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
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A multidimensional framework of bi- and multilingual disciplinary literacies

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ABSTRACT

This paper presents a conceptualisation of bi- and multilingual disciplinary literacies (BMDLs) designed as a dynamic and versatile thinking tool for researchers and practitioners in bi- and multilingual educational settings. It builds upon established theoretical foundations and the work conducted within the COST network CLILNetLE, moving beyond traditional perspectives of literacy development that are often viewed as linear or narrowly confined to reading and writing. Instead, this framework conceptualises disciplinary literacies as situated and socially constructed processes that involve deeply intertwined aspects of knowledge-building, communication, and identity formation. These processes encompass diverse modes of meaning-making resources, manifesting differently across educational levels and disciplinary areas. The conceptualisation outlines several dimensions of bi- and multilingual disciplinary literacies: the bi-, multi- and translingual; multi- and transsemiotic; functional–textual; critical; and technological–digital dimensions. It acknowledges the inherently multifaceted nature of disciplinary literacies, which allows the framework to remain responsive to evolving needs and practices. The proposed flexible and adaptable framework aims at enhancing instructional practices and fostering collaborative approaches across language and content education. This approach ultimately seeks to equip learners with the skills and agency necessary to effectively participate, navigate, and contribute within increasingly complex and multilingual academic, professional, and civic domains.

Introduction

The concept of disciplinary literacy (DL) refers to 'the specialised ways reading, writing, and oral language are used in academic disciplines' (Shanahan 2019, 1). Disciplines embody distinct epistemologies, discourse conventions, and cognitive practices (ranging from understanding complex

concepts to producing knowledge in various formats) that learners need to acquire for both disciplinary and civic participation (Fang and Coatoam 2013; Moje 2008, 2015; Shanahan and Shanahan 2008, 2012). We use the plural form 'disciplinary literacies' (DLs) to emphasise that disciplines, and school subjects that draw on them, enact diverse epistemologies, practices, and communicative conventions (Bernstein 2000).

Earlier conceptual and pedagogy-oriented models and frameworks have laid important groundwork for understanding DL as a multidimensional and situated phenomenon. Goldman et al. (2016) position DL as a process of reasoning deriving from sustained engagement with texts that reflect disciplinary purposes and norms, and identify five core components: epistemology, inquiry and reasoning strategies, overarching disciplinary principles, information/text types, and discourse structures. Similarly, Spires et al. (2018) identify three interrelated components of DL, i.e. source literacy, analytic literacy, and expressive literacy, with varying manifestations across different subjects. Foregrounding disciplines as cultural communities, Moje's (2015) 4Es framework is proposed as a heuristic for DL teaching to foster learners' epistemic access and critical agency. The four Es involve *engaging* learners in discipline-specific practices, *eliciting/engineering* knowledge for participation, *examining* disciplinary discourses explicitly, and *evaluating* the affordances and constraints of disciplinary discourses.

In parallel to these developments in DL research, rising numbers of migrant learners, increasing linguistic diversity in classrooms and demands towards multilingual competence in higher education and the workplace (Beacco et al. 2016; García and Wei 2014; OECD 2018) have contributed to changing landscapes of schooling. Criticisms around educational policies grounded in monolingual ideologies have led to calls for multilingualism as a guiding educational principle, in line with the multilingual turn (May 2014). Such calls have increasingly highlighted a departure from language as a fixed and uniform system for transmitting subject knowledge towards languaging as a dynamic process that draws on multiple linguistic and semiotic repertoires in context-sensitive ways (Lin 2015a).

Content and language integrated learning (CLIL) is one response to the calls for bi- and multilingual educational approaches. While interest in matters of language learning characterised early CLIL research, today it is increasingly common to direct attention to the very notion of integration and its subject-specific realisations and to DL perspectives (e.g. Hüttner and Dalton-Puffer 2024). The work by Llinares, Morton, and Whittaker (2012) marks a turning point in this respect with its explicit focus on the role of language in teaching and learning different subjects. In a similar vein, several models devised within bilingual education research more generally are drawing attention to the complex task teachers face in fostering the simultaneous development of content knowledge and subject-specific literacy. Cammarata and Cavanagh's (2018) *Interconnected Knowledge for Integration* model accounts for interrelating language and literacy and their connections with discipline-specific content knowledge. Also, Lin's (2016) concentric circle model indicates how DL in CLIL extends from vocabulary to genres and registers, encompassing different levels of granularity. Finally, the pluriliteracies model (e.g. Coyle and Meyer 2021; Meyer and Coyle 2017) has been influential in explicitly linking conceptual and language development in CLIL as a gradual progression along 'knowledge pathways'. This notion captures the need to approach DL development both in age-appropriate ways and take into consideration learners' earlier learning experiences. The prefix pluri- makes salient that in CLIL contexts, DL develops in different subjects and through different languages.

