relationships of a word, similar to what He and Lin (this issue) have done through their concept + language mapping approach.

Finally, Ho et al.'s (this issue) contribution to this special issue is the foregrounding of the semiotic role of a visual representation. In their analysis, they provided two examples of how several features in the students' concept sketches served as a semiotic resource that complements the classroom talk. The first feature was the drawing of arrows to show directionality of H+ ions' movement, while the second feature was the drawing of enclosing shapes to show the "stuff inside" a stalked particle. Semantically, these two visual features represent transitivity relationship and part-whole (meronym) relationship (Kress & van

Leeuwen, 1996), and they complement similar semantic relationships that were built through the oral discourse, for example in line 33 (H+ will *go out into* the…) and line 51-53 (What do you think is a stalked particle *made up of*?). Ho et al.'s primary focus in their article was to show how the verbal interaction (i.e. talk moves) guided the students' meaning-making of their diagrams. However, the reverse could also be argued and highlighted; that is, the classroom talk could not have occurred without the semantic relationships realized in the students' concept sketches. For instance, from line 44 and 46, there were many references to "*this* part" and "draw it *this* way" where presumably, the teacher was using gestures to point at several parts of the student's diagram. A more detailed multimodal analysis will therefore show the semiotic role of the drawing in scaffolding the classroom talk, and thus illustrate more generally how science meaning-making is mutually and symmetrically combined through a range of semiotic modes.

2.4 Epistemic and Affective Roles

Besides its discursive, cognitive, linguistic, and semiotic functions, language also has an epistemic and affective role that shape how students learn science language as well as learn science through its language. The language of science has a distinctive epistemic role that is integral to the construction of scientific knowledge (Shanahan, 2012). Some expressions of this language include the connection between claim and evidence, reasoning from theory, and the uncertainty of empirical finding. These expressions are embedded within certain communication patterns and structures in what many science educators call "scientific practices". The Next Generation Science Standards (NGSS) defines eight of these practices, which include investigation, using models, constructing explanation, engaging in argument and communicating information. From a language perspective, scientific practices roughly correspond to the notion of genre, which is conceptualized within SFL as the sociocultural cultural context that shapes the production and interpretation of texts (Martin, 2007). In SFL, several researchers have also identified four major genres in science, namely experimental report, informational report, argument, and explanation (Halliday & Martin, 1993).

A number of articles in this issue have findings that are relevant to the learning of scientific practices or genres. A good example is the language-oriented episode shown in Lo et al.'s (this issue) study where the teacher (Miss A) supported her students to "describe the results from a graph". In this episode, we could say that the class was partially involved in the genre of experimental report, and Miss A did well to unpack this particular genre for her bilingual students. However, Miss A focused more on the linguistic structure of the genre at a sentence and text level, which was understandable given that her students would need that kind of support. An epistemic focus, on the other hand, would manifest quite differently. For example, instead of learning the sentence pattern, the teacher would be asking students why they (or scientists in general) would choose this kind of language to describe their results or discussing the extent of how the graph (as a form of language) could represent the experimental results. For the genres of explanation and argument, an epistemic focus would question how a scientific explanation works based on an accepted theory, and likewise, how a scientific argument works based on empirical evidence (see Tang, 2016). Such epistemic emphasis is relevant not only in learning the content of science, but also the nature of science (NOS) itself.

Last but not least, the affective role of language is probably the most understudied in science education. This is likely because scientific language is often perceived to be factual, impersonal, and technical. Such interpersonal aspects of scientific language can present a learning barrier for children who are more comfortable with the personal and expressive forms of language used in everyday communication. The article by Turner (this issue) reminds me of how a second language like Japanese (or the children's L1) may provide an additional resource that could bridge the affective barrier of scientific language, which is taught through another language (e.g., English). In a study on English language learners (ELLs) conducted in Singapore with a colleague some years ago (see Wu, Mensah, & Tang, 2018), we observed that ELLs were translanguaging with their peers using L1 (Chinese) not in a conceptual manner to discuss scientific terminologies or meanings (e.g., cell nucleus), but more in a functional and social manner to express their emotions (e.g., disgusting over how plant cells look like under the microscope). This observation concurs with our knowledge and Turner's finding that bilingual learners tend to separate the use of their L1 from the official target language used to learn a content area like science, for a multitude of conceptual as well as social reasons. These social reasons warrant further investigation that considers the affective role of language in supporting bilingual learners in learning science.

3. Content & Language as Integrated or Separate Entities?

Having elaborated the discursive, cognitive, linguistic, semiotic, epistemic, and affective roles of language in scaffolding student learning of science, I will now discuss the second question: to what extent can content and language be integrated and separated in CLIL instruction and assessment? As this is not a simple question that can be resolved easily, I will only offer some observations based on my reading of this issue.

