Routledge
Taylor & Francis Group

Journal of Multilingual and Multicultural Development

ISSN: 0143-4632 (Print) 1747-7557 (Online) Journal homepage: www.tandfonline.com/journals/rmmm20

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To cite this article: Tessa Mearns, Pilar Gerns, Silvia Minardi & Fred Janssen (28 Mar 2026): Disciplinary perspectives meet disciplinary literacies: a heuristic toolbox for content-language integration, Journal of Multilingual and Multicultural Development, DOI: 10.1080/01434632.2026.2646262

To link to this article: https://doi.org/10.1080/01434632.2026.2646262

JOURNAL OF MULTILINGUAL AND MULTICULTURAL DEVELOPMENT
https://doi.org/10.1080/01434632.2026.2646262

Disciplinary perspectives meet disciplinary literacies: a heuristic toolbox for content-language integration

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ABSTRACT

Learning in any subject area involves learning to think and build knowledge in particular discipline-specific ways. This is a belief underscored by theory and research from several educational perspectives, although approaches to supporting development of disciplinary thinking vary. Examples of two such differing approaches are the perspective-based approach, and bi- and multilingual disciplinary literacies (BMDLs). While the perspective-based approach focuses on the way the organisation of subject content promotes disciplinary thinking, BMDLs address the communicative aspects of subject learning, in particular in multilingual classrooms. This paper argues that these two approaches can be viewed as complementary, and explores how bringing them together can help bridge the gap between content-oriented and communicative aspects of disciplinary learning. We approach this both theoretically and practically. We begin with introductions to both approaches, followed by an exploration of their conceptual complementarity. Taking biology as an example, we then present a heuristic toolbox in which subject-specific perspectives are combined with the BMDLs-related construct of cognitive discourse functions (CDFs) to support the design and selection of learning activities. On the basis of practical examples, we discuss how this toolbox can help teachers systematically connect the conceptual and communicative dimensions of their subject in multilingual learning contexts.

ARTICLE HISTORY
Received 25 November 2025
Accepted 11 March 2026

KEYWORDS
Bi- and multilingual disciplinary literacies (BMDLs); perspective-based approach; cognitive discourse functions (CDFs); content and language integrated learning (CLIL); biology education; content learning

Introduction

The idea that disciplinary learning can best be promoted through attention to disciplinary 'forms of knowledge and experience' (Hirst and Peters 1970, 69) has been echoed in various educational approaches. Two of these are the perspective-based approach, and bi- and multilingual disciplinary literacies. The perspective-based approach has been proposed as a way to organise and present subject content in order to help learners understand the 'big ideas' behind a discipline, guiding them in asking discipline-specific questions to further their knowledge and understanding (Janssen, Hulshof, and van Veen 2019). Disciplinary literacies have been defined as 'specialised ways of thinking and communicating that are essential to each academic discipline' (Nikula et al. 2024, 1). Building on this definition, the COST CLIL Network for Languages in Education (CLILNetLE) developed a multidimensional model of *bi- and multilingual* disciplinary literacies (BMDLs), which acknowledges the multimodal and multilingual realities of education (Nikula et al. 2026).

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/01434632.2026.2646262.

While both approaches aim to support disciplinary thinking as part of subject-specific learning, they do so from different starting points: one emphasising the organisation of subject content, and the other, the communicative features of the subject. These different starting points do not, however, place the two approaches in opposition – rather, they reflect a productive tension that points towards the need for dialogue between them. The most recent conceptualisation of BMDLs does acknowledge 'disciplinary knowledge and epistemology' as ever-present and fundamental elements of subject learning (Nikula et al. 2026, 3), suggesting that content is never entirely absent from the communicative framework; similarly, the perspective-based approach, in foregrounding how knowledge is selected and structured, implicitly shapes the kinds of meaning-making and communication that become possible in the classroom. In this sense, both approaches are already approaching the same terrain – they simply enter it from different directions. The risk, then, lies in what each leaves undertheorised when taken in isolation. Given that most content teachers identify primarily as specialists in their subject rather than in language, the absence of concrete attention to the role of content in BMDLs could pose a risk to how relatable this valuable conceptual work is to content teachers (Dale and Mearns 2023; Hüttner, Llinares, and Nikula 2025; Moje 2015), and therefore to its impact in practice. Conversely, the perspective-based approach, without explicit engagement with subject-specific literacies and disciplinary communication, risks overlooking how language mediates access to disciplinary knowledge – a gap with particular consequences for learning and equity in bi- and multilingual contexts (Coyle and Meyer 2021; Moje 2015; Nikula et al. 2026).

With the above complementarity in mind, this paper aims to explore how bringing together the perspective-based approach and BMDLs can help bridge the gap between communicative and content-oriented aspects of disciplinary learning. Each can address the blind spots of the other, and together they offer a more integrated account of how disciplinary thinking develops through both the content and the communicative practices of subject learning. As an interdisciplinary team of specialists in language teaching, teacher education, linguistics, and subject-specific pedagogies, we do so in the form of a tool that is intended to be practical and relatable to content teachers, with solid groundings in both educational and linguistic research.

We begin with a brief theoretical exploration. First, we introduce the principles of BMDLs, focusing in particular on the construct of cognitive discourse functions (CDFs; Dalton-Puffer 2013): a widely used tool for understanding the relationship between content, language and literacy as part of disciplinary learning, and prominent in the current conceptualisation of BMDLs (Nikula et al. 2026). We then present the perspective-based approach, which, while well-established in practice and research, is not widely known outside the fields of biology and chemistry education. These brief theoretical outlines are followed by an exploration of the complementarity between the perspective-based approach and BMDLs through the lens of Coyle's 4Cs (Coyle 2015): a model widely used in content and language integrated learning (CLIL) to conceptualise the relationship between content, cognitive, communicative and cultural aspects of subject learning.