The pluriliteracies model thus acknowledges the existence of multiple language competencies, yet multilingualism is not its chief entry point into DL. There is, therefore, a need for models of DL that explicate multilingualism both as a contextual factor and a target of education. While challenges in DLs are not limited to learning in a second/additional language (L2) as learners may also encounter similar difficulties in their first language (L1), such a model would address the question of whether components of DL might take different forms in bi- and multilingual contexts compared to those practiced in linguistically more homogeneous settings. Responding to this question

requires building upon and extending prior conceptualisations of DL in a way that foregrounds its enactment in bi- and multilingual educational settings. Moreover, the model needs to be flexible, open-ended, and resonant with teachers' lived experiences, operationalising DL in ways that are pedagogically transparent and adaptable.

As a response to these needs, we offer the concept of bi- and multilingual disciplinary literacies, (i.e. BMDLs, Nikula et al., 2024; Hüttner, Llinares, and Nikula 2025). Developed within the CLIL-NetLE COST Action and with a focus on secondary CLIL education, the initial conceptualisation of BMDLs (Nikula et al., 2024) forefronts the plurality of resources involved in meaning-making and positions multilingualism and multimodality as integral to DLs. The present conceptualisation builds on that foundation, offering a refined grounding of BMDLs.

The refined framework retains the five core dimensions of the initial conceptualisation (i.e. bi-, multi- and translingual, multi- and transsemiotic, functional–textual, critical, and technological–digital) while providing a more in-depth coverage of each. We also offer justifications for considering these as key dimensions of BMDLs and explain how they help understand DLs as adaptable and situated in bi- and multilingual contexts. To represent different dimensions of BMDLs, we draw on the metaphor of a tree. Figure 1 shows the tree figure in the initial conceptualisation on the left (Nikula et al., 2024) on the left, and the refined figure on the right.

Central to our conceptualisation is to argue that different dimensions of BMDLs are inherently intertwined, non-hierarchical, and context-sensitive. In disciplinary and educational practices, these dimensions operate in constant interaction. The refined framework thus places more emphasis on disciplinary practices as situated and emergent, unfolding through the dynamic deployment of a flexible constellation of resources whose mobilisation and salience will vary across disciplines, tasks, and contexts. The revised tree figure seeks to more explicitly convey this perspective by foregrounding the interconnectedness of the dimensions and illustrating the absence of hierarchical ordering by its balanced positioning of branches.