It is obvious that the central premise for promoting CLIL rests on the intertwined connection between content and language. This justification is based on not just a political convenience to support a country's language policies for a multilingual population, but also on a theoretical argument drawing upon the works of Vygotsky, Halliday, Lemke, and other theorists. Yet, in practice, it seems common to separate content and language as distinct entities for various pedagogical and analytical reasons. This somewhat paradoxical tension was partly raised by An et al. (this issue). While acknowledging the inextricable link between content and language within CLIL, they sought out to "establish whether it was actually possible” *for analytical purpose* to differentiate and identify “language focused episodes” that showed a teacher focusing on an aspect of language as opposed to “explaining about a scientific concept”. A similar distinction can also be seen in Lo et al.’s (this issue) analysis where they had coded content and language as separate episodes in their video corpus.

There are of course many merits in separating content and language components for the purpose of analysis. One advantage is that the separation renders a complex phenomenon or case study into discrete categories or variables, which could then be further investigated. After this initial separation, the analyst’s eventual goal is to put them back through some kind of meaningful comparison or connection. For example, while Lo et al. (this issue) coded content and language separately, they later showed how Miss A exemplified the objectives of CLIL by focusing more, as compared to Miss B, on *both* content and language aspects of science teaching. Pedagogically, it is also common to find CLIL lesson plans that have both content and language as distinctive learning outcomes. For instance, a content learning outcome could be “to state weight as the force of gravity and define it as the product of mass and acceleration due to gravity”, while a language learning outcome could be to “use appropriate vocabulary related to describe forces and motion”. Such distinction has the benefit of raising a teacher’s awareness of achieving both content and language objectives at the same time in their CLIL lessons, even though both objectives are intertwined.

However, from other studies in this issue (e.g., He & Lin; Turner), it is also evident that what can be considered as content as opposed to language is sometimes difficult to differentiate. In these studies, content and language seem much more intertwined. In particular, I observe that specific to the discursive, cognitive, and linguistic roles of language, it is perhaps easier to differentiate content and language as two separate entities. By contrast, when discussing the semiotic, epistemic, and affective roles of language, the boundaries between content and language become more fuzzy and indistinguishable. In the semiotic role for instance, the understanding of “concepts”, which is typically associated to content learning, was shown to be learned though the semantic relationships of language (realized through words, symbols, and other signs). In other words, learning the content is equivalent to learning the language, and these two aspects are actually two sides of the same coin.

Another way to think about these differences is through the various levels of language as used by Lo et al. and An et al (this issue) in their analytical framework. At a lower level of language, such as lexico-grammar that deals with vocabulary, morpheme, spelling, punctuation, and noun phrases, it is perhaps easier to delineate content from the language aspect. For instance, if a student misspells or mispronounces a word or uses an improper grammar within a sentence, we can still easily infer the meaning (hence content) that he is trying to make based on the other words he has written in the sentence. In this case, we can ascribe the error as simply an expression issue and still able to discern the content separately. However, at a higher level of language (e.g., text-level) that deals with the thematic patterns and genres of science, it is not so easy to make the distinction. Thus, if a student does not have the language ability to put together the words and semantic relationships that form the thematic pattern of a concept, how else would he be able to demonstrate to others (and himself) an understanding of the content? This ability applies both during instruction when the student is learning a new concept through listening or reading as well as during assessment when the student has to demonstrate his understanding through oral discourse or a written test. Therefore, in scenarios that involve higher levels of language, it may not be feasible to separate content and language as distinct objectives or foci, for both analytical and pedagogical purposes.

4. Closing Remarks

The six articles in this special issue has provided a number of thought provoking insights that expand our understanding of the roles of language, scaffolding, implicit vs. explicit instruction, and content-language integration. These contributions are important not only for researchers and teachers working in CLIL environments, but also more generally for science and other content-area educators that understood the importance of language. As I have mentioned earlier, although the language and science education research communities have come from different theoretical background and orientation, what draws both communities together is a common interest in understanding how the learning process in the science classroom is mediated by language, through its various discursive, cognitive, linguistic, semiotic, epistemic, and affective functions.

Based on this special issue, it is perhaps understandable why the science classroom provides such a fascinating research site that draws researchers from both communities. Among the various disciplines, science is highly regarded as a “content-heavy” subject. Bernstein (1999) describes the natural sciences as having a hierarchical knowledge structure where the content knowledge is accumulative as opposed to a horizontal knowledge structure. At the same time, we have also learned from years of previous research that the language of science (including the use of mathematics and other multimodal representations) is distinctively different from everyday communication. As such, the teaching and learning of science provide a favourable combination of content and language for researchers to explore and investigate. For CLIL researchers, the distinction between content and language in the context of science, as well as their integration in the classroom, therefore become a point of interest that warrants further investigation.

In this regard, as someone who works mostly within science education, I am delighted to see more researchers from the CLIL community coming to investigate this interesting space and sharing our intellectual resources to tackle an important educational problem. In closing, I thank all the authors in this special issue for being the pioneers in this field. As they are forging the integration of content and language within CLIL science classrooms, they are also simultaneously advancing a deeper convergence between the science education and language education communities at large.

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