The theoretical exploration is followed by a practical application. We present a heuristic toolbox, exemplified for secondary biology teaching, in which CDFs are combined with discipline-specific perspectives to support teachers' repertoire development and promote more effective content-language integration. We conclude by presenting and analysing a series of concrete, practical examples of how the heuristic toolbox could be implemented to support lesson planning, preparation and assessment in a content and language integrated learning (CLIL) biology context. We suggest that this marriage of BMDLs and the perspective-based approach could mark a new way forward for research and practice in content and language integration, and for meaningful and fruitful collaboration between content and language specialists.

Two approaches, a single goal?

BMDLs and the perspective-based approach have both grown out of concern for the role of subject-specific knowledge-building as a feature of disciplinary learning. Their different theoretical origins,

however, lead them to emphasise different features in the process of subject learning. In the sections 'Bilingual and multilingual disciplinary literacies' and 'The perspective-based approach', we will describe the principles of each approach in turn. In the section 'Converging goals, complementary approaches', we will explain how the differences between the two approaches can be viewed as complementary, and therefore how, together, they create an opportunity to promote disciplinary learning with emphasis on both content and communication.

Bilingual and multilingual disciplinary literacies

At the core of the concept of disciplinary literacies (DL) is the conviction that learning involves apprenticing learners into specific ways of thinking, understanding and communicating that align with conventions and cultures typical of a given discipline (Lo, Lin, and Liu 2020). When introducing learners to DL in history, for instance, it is important that they engage not only with historical dates, events, phenomena, and subject-specific terminology, but also with subject-specific genres, specific lexico-grammatical features, issues of register and style, and multimodal and multilingual resources (such as graphs, images, and sources in other languages), albeit on a level appropriate to their cognitive and linguistic development (Leung and Morton 2016). Content teaching with attention for DL, therefore, involves structuring the learning process so that it supports learners in meaningfully accessing, processing and demonstrating content knowledge through disciplinary forms of communication. This carries through to assessment that is constructively aligned with the learning process, not only in terms of content but also in the ways learners are required to communicate about content (Biggs 1996; Llinares, Morton, and Whittaker 2012).

Nikula et al. (2024, 2026) expand the existing concept of DL through their model of bi- and multilingual disciplinary literacies (BMDLs). This model takes into account that, in many educational contexts, learning often takes place through an additional or foreign language. Their refined conceptualisation of BMDLs therefore acknowledges the bi-, multi-, and translingual dimensions involved in content learning. As highlighted by Lorenzo and Dalton-Puffer (2016), however, developing disciplinary knowledge and literacies through an additional language can place greater demands on teachers and students. Learners are required not only to learn new subject content but also to engage with it through its respective disciplinary language conventions and in a language that may not be their first. Teachers are expected to present content in ways that are more accessible to learners; for example, by providing appropriate scaffolding to address potential conceptual challenges, general language difficulties, and subject-specific language demands (Ertugruloglu, Mearns, and Admiraal 2023; Meyer et al. 2015). While Nikula et al.'s (2026) conceptualisation of BMDLs grew out of the field of CLIL, its relevance is not limited to CLIL settings: learners and teachers in any context navigate diverse named languages, dialects, registers and semiotic features present in school and in their communities, as well as the literacies of multiple school subjects (Coyle and Meyer 2021; Moje 2015; Nikula et al. 2026).

Research on BMDLs has aimed to address the challenges students face when learning through a second or additional language. It has done so by focusing on aspects such as subject-specific vocabulary, thematic patterns, genres and registers, and, more recently, the construct of cognitive discourse functions (CDFs; Dalton-Puffer 2013). The CDFs construct has gained increased attention in the study of BMDLs (Dalton-Puffer, Hüttner, and Nikula 2024), as it offers an operational framework that makes subject knowledge, its underlying thought processes, and disciplinary literacies more accessible to both content and language specialists in bi- and multilingual teaching and learning contexts such as CLIL.

The CDFs construct (Table 1) presents a set of cognitive functions that feature repeatedly in formal education, and which are performed through specific language forms (Dalton-Puffer 2016). These functions have been described as 'building blocks' (Morton 2020, 11) inherent to content learning and subject pedagogies (Dalton-Puffer et al. 2018), and as a means of inducting students into subject-specific literacies and language demands (Dalton-Puffer, Hüttner, and Nikula 2024). As

Table 1. Overview of the CDF construct, adapted from Dalton-Puffer and Bauer-Marschallinger (2019).

CDF type	Members	Communicative intention
CATEGORISE	Classify, compare, contrast, exemplify, match, structure, categorise, subsume	*I tell you how we can cut up the world according to certain ideas*
DEFINE	Define, identify, characterise	*I tell you about the extension of this object of specialist knowledge*
DESCRIBE	Describe, label, identify, name, specify	*I tell you details of what I can see (also metaphorically)*
EVALUATE	Evaluate, argue, judge, take a stance, critique, comment, reflect, justify	*I tell you what my position is vis-à-vis X*
EXPLAIN	Explain, reason, express cause/effect, deduce, draw conclusions	*I tell you about the causes or motives of X*
EXPLORE	Explore, hypothesise, predict, speculate, guess, estimate, simulate	*I tell you something that is potential (i.e. non-factual)*
REPORT	Report, inform, summarise, recount, narrate, present, relate	*I tell you something external to our immediate context on which I have a legitimate knowledge claim*

Morton (2020) clarifies, if students are, for instance, expected to *explain* a phenomenon by identifying its causes and effects (content and cognition), they may be asked to produce an explanation genre (literacy) and to use specific lexico-grammatical resources for expressing causality (language). A focus on CDFs can raise teachers' awareness of the linguistic demands of those cognitive operations (Morton and Llinares 2024).

As Table 1 shows, the CDF construct consists of seven main functions (referred to as *CDF types*), each of which represents a key *communicative intention* and subsumes a range of related CDF verbs (*members*) (Dalton-Puffer 2013). The lists of possible members, taken here from Dalton-Puffer and Bauer-Marschallinger (2019), are intended as examples, and are not considered to be exhaustive.