Other changes in the figure include explicating the key role of *disciplinary knowledge and epistemology* as the tree trunk upon which BMDLs dimensions depend and the *dynamic social, cultural, and community norms and practices as* the soil from which BMDLs grow. Disciplinary knowledge refers to understandings built in a field, including, for example, factual elements (e.g. terms, data), conceptual frameworks (e.g. models, theories), and procedural know-how (e.g. methods, techniques, inquiry strategies), while epistemology, i.e. theory of knowledge and justification (Audi
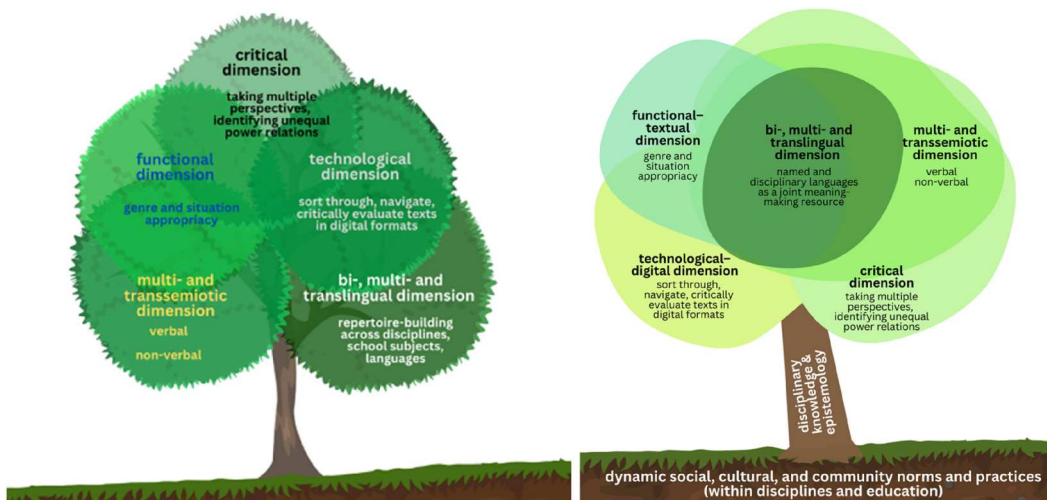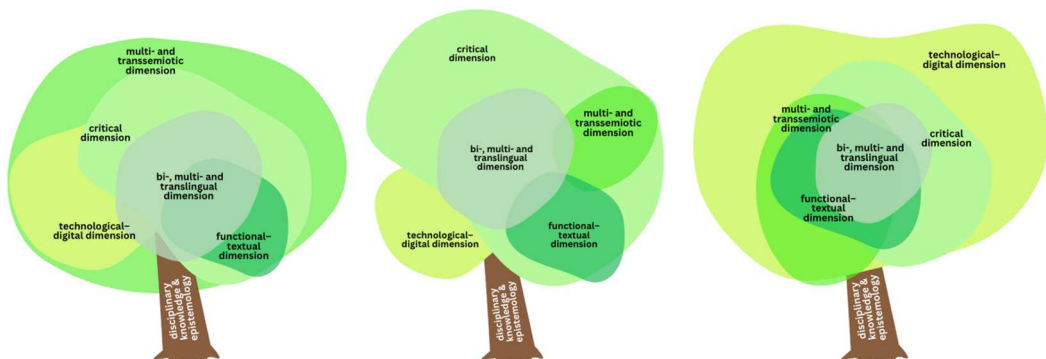

Figure 1. Dimensions of BMDLs: the initial and the refined figure (illustration created on Canva, www.canva.com, with icons and graphics from Canva's content library).

2010), relates to the bases for knowledge production and validation in that field (Johnston, Hipkins, and Sheehan 2017). Their inclusion highlights that instead of being reduced to language skills, literacies in our framework are situated within the broader processes of meaning-making, reasoning, and knowledge construction that characterise disciplinary practices. These practices are not neutral; rather, they are enacted within 'value-laden, ideologically shaped contexts' (Clarence and McKenna 2017, 46), where legitimacy of knowledge is continuously negotiated and conventions for reasoning and communication (re)established (Goldman et al. 2016). There is a growing understanding of how the legitimacy of knowledge claims depends on the social and cultural norms and practices (see Maton, Hood, and Shay 2015). While disciplinary norms exhibit relative stability, especially over shorter timescales and within specific communities of practice, this does not preclude the possibility of tensions between stability and change that may eventually reconfigure those norms. Building on such understanding, our framework perceives disciplines as continually changing rather than fixed constructions, positioning *dynamic social, cultural, and community norms and practices* as the foundation through which both *disciplinary knowledge structures* and *conventions of meaning-making and communication* are shaped.

The dynamicity and situatedness of disciplinary knowledge-production and communication practices mean that the dimensions of BMDLs will be differently emphasised depending on disciplinary and contextual variations. Such variations include the epistemic and communicative demands of specific disciplines and educational contexts, curricular goals, affordances of the teaching-learning environment (e.g. available resources), learners' developmental level, and linguistic and cultural repertoires of the participants, to name a few. For example, in mathematics, diagrammatic representations may take precedence over extended written explanations; in social sciences and humanities, critical engagement with sources, arguments, and perspectives is frequently needed; in STEM fields, navigating simulations or creating visualisations may require more frequent integration of digital resources. Figure 2 presents three versions of the tree figure to illustrate such variability and contextual adaptability.

While the initial conceptualisation acknowledges that schooling involves recontextualisation of disciplinary knowledge as pedagogic subjects (Nikula et al., 2024), it does not illustrate how this process unfolds. To this end, we introduce Figure 3 here. Knowledge building, informed by epistemological orientations, takes shape through dynamic social, cultural, and community practices. Disciplinary knowledge, produced and communicated in discipline-specific ways by and among members of disciplinary communities, is subsequently recontextualised, i.e. selected, reorganised, and transformed, into school subjects and pedagogic discourse (Bernstein 2000), where the degree of recontextualisation varies along a continuum from foundational to advanced competencies across different educational levels. Such recontextualisations indicate that school subjects and

Figure 2. Variability and contextual adaptability of BMDLs practices (illustration created on Canva, www.canva.com, with icons and graphics from Canva's content library).
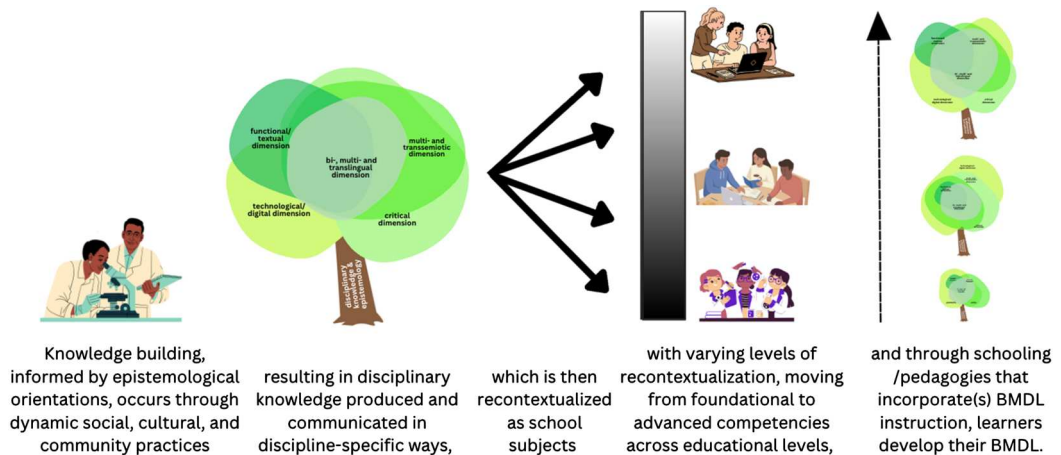
Figure 3. Recontextualisation of disciplinary knowledge and practices as school subjects (illustration created on Canva, www. canva.com, with icons and graphics from Canva's content library).

scientific disciplines are not mirror images of one another, and that even within the same subject area, conceptualisations of BMDLs will vary across grade levels.

Through pedagogical processes, schooling can enable learners to progressively develop their BMDLs. However, this is not a one-way process, as educational practices and products also feed into the creation of new disciplinary knowledge by being 'absorbed into production fields as part of the antecedent knowledge that serves as raw material for creating 'new' knowledge' (Maton 2014, 51). Also, the development of BMDLs is marked by continual recontextualisation, refinement, or even regression, where knowledge and skills linked to a particular practice may diminish when, for example, engagement in that practice is not sustained.

Against this backdrop, we provide a more detailed account of the five core dimensions of BMDLs below.

The bi-, multi- and translingual dimension

The bi-, multi- and translingual dimension plays a key role in BMDLs, since it foregrounds the ability to engage with, construct and communicate disciplinary knowledge across different languages, registers and genres (Hüttner, Llinares, and Nikula 2025). Regarding languages, this dimension recognises that disciplinary meaning-making is not confined to a single linguistic code but is shaped through the dynamic language repertoires and multilingual practices today's students bring to the classroom (ibid.). These repertoires reflect the diversified and 'glocalised' realities of contemporary schools and professional contexts, where named languages interact fluidly and meaning is co-constructed across linguistic boundaries (Dalton-Puffer 2007; Nikula 2010). From this perspective, learners access and express disciplinary knowledge through flexible, context-sensitive use of their full linguistic resources (e.g. Meyer and Coyle 2017). In this regard, the bi- and multilingual framing marks a significant departure from traditional, monolingual models of DLs, which often assume a fixed, standardised use of the L1 as the sole medium for academic engagement. Concerning register-shifting, in CLIL settings, learners need to move beyond everyday Basic Interpersonal Communicative Skills (BICS), typically acquired in their L1(s), and gradually develop the more demanding Cognitive Academic Language Proficiency (CALP) (see Cummins 2000) required in their L2. The challenge, therefore, lies in supporting learners through this transition and in scaffolding the strategic use of linguistic repertoires to foster academic literacy, particularly through engagement with genre practices (see functional–textual dimension).