The seven CDF types displayed in Table 1 are the result of a systematic review of educational learning objectives (e.g. Anderson and Krathwohl 2001) and research on academic discourse and language functions (e.g. Trimble 1985), further refined through analyses of curricula (Dalton-Puffer 2013) and classroom interactions (Dalton-Puffer et al. 2018). Thus, they offer CLIL teachers a set of concrete, operational teaching and learning objectives, which draw on contributions from both educational and applied linguistics research (Llinares 2025) and enable a systematic, focused, and accessible integration of subject content, literacy and language (Morton 2020; Roca de Larios, Coyle, and García 2022). The CDF construct is not conceived as a closed or rigid taxonomy. Dalton-Puffer (2013) explicitly characterises it as a heuristic, with fuzzy boundaries and considerable variability in its linguistic realisations across subjects and contexts. Its value lies not in prescribing specific language forms, but in providing teachers and researchers with a shared and workable terminology for linking content learning objectives with the literacy and language resources required to express them.

Studies that have applied the CDF construct in second language (L2) or multilingual learning contexts have made important contributions clarifying its linguistic features (see e.g. Arias-Hermoso et al. 2025; Evnitskaya and Dalton-Puffer 2023; Nashaat-Sobhy and Llinares 2023). Studies addressing the role of CDFs in relation to students' conceptual and cognitive learning and development, while less numerous, have highlighted the potential of the CDF-construct to integrate insights from both language and subject education research (Bauer-Marschallinger 2022; Gerns 2023). Such studies also underscore the need for more subject-specific and content-oriented research in order to fully realise the CDF construct's potential for supporting students' disciplinary learning. This could go hand-in-hand with further refinement of the construct to account for discipline-specific needs, discourse and thinking patterns, as called for by, among others, Evnitskaya and Dalton-Puffer (2023) and Kääntä (2021). Some initial efforts have already been made in this direction, such as Lorenzo (2017) or Bauer-Marschallinger (2022) in history, and Minardi (2024) in biology.

The perspective-based approach

The perspective-based approach (e.g. Janssen, Hulshof, and van Veen 2019) has been presented as a concrete, practical approach to organising subject content and structuring teaching in meaningful

ways, so as to promote development of disciplinary thinking. Grounded in the principle that people deal with complexity by asking questions from multiple points of view (Wimsatt 2007), this approach involves having learners examine phenomena through subject-specific 'lenses'. Those lenses take the form of 'core questions' formulated based on a 'big idea' that characterises and forms the foundation of the subject in question.

For example, in biology, for centuries, people have marvelled at both the diversity and the functionality of organisms: the diversity of life forms is enormous, and all those life forms have adapted to survive and reproduce in the environments in which they occur. This diversity and functionality have come about through a long evolutionary process. Moreover, every organism has a life cycle from birth to death. The big idea of biology can therefore be summarised as follows: **organisms have evolved and developed in such a way that they can function in the environments in which they occur**.

Based on this big idea, the following core questions can be asked regarding any organism and its characteristics (e.g. the human heart or the robin's song):

- **What is it?** (taxonomic perspective)
- **What is it for?** (functional perspective)
- **How does it work?** (mechanical perspective)
- **What environment does it need?** (ecological perspective)
- **How does it develop?** (developmental perspective; refers to change within an organism's lifetime)
- **How did it evolve?** (evolutionary perspective; refers to change across generations)

As exemplified in Figure 1, these core questions help steer learners towards exploring answers in ways that align with the ways of thinking inherent to the field of biology, and also to the

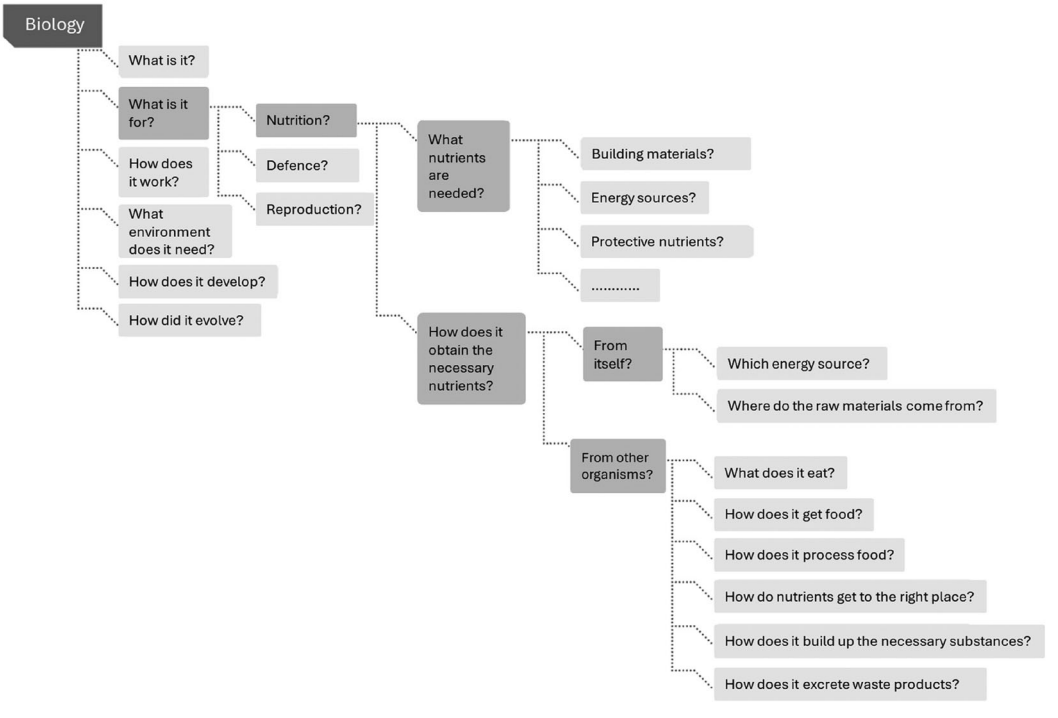

Figure 1. Core and sub-questions in the biological perspective (translated from Janssen, Hulshof, and van Veen 2019).

formulation of sub-questions at increasing levels of detail and complexity. The core questions remain the same regardless of the learners' age or academic level. Younger or beginner learners can already be introduced to analysing phenomena through the core questions, while older or more advanced learners will address increasingly detailed, complex and specific questions, branching out from but always related to the core. Which specific questions are selected as the main focus of an individual lesson or unit will vary according to the curriculum and the readiness of learners, although a key principle is that they always be explored in relation to the 'core' of the subject.