An exemplification of how bi- and multilingual practices are mobilised can be seen in the development of concrete knowledge-building epistemic practices. In CLIL classrooms, this often entails drawing on students' different languages across the various stages of the learning process. For instance, the L1 may be used for conceptual grounding to grasp complex and abstract scientific concepts and ensure understanding through peer discussion. The L2 then can be employed to co-construct disciplinary knowledge with the teacher and peers and gradually help to develop the discipline's specialised genres and multimodal practices (see the multi- and transsemiotic dimension). The uses of L1 and L2 in CLIL classrooms, however, do not necessarily follow a fixed or consecutive order; rather, they are iterative, with learners moving back and forth between languages as needed to negotiate meaning, consolidate understanding, and articulate disciplinary knowledge (e.g. Lin 2015b; Nikula and Moore 2019).

This dynamic movement between languages exemplifies translanguaging, a construct which emerged from a critical pedagogical approach to multilingual classrooms that recognises students' diverse linguistic repertoires as epistemic resources (García and Wei 2014). García and Wei (2014) conceptualise translanguaging as the dynamic and purposeful use of a speaker's entire linguistic repertoire, challenging monolingual ideologies and the notion of languages as separate systems. This fluid mobilisation and transcending of language resources supports learners' engagement with academic discourse while, concurrently, affirming their linguistic identities and creating opportunities for developing critical literacy (see the critical dimension). Creese and Blackledge (2015) regard translanguaging as a socially situated practice through which learners negotiate hybrid identities and may also resist monolingual norms. They illustrate how students draw on their full linguistic repertoires to participate meaningfully in classroom discourse, assert epistemic agency, and cultivate a sense of belonging within superdiverse educational contexts. Moreover, pedagogical translanguaging can aim to counteract the marginalisation of language-minoritised students and promote equitable access to disciplinary knowledge (Juvonen and Källkvist 2021).

In sum, bi-, multi- and translingual practices are central to disciplinary literacy development, as learners' diverse repertoires function as epistemic resources that shape identity formation and underscore the transformative potential of translanguaging in fostering inclusive learning environments.

The multi- and transsemiotic dimension

The multi- and transsemiotic dimension refers to semiotic resources, such as visual, spatial, embodied, material and linguistic, that are essential to teaching and learning procedures as well as to disciplinary knowledge. Multisemiotic resources constitute a central part of subject-specific knowledge: graphs, formulas, maps, or models are the means through which disciplines conceptualise and represent their objects of inquiry (Doran 2019). The transsemiotic dimension is most evident when students transition among various semiotic resources, such as converting circuit diagrams, mathematical formulas, and graphs into coherent verbal explanations or technical reports. For instance, in Boolean algebra classes, students often have to explain their reasoning by writing or speaking about how they understand complicated equations and circuit diagrams. This demonstrates the interplay between visual, symbolic, and textual modalities.

In CLIL settings, learners contend with the added complexity of bi- and multilingual meaning-making. Semiotic resources in these settings not only scaffold conceptual understanding but also mediate between linguistic repertoires, enabling learners to access disciplinary content through trans-semiotic pathways. The acquisition of subject-specific ways of reasoning, arguing, and representing knowledge is distributed across languages and modes, meaning that non-verbal semiotic resources actively participate in constructing conceptual meaning, often serving as 'anchors' or 'bridges' between L1 and L2. In this respect, multisemiotic resources may offer effective scaffolding to understand and learn disciplinary content (Nikula, Jakonen and Kääntä, 2024) and so alleviate language barriers and mitigate students' linguistic insecurity. CLIL students may also use resources

like images, diagrams or facial expressions to help internalise complex knowledge before rearticulating it in an L2, addressing the aspect of disciplinary practices in displaying knowledge appropriately. This dual function of multisemiotic resources reveals the connection between students' meaning-making and disciplinary practices. For instance, a teacher's demonstration of a chemical reaction in a CLIL science lesson may be first addressed through observation and embodied action, then converted into a labelled diagram, and finally articulated in a written explanation in the L2. Such processes exemplify trans-semiotising, the dynamic coordination of meaning across modes and languages (Lin 2015a). This creates a dynamic interplay between language and other modes that is less pronounced in monolingual classrooms (Escobar-Lluch and Ruiz-Madrid 2025).