Since its conception in the context of biology education, the perspective-based approach has been developed and validated for many subjects in primary, secondary, and higher education (e.g. Janssen and de Hullu 2008; Janssen and van Berkel 2015; Janssen, Hulshof, and van Veen 2019). Research has also shed light on the broader applicability of the approach for the design, implementation and evaluation of learning activities, and for the development of teaching repertoires and school curricula (de Boer et al. 2019; den Otter et al. 2024), although its relationship with language and literacy demands has not yet been addressed.

Converging goals, complementary approaches

When set alongside each other, it becomes apparent that BMDLs and the perspective-based approach both work towards the goal of supporting learning through emphasis on ways of thinking and knowing inherent to the cultures of specific disciplines (Coyle 2015). As illustrated in Figure 2, however, their means of achieving that goal appear to differ.

The approaches also align in their attitude that development of disciplinary thinking should be an explicit focus of teaching and learning, adapted to learners' level of readiness. That adaptation can involve breaking learning down into either chunkier or more specific pieces (Janssen,

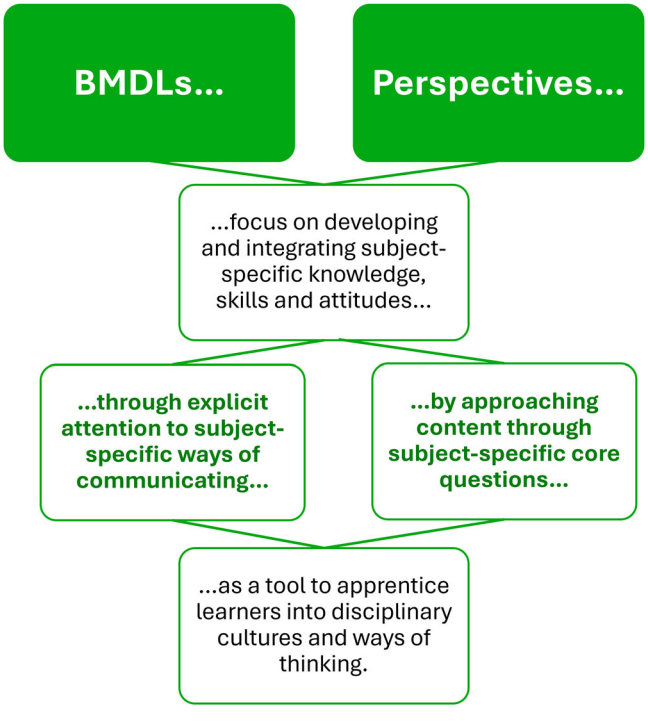

Figure 2. Converging goals and complementary approaches of BMDLs and the perspective-based approach.

Hulshof, and van Veen 2019; Meyer et al. 2015) as appropriate to the learners and their context, and providing adaptive support or scaffolding (de Boer et al. 2019; Ertugruloglu, Mearns, and Admiraal 2023). As such, both are underpinned by the belief that apprenticeship into disciplinary thinking can be achieved at any age and educational level, and that failure to promote disciplinary thinking in the early stages means missing out on the opportunity to build a solid foundation for the more complex tasks and thinking that come later.

Where the two approaches differ is in their means of supporting and developing disciplinary thinking. This can be understood through the lens of Coyle's 4Cs model (Coyle 2015). We refer specifically to the 2015 version of the model due to its expanded definition of 'culture' to include disciplinary culture. This model's emphasis on the interconnectedness between subject content and its communicative, cognitive and cultural features aligns with the shared focus of BMDLs and the perspective-based approach on the development of disciplinary thinking, as evident in Figure 2. In addition, it highlights the key differences between these approaches. While the 4Cs model positions its four elements as equally important, BMDLs and the perspective-based approach each address explicitly the roles of and interconnection between three of the four Cs, but leave one of the four under-addressed. These similarities and differences are illustrated in Table 2.

As Table 2 illustrates, while present in the 4Cs model, content has historically been treated as a 'given' in CLIL and BMDLs (Dale and Mearns 2023). For example, until recently, research on CLIL practice rarely acknowledged the role of content in determining pedagogical choices (van Kampen et al. 2018). Similarly, in the CLILNetLE's initial conceptualisation of BMDLs (Nikula et al. 2024), the dimensions of BMDLs are all related to subject content, but the content itself is not addressed. Recent times have seen increasing efforts and explicit calls to involve more content teachers and subject experts in work on CLIL and BMDLs, in order to take their perspectives, identities and practical realities into account (Dale and Mearns 2023; Hüttner, Llinares, and Nikula 2025). Furthermore, the publication of content-oriented CLIL research such as van Kampen et al. (2020) and Oattes et al. (2022) and more detailed exploration of content aspects in conceptual works such as Coyle and Meyer (2021), and the CLILNetLE's refined conceptualisation of BMDLs (Nikula et al. 2026), may signal a readiness to move CLIL and BMDLs in more content-focused directions.

Communication holds a similar position in literature on the perspective-based approach: its presence is acknowledged, but its role as a means of accessing, guiding and demonstrating learning of subject content and the development of disciplinary thinking is not explored. For example, in Janssen, Hulshof, and van Veen (2019), communicative aspects of non-language subjects are mentioned only fleetingly (e.g. as cross-curricular skills). Similarly, in research on the

Table 2. Comparative analysis of BMDLs and the perspective-based approach based on the 4Cs (Coyle 2015), where the shaded cells indicate the aspects under acknowledged in each approach.

4Cs	BMDLs	Perspectives
Content	Disciplinary knowledge-building acknowledged as central, but the question of *what to teach* and *how* still under-addressed	Broken down into perspectives to support the development of subject knowledge and skills, and **subject-specific thinking**
Communication	A subject's cognitive demands are intrinsically related to its **communicative demands** (i.e. academic and disciplinary communication skills, languages, semiotic systems and modalities); together, these reflect specific **disciplinary cultures and ways of thinking**	Communicative and linguistic features are implicitly present, but generally receive no explicit attention
Cognition	Multifaceted and intrinsically related to **disciplinary communication**; explicit, integrated attention for both cognition and communication supports apprenticeship into **disciplinary cultures**	Questions reflect subject-specific ways of making sense of **subject content** and **disciplinary culture**
Culture	The culture of a discipline is manifested in the way **subject-specific ways of thinking** are reflected in **disciplinary communication**	The culture of a discipline is manifested in the way **content** is addressed through questions related to **subject-specific ways of thinking**

perspective-based approach, while language is implicitly present, its role is not explored or addressed explicitly. For example, in de Boer et al.'s (2019) study of biological questioning among student teachers, levels of conceptual complexity were determined based on content (e.g. whether or not prior knowledge was required in order to answer the question) rather than on linguistic markers such as CDFs.

This brief analysis of the relationship between BMDLs and the perspective-based approach appears to point to an opportunity to harness their complementarity in order to optimise disciplinary learning. We now move beyond the theoretical discussion to one that is of practical use in helping teachers design learning experiences that truly integrate the disciplinary 4Cs.

From theory to practice

In this practical section, we begin by presenting a heuristic toolbox that brings together BMDLs and disciplinary perspectives by connecting two existing heuristics: CDFs and disciplinary core questions. This tool can support teachers' planning and reflection and thereby help broaden their repertoire of strategies for scaffolding content, language and literacy learning in multilingual classrooms. Since each discipline has its own specific characteristics, we have developed this example for one subject, namely Biology. Following the introduction to the heuristic toolbox (see Table 3), we present and discuss concrete examples illustrating how it can be applied in a CLIL context to integrate conceptual, cognitive and communicative learning aspects.

A heuristic toolbox for repertoire building and content-language integration in biology teaching

Table 3 presents the proposed *Heuristic toolbox for repertoire-building and content-language integration*. The vertical axis contains the six core questions from the biological perspective, each representing a distinct way of examining organisms and their characteristics. The horizontal axis displays the seven CDF types. As demonstrated in Table 2, the CDF types can also be replaced by some of their members (for example, *categorise* could be replaced by *compare*).

The idea is to use the heuristic toolbox as a flexible planning and reflection tool, which allows content and language learning demands to be considered together. The intersections between the biological core questions and the CDF types enable teachers to define subject-specific learning objectives more precisely by identifying what students need to know, how they are expected to process that knowledge from the disciplinary perspective, which subject-specific questions are involved, and the communicative intention, along with the literacy and language required to express that knowledge.

To illustrate how this can be done – that is, how students can process content knowledge through core questions and verbalise it through CDFs – examples of core activities have been included in italics in each of the corresponding cells. These can be further specified with relevant content. For example, work on photosynthesis from the ecological perspective [ECO] can be combined with CDF-DESCRIBE [des] through the following activity: *Describe what a plant needs from its environment in order to survive* or, using a different member, *Identify features of the environment that help the plant survive* [ECO-des].

Building on Morton's (2020) metaphor of CDFs as building blocks, the 42 cells in this matrix can be pieced together in almost endless ways to create structures of varying sizes and complexities. As such, the heuristic toolbox offers teachers a repertoire of modular options that they can flexibly select and combine across different stages of a lesson or learning experience: for generating objectives, selecting and designing teaching and learning activities, and developing and implementing well-aligned assessments. The heuristic toolbox can be adapted to different levels of language proficiency and cognitive readiness, from basic to more advanced, providing a student-centred framework in a manner similar to that proposed in Meyer et al.'s (2015) 'Lego' model, and in line with Janssen, Hulshof, and van Veen's (2019) intention that core questions

Table 3. Heuristic toolbox for repertoire-building and content-language integration, based on CDFs (Dalton-Puffer 2013) and the biological perspective (de Boer et al. 2019).

	Cognitive Discourse Function (CDF) Types						
Perspectives + core questions	*Categorise [cat] E.g. classify, compare, contrast, exemplify, match, structure, categorise, subsume*	*Define [def] E.g. define, identify, characterise*	*Describe [des] E.g. describe, label, identify, name, specify*	*Evaluate [eva] E.g. evaluate, argue, judge, take a stance, critique, comment, reflect, justify*	*Explain [exa] E.g. explain, reason, express cause/effect, deduce, draw conclusions*	*Explore [exo] E.g. explore, hypothesise, predict, speculate, guess, estimate, simulate*	*Report [rep] E.g. report, inform, summarise, recount, narrate, present, relate*
Taxonomic [TAX] *What is it?*	*Categorise according to group*	*Define its most important characteristics*	*Describe its characteristics*	*Evaluate why it belongs to this group and not to another*	*Explain why it belongs to a particular group*	*Explore to which groups it could belong*	*Report critically on the taxonomic question, approach, and findings*
Functional [FUN] *What is its purpose?*	*Categorise according to function*	*Define its most important activities*	*Describe what it does*	*Evaluate why it has this/ these function(s) and not others*	*Explain the function and why it must be fulfilled*	*Explore disadvantages for the organism if this element were lacking*	*Report critically on the functional question, approach, and findings*
Mechanical [MEC] *How does it work?*	*Categorise according to mechanism*	*Define the most important parts*	*Describe its parts*	*Evaluate why it works this way and not differently*	*Explain why it works this way*	*Explore ways in which a function could be fulfilled*	*Report critically on the mechanical question, approach, and findings*
Ecological [ECO] *Which environment does it need?*	*Categorise according to the environment in which it occurs*	*Define the most important environmental factors*	*Describe what it needs from its environment*	*Evaluate why it has adapted to these environmental factors and not to others*	*Explain why these environmental factors are necessary*	*Explore what would go wrong if certain environmental factors were different*	*Report critically on the ecological question, approach, and findings*
Developmental [DEV] *How does it develop?*	*Categorise according to development*	*Define the most important stages in its development*	*Describe stages of its development*	*Evaluate why it develops in this way and not differently*	*Explain why it develops this way*	*Explore what would go wrong if a stage of development were missing*	*Report critically on the developmental question, approach, and findings*
Evolutionary [EVO] *How did it evolve?*	Categorise according to evolutionary development	Define the most important stages in its evolution	Describe stages of its evolution	Argue why it evolved in this way and not differently	Explain why it evolved this way	Explore what would go wrong if a stage of evolution were missing	Report critically on the evolutionary question, approach, and findings

lead to more detailed and specific questions as learners' levels of readiness progress. Furthermore, research on CDFs has shown that not all functions are equally activated in practice: functions such as *define*, *describe*, and *explain* often dominate, while *evaluate* and *explore* tend to be less frequently used (Dalton-Puffer et al. 2018). The heuristic toolbox encourages a more systematic inclusion of all seven functions, integrating them meaningfully with disciplinary perspectives.