Research in CLIL is increasingly foregrounding this multisemiotic dimension of classroom discourse as a critical component of effective communication and learning (Liu and Lin, 2021). Several studies have documented how teachers and learners employ diverse semiotic resources to co-construct and guide disciplinary knowledge-construction (Jakonen and Evnitskaya 2020; Kääntä, Kasper, and Piirainen-Marsh 2018). Other examples of studies foregrounding the multisemiotic nature of learning include research on the multimodal resources (Forey and Polias 2017) and on visual thinking scaffolds (Fernández-Fontecha et al. 2020) in CLIL science classrooms or on the usefulness of the Multimodalities-Entextualisation Cycle (MEC) (Lin 2015b) that involves transcending of linguistic and other semiotic resources to facilitate concept-building and disciplinary reasoning. The role of multiple semiotic resources in shifting between abstract and concrete representations of knowledge and hence supporting learning in CLIL classrooms has also been noted (Nikula, Jakonen and Kääntä 2024).

Recently, new angles to researching the multisemiotic dimension have started to emerge. These include efforts to empirically validate Lorenzo et al.'s (2024) disciplinary science literacy assessment criteria developed within CLILNetLE. This is being pursued by examining a CLIL Physics teacher's multisemiotic repertoire when engaging students in DLs during classroom interactions (Gerns et al., in progress), as well as by validating the criteria with pre-service chemistry teachers who have received multi-representational instruction (Adadan et al., in progress). In another study, DLs in engineering courses were found to be largely dependent on multi-semiotic resources, as students needed to comprehend and integrate verbal, mathematical, graphical, and diagrammatic resources to analyse problems, create solutions, and effectively communicate their knowledge (Bayyurt et al., in progress).

Investigating multisemiotics in CLIL thus sheds light on how disciplinary knowledge is recontextualised across linguistic boundaries, revealing the fluidity with which learners navigate between semiotic systems. It also highlights the importance of preparing teachers to strategically orchestrate multimodal resources so that content learning and language learning are mutually reinforcing rather than competing aims.

The functional–textual dimension

This dimension combines two interconnected domains of BMDLs, functional and textual. By this combination, we align with the conceptualisation of 'functional' in linguistics as language used for communication, inseparable from the context where it is employed while particularly addressing the functions of texts as they operate across disciplines. Thus, the functional–textual dimension addresses how learners engage with the forms, structures, and functions of communication that are central to knowledge construction in disciplinary contexts. It focuses on how meaning is shaped through the strategic use of genre, register, and textual organisation to serve epistemic goals, such as explaining, describing, justifying, or evaluating, and to do so in ways that are appropriate to both audience and context (e.g. Eggins and Martin 1997; Halliday and Hasan 1989). This development takes place not only through an L2 that is still developing but also in the L1, where disciplinary discourse is being acquired (see the bi-, multi- and translingual dimension).

In CLIL contexts this dimension plays a pivotal role. As students move to higher levels of schooling, they encounter the increasing challenge of learning academic and disciplinary language for the expression of knowledge. Added to this, the functional–textual dimension in CLIL is characterised by its diversity both in terms of the different language resources specific to each discipline, and in teachers' and learners' use of linguistic resources drawing on diverse linguistic repertoires. This creates a strong need for explicit scaffolding of how language and other semiotic resources function in disciplinary meaning-making. This dimension operates as a bridge between language development and subject learning, enabling teachers to focus not just on *what* students say or write, but *how* and *why* they structure their meanings in particular ways.

In order for students to succeed in the expression of disciplinary knowledge in an L2, it is important to identify the structure and language features of the texts that characterise different disciplinary cultures. To support this process, genre-based pedagogies (e.g. Rose and Martin 2012) and Cognitive Discourse Functions (CDFs, Dalton-Puffer 2013) are of particular importance. The initial interests in DL in CLIL started with the identification of the genres that characterised the most frequently taught subjects (e.g. Llinares, Morton, and Whittaker 2012). Genre-based approaches were considered to help learners recognise and produce the staged, goal-oriented text types that are typical of disciplinary communication, such as explanations, reports, or arguments, and understand how these genres may vary in form and function across subjects like science, history, or geography. However, it soon became apparent that in most CLIL school contexts classroom discourse and assignments expected students to express knowledge in smaller units rather than in staged texts that characterised genres. The CDF construct (Dalton-Puffer 2013) contributed to fill this gap and, since then, it has been widely applied both as a research and pedagogical tool. The framework, including seven main CDFs (CATEGORISE, DEFINE, DESCRIBE, EXPLAIN, EXPLORE, EVALUATE, and REPORT) has shown transfer across languages in students' writing (Evnitskaya and Dalton-Puffer 2023) and offers potentially interesting pedagogical opportunities for collaboration between different language and content specialists (e.g. Morton and Nashaat-Sobhy 2024).