In summary, integrating content and language through the use of the heuristic toolbox will not only familiarise students with subject-specific questions, perspectives, and literacy conventions, but also allow teachers to address the disciplinary four Cs – content, cognition, culture and communication – in varied and integrated ways. It supports flexible and deeper learning, as different combinations of building blocks – and their levels of detail – can be tailored to learners' needs and their developmental stages, as well as supporting teachers' awareness of the breadth of cognitive-linguistic functions at play in their discipline.

Application in practice: CLIL lessons on the heart

To illustrate further how the heuristic toolbox in Table 3 can be implemented in practice, we now present three CLIL biology lessons about the heart, each consisting of a specific selection and combination of teaching and learning activities, and subsequent assessment procedures. Example 1 represents a lesson designed without either the biological perspective or BMDLs in mind. Examples 2 and 3 show how, with the use of the heuristic toolbox, linguistic, cognitive and conceptual demands can be addressed in integrated ways.

Example 1. 'Traditional' lesson on the structure and function of the heart.

The teacher first explains the structure of the heart and then explains the function of its parts. Students are then given a diagram of the heart and must place the correct names by the correct parts. In assessment, they are presented with a similar diagram, and asked to fill in the missing labels. For some of those parts, they then have to write down which function they fulfil.

Example 2. What if … ?

This example focuses on hypothetical reasoning about the necessity of heart structures, using 'what if?' scenarios. This way, students not only gain insight into how the heart works, but also into the environment in which this must take place [ECO-eva], and why all parts and functions are necessary [MEC-eva; FUN-eva].

Students are given a diagram of the heart. For the marked parts, they must determine what the disadvantage would be if that part were missing [MEC-exo], e.g. What would be the disadvantage if the heart had no left atrium? The teacher supports their process of exploration by modelling the language of hypothetical reasoning and consequence prediction, i.e. conditional structures (e.g. *If the heart had no X, then Y*), consequence chains (*This would result in …*), and explanations of necessity (*A is essential for B*). If needed, the teacher might also explicitly teach this language, or provide prompts as extra scaffolding for those who require it. As groups of students work on the task, they complete a consequence chain based on a provided structure [MEC-exo/eva; FUN-exo/eva].

The teacher extends the activity by asking the class, 'Under what conditions might this disadvantage become more severe?' [ECO-eva], and supports students in expressing further considerations in conditional and evaluative/judgment forms.

By way of assessment, students later write up hypothetical and evaluative analyses for three heart parts, explaining *what would happen if* each were missing [MEC-exo/exa/eva; FUN-exo/exa/eva], and provide each other with peer-feedback focusing on clarity of hypothetical reasoning, and logical connection between consequences.

Example 3. What happens after birth?

With the help of an animation, students identify the components and functioning of the heart and circulation, and complete a diagram [FUN-des/def; MEC-des/def]. The teacher guides them in formulating definitions and precise descriptions, and in identifying and locating parts and describing their function.

They then draw and label the heart and circulatory system at two stages in a baby's development [FUN/MEC/DEV-des/def] – just before birth and just after – and explain the differences through a structured comparison [DEV-cat/exa; ECO-cat/exa]. At this stage, the teacher offers differentiated support for both process and language, for example in the form of a graphic organiser, working through the comparison in stages, and/or scaffolding and modelling language such as temporal markers (e.g. *Prior to birth, … ; Following delivery, …*), language of change (*X develops into Y*), contrastive structures (*In the fetus, X, whereas in the newborn, Y*), causal explanations (*This change occurs because …*), and linking environment to development (*In the womb, X, therefore Y*).

Assessment is based on the two diagrams (foetal and newborn), with key structures identified, a written comparison identifying at least three major differences between the stages of development, using appropriate contrastive language, and explanations for why each change occurs, connecting developmental changes to environmental transitions. Assessment criteria include: accurate identification of structures, clear use of temporal and comparative language, logical causal explanations, and explicit connection between environmental change and circulatory adaptation.

Each example is presented as a concise vignette, summarising very briefly the focus and procedures of the lesson and the subsequent assessment of learning. The presence of intersecting biology perspectives and CDFs – our building blocks – is indicated in parentheses, where upper-case letters refer to the biology perspective(s) at play, and lower-case letters refer to the relevant CDF(s). For instance, an activity addressing the mechanical perspective (MEC) through the CDF 'evaluate' (eva) is tagged with 'MEC-eva'. Following the three vignettes, we present an analysis of how these examples demonstrate how the combination of CDFs and subject-specific perspectives can add breadth and depth to integrated content and language teaching.

As explained above, we believe the heuristic toolbox can be adapted to incorporate different subject perspectives, and that its building blocks can be adjusted in terms of both conceptual/cognitive and linguistic complexity to accommodate the needs of learners with varying levels of readiness and proficiency in the language of instruction. While the examples offered are framed in a particular subject (biology) and context (English-medium secondary school CLIL), the principles behind them are transferable to other disciplines and educational settings, including those where learners learn through a L1.

Example 1 is a 'negative' example of a lesson based on a model of the teacher transmitting information and learners applying it to a theoretical exercise. This example is included in order to show how this approach limits the potential to address multiple biological perspectives and CDFs, thus falling short of the goal of supporting apprenticeship into disciplinary cultures.

This 'negative' example shows how teaching designed for the transmission of facts misses the potential for the development of disciplinary thinking and disciplinary literacies. It highlights the common practice in both CLIL and biology classrooms of focusing on terminology (Dalton-Puffer, Hüttner, and Nikula 2024; McDonnell, Barker, and Wieman 2016), rather than on more complex cognitive and linguistic functions. Furthermore, learners practice labelling the parts, but only listen to the teacher's explanation of their functions; in assessment, however, they are asked to reproduce written explanations of function, without having spent time in class practising the language needed to do so. This reflects the risk of teachers inadvertently assessing language demands not addressed in teaching (Llinares, Morton, and Whittaker 2012; Mearns et al. 2025).

Examples 2 and 3 demonstrate practices that focus on learners' own construction of knowledge and offer opportunities for further enrichment through the integration of disciplinary perspectives and CDFs. In these cases, the proposed heuristic toolbox can help teachers avoid the pitfalls observed in Example 1 by stimulating varied and meaningful lessons that integrate support for both disciplinary language and disciplinary thinking in ways that expand both teachers' and learners' repertoire of approaches to disciplinary knowledge, skills and understanding.

More detailed accounts of these lessons, including suggestions for scaffolding materials, and proposals for how Example 1 could be enriched, can be found in the online supplementary materials, alongside four further example lessons.

Lessons learned

The examples above illustrate how the heuristic toolbox presented in Table 3 can guide the integrated planning of content and language teaching as part of subject-specific conceptual and disciplinary literacy development. Each lesson foregrounds different intersections between biological perspectives and CDFs, and shows how meaningful, perspective-based education can be combined with explicit scaffolding that makes language demands visible and supports students in engaging with disciplinary thinking. Several important principles and shifts in thinking emerge from

examining these applications, offering important insights into how CLIL teachers might approach lesson planning.

Perhaps the most fundamental insight is that *the heuristic toolbox makes language demands visible and predictable by linking them directly to subject content in ways that are relatable to subject teachers*. As discussed earlier in this paper, existing work on CDFs and BMDLs has largely focused on linguistic requirements, with less attention to conceptual and content-related aspects – an area that has only recently begun to receive more focus. Without such a framework, a teacher might continue planning their CLIL lessons as they are used to in an L1 content class, focusing primarily – or even solely – on broad content objectives, such as 'students will learn about the heart'. They might notice that students have difficulties expressing their knowledge, but not know how to address those language difficulties. They might only realise during the lesson that students struggle to express hypothetical consequences or compare developmental stages. With this tool, however, a teacher planning a lesson similar to Example 2 can recognise upfront that exploring what happens if parts of the heart are missing requires exploratory reasoning from a mechanical perspective (MEC-exo), which involves hypothetical thinking. Therefore, students need to be taught conditional structures and consequence language. This shifts lesson planning from vague notions of language support to targeted, predictable scaffolding. Through the focus not only on linguistic aspects but also on specific disciplinary perspectives and their guiding core questions, CLIL teachers are able to approach CDFs from their own disciplinary standpoint, using them to plan, teach, and assess content learning.

Closely related to this is the recognition that *different tasks require different language*, even within a single topic. As shown in the examples here and in the supplementary materials, language demands vary depending on the perspective and CDF combination activated. For instance, reasoning about missing parts (Example 2) requires conditional and hypothetical language, while comparing foetal and newborn circulation (Example 3) calls for temporal markers, contrastive structures, and causal explanations. Teachers often assume that mastering heart-related vocabulary (as in Example 1) enables students to handle any heart task, but this is incorrect: knowing terms like *atrium* or *valve* does not equip students to hypothesise, evaluate, or explain developmental or evolutionary changes. Each cognitive operation requires its own language repertoire (Dalton-Puffer et al. 2018), meaning scaffolding must align with the task's cognitive demand, not just its content domain. Thus, planning shifts from asking 'What language does this topic need?' to 'What cognitive operation does this task require, and what language enables it?' (Llinares and Dalton-Puffer 2015). Again, by combining CDFs with a specific disciplinary perspective, subject content is placed at the centre of this question rather than on the periphery.

Another crucial consequence is that *explicit language instruction becomes content-embedded*. In traditional CLIL approaches, language support often feels like an addition, i.e. a moment when the teacher says, 'Let's stop and learn some words or grammar' before returning to content (Villabona and Cenoz 2021). With the heuristic toolbox, language instruction becomes inherent to learning the content. In Example 2, for instance, learning conditional structures is not a language interlude, it is the only way to engage with the biological thinking the task requires, namely understanding the necessity of parts of the heart through hypothetical reasoning. This reflects an important truth about disciplinary literacy: the language patterns are not just 'school language' but rather *how biologists think* (Dalton-Puffer, Hüttner, and Nikula 2024). Biologists, for instance, use conditionals to reason about mechanisms, comparative structures to trace evolution, and causal language to explain function. Teaching these structures is teaching the tools of biological thinking and learning. This shifts planning from a sequential model of 'content first, then language support' to an integrated model where specific language structures are recognised as the tools of disciplinary thinking.

Implications for teaching

Building on these pedagogical principles, the framework has the potential to make teacher planning more systematic. Teachers can follow a clear process: identify the biological perspective needed

(taxonomic, functional, mechanical, etc.), identify the cognitive operation required (*describe*, *explain*, *evaluate*, etc.), locate the intersection in the framework, and select corresponding CDFs and associated language structures. This provides a systematic starting point rather than intuitive guessing about language needs. For example, if a teacher wants students to understand why heart valves are necessary, they can reason through the framework: this requires the mechanical perspective (understanding how parts work), the cognitive operation would be exploring its necessity through hypothetical reasoning, which activates mechanical exploration (MEC-exo), requiring conditionals, consequence chains, and exploratory and speculative verb forms. This shifts planning from the overwhelming and unsystematic question, 'What language might students need?' to the manageable and systematic equation: 'this perspective + this CDF = these predictable language demands'.

Most fundamentally, therefore, the heuristic toolbox reveals that CLIL planning needs to be integrated from the start. The planning process is not sequential (first plan the biology content, then add language support afterwards) but rather integrated, as follows:

- With which biological perspective will students engage?
- What cognitive work will they do with that perspective?
- Which CDF(s) does that cognitive work require?
- What language enables those CDFs?
- How will I scaffold that language?
- How will students demonstrate integrated competence in (formative) assessment?

This integrated planning ensures that content goals are achievable because students have the language tools to engage. It makes language instruction meaningful by enabling real disciplinary thinking. Assessment is authentic and constructively aligned, as it measures integrated competence. Importantly, no student is excluded from cognitively demanding work due to language barriers.

Where do we go from here?

As the analysis above shows, the proposed heuristic toolbox – combining CDFs with a specific subject perspective and its related core questions – could be the missing component in bridging content and language in disciplinary learning. As our series of examples demonstrates, the framework transforms CLIL planning in multiple ways: it addresses the language requirements from the perspective of the discipline, makes them visible and predictable, connects them with concrete cognitive operations and key disciplinary questions, and enables progressive and constructive subject learning across lessons. Additionally, it aligns assessment with integrated competences, systematises teacher planning processes, ensures students can access cognitively demanding content, and integrates content and language decisions from the start.

Most fundamentally, the framework shifts CLIL planning from an intuitive art, guessing language needs based on teacher experience and instinct, to a principled practice where teachers systematically identify and scaffold the language that specific content perspectives and cognitive operations require. This does not reduce teacher creativity or professional judgment; rather, it channels that creativity more effectively by clarifying where decisions need to be made and what those decisions should attend to. The result is CLIL instruction that truly integrates content and language learning, where deep disciplinary understanding and communicative competence develop together as inseparable dimensions of meaningful learning. In theoretical terms, we hope this contribution will go some way to supporting and informing further development of the *disciplinary knowledge and epistemology* element of the revised conceptualisation of BMDLs proposed by Nikula et al. (2026), which – depicted as the trunk of the BMDLs tree – appears to feed and inform the other dimensions, yet is not expanded upon in detail in terms of its manifestations and workings.

The proposed heuristic toolbox is, of course, purely theoretical. The next logical step is to transfer the tool to practice, for example, through work with teachers in professional learning

communities, or in initial teacher education. Such practical implementations could involve empirical exploration through participatory or collaborative research, as already found to be effective in earlier work on CDFs and CLIL (e.g. Banegas and Mearns 2023; Bauer-Marschallinger 2019). Essential in such undertakings will be the active involvement of subject specialist teachers and teacher educators, who are often a missing voice in CLIL research (Hüttner, Llinares, and Nikula 2025; Mortimore et al. 2026). Indeed, we hope the emphasis on subject-specific perspectives will appeal particularly to content specialists by highlighting the integral function of BMDLs in their specialist role and disciplinary identity (Moje 2015).

The emphasis in this contribution has been on CLIL settings, whose explicitly bilingual nature lends itself particularly well to explorations of content-language integration. Such practical and empirical validation could also take place in other educational settings, in line with the conviction that all learning contexts are inherently multilingual (Coyle and Meyer 2021), and therefore that BMDLs are not solely a CLIL concept (Nikula et al. 2026). Given recent examples of studies where CLIL and other L2 learning contexts have been addressed as one (Ertugruloglu, Mearns, and Admiraal 2026; Rutgers 2024), this might mark an opportunity to bring previously separate educational communities together in practice. By exploring with teachers the practical application of the heuristic toolbox in diverse contexts, we hope not only to validate the tool and its related principles, but also to strengthen its practicality and relatability for a broad range of teachers.

Another necessary area for further development is to facilitate and explore transfer to other subject areas, topics and educational contexts. In the current paper, we took biology as an example, with a specific focus on topics related to the human heart, and on teaching units that could each equate to a single lesson or a short series of lessons in a secondary school CLIL context. As has been highlighted in research on CDFs and in the various subject-specific chapters in Janssen, Hulshof, and van Veen (2019), however, disciplinary knowledge building and the related linguistic demands differ significantly between subject areas and between specific topics within those subject areas, even within broader domains such as natural sciences (Evnitskaya and Dalton-Puffer 2023). The development and validation of multiple subject-specific renderings of the heuristic toolbox will therefore be an essential – albeit challenging – task.

In addressing practical and theoretical applications of the heuristic toolbox, we also hope to contribute to developing the emphasis on teacher content language awareness (TCLA; Lindahl and Watkins 2015) in teacher education and professional development *from discipline-specific perspectives*. In light of studies indicating that promotion of language-oriented practices does not always align with subject-specialist teacher educators' perception of their role (e.g. Ballinger et al. 2024; Mortimore et al. 2026), approaching language as an integral aspect of their discipline, through a perspective-based approach combined with CDFs, could support the integration of BMDLs in teacher education for diverse subject learning contexts, whether L1, L2 or multilingual.

Author contributions

TM brought the interdisciplinary team together, coordinated their activities and completed all administrative tasks. All authors contributed to the conceptualisation, in particular exploring the relationship between BMDL and the perspective-based approach, and development of the heuristic toolbox (Table 3). FJ and SM provided the bulk of the input for the practical examples in 'Application in practice: CLIL lessons on the heart' and the supplementary materials, both of which were adapted and refined by TM, and reviewed by PG. All authors contributed to writing the original draft, in different constellations: 'Introduction' and 'Converging goals, complementary approaches' by TM, with assistance from PG; 'Bi- and multilingual disciplinary literacies' by TM and PG collaboratively; 'The perspective-based approach' by TM and FJ; 'A heuristic toolbox for repertoire building and content-language integration in biology teaching' by PG and TM; 'Application in practice: CLIL lessons on the heart' by SM, based on input from FJ; 'Lessons learned' by SM; 'Implications for teaching' and 'Where do we go from here?' jointly by SM and TM, with input from PG.

Reviewing and editing was conducted in several rounds by TM and PG, focusing on bringing the different sections and concepts together into a coherent and cohesive whole, as well as on style and formal aspects. FJ and SM contributed to this process by providing input and feedback on specific sections. TM reviewed the supplementary materials in terms of practical value and alignment with the article, and completed the final round of revisions, prior to submission. TM and PG collaborated on the revisions following peer review, with input from SM and FJ.

Disclosure statement

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

Funding

This work was supported by COST under Grant CA21114.

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