Rather than viewing texts as static products, the functional–textual dimension sees them as dynamic and situated social practices that reflect disciplinary values and ways of knowing. A laboratory report (as a scientific genre) or the definition of a historical term (as a type of CDF) are not simply containers of information, but purposeful textual performances through which learners demonstrate and deepen their understanding. As an example, CLIL students seem to define differently orally or in writing: primary school CLIL students of biology produced more formal definitions in writing, but their spoken definitions co-constructed with their peers included more expansions and displayed additional knowledge (Llinares and Nashaat-Sobhy 2021). Genres and CDFs realised through different modes or combined with other multisemiotic resources can help cater to students with different cognitive and linguistic abilities and offer a better adaptation to different CLIL classroom cultures in Europe and around the world.

Another crucial characteristic of this dimension is its developmental nature. Over time and with scaffolded experience, learners move from surface engagement with familiar text types and CDFs toward a more nuanced understanding of the symbolic and epistemic functions of texts. They begin to make informed choices about language, structure and modality, developing what could be called *textual agency*, as they internalise the 'unspoken habitus' of a discipline. As they do so, they increasingly recognise the textual fingerprints of knowledge: the typical ways of arguing in history, representing cause-effect in science, or using diagrams in physics. As Arias-Hermoso, Imaz Agirre, and Garro Larrañaga (2025) demonstrate, argumentation and comparison seem to develop throughout secondary education, and there seems to be transfer across languages. This points to the need for collaborative work focusing on BMDLs development in different contexts, involving different target languages as put forward in the bi-, multi- and translingual dimension.

Ultimately, this dimension highlights that becoming literate in a discipline, especially in bi- and multilingual contexts, requires developing a flexible understanding of how texts function to do epistemic work, how they vary across languages and modes, and how they serve to construct, challenge,

and communicate disciplinary knowledge in socially and culturally meaningful ways. There is a clear interplay with the previous two dimensions as the functional–textual dimension can and does involve multiple languages and other semiotic modes when positioned in a CLIL (or other bi- and multilingual) setting.

The critical dimension

Just as it is part of schooling that students engage in the elaboration of concepts and the negotiation of meaning to attain the core concepts and contents of curricular topics, they must also engage in reasoning and inquiry strategies and practices (Goldman et al. 2016). Students need to use the language of the discipline to justify claims with evidence, evaluate competing accounts, and recognise how knowledge is positioned. This dual orientation towards conceptual depth and critique is central to criticality, which is the focus of the critical dimension in BMDLs.

Criticality involves two complementary perspectives, which are critical thinking and critical literacy. Critical thinking highlights cognitive strategies such as analysis, inference, hypothesis-building, and evaluation (Abrami et al. 2015; Willingham 2008). These strategies enable learners to interpret evidence, solve problems, and make judgments, with an emphasis on logic and evidence (Crawford 2014). Critical literacy, by contrast, refers to the interrogation of texts and discourses, questioning whose knowledge is legitimised and how it is situated within cultural, historical, or ideological frames (Norris, Lucas, and Prudhoe 2012). It may take a weak form, where students recognise perspective and bias, or a strong form, where they challenge and transform unjust or exclusionary structures (Morton et al. 2025). These two perspectives may intersect and intertwine, as both contribute to learners' ability to reason and evaluate meaning. As argued by Morton et al. (2025), critical thinking serves as a necessary foundation for critical literacy: students must first develop the analytical and inferential skills that allow them to then interrogate texts in relation to power, ideology, and representation.

CLIL provides distinctive affordances for fostering criticality. The 4Cs framework (Coyle, Hood, and Marsh 2010) integrates content, communication, cognition, and culture, with cognition directly linked to reasoning and inquiry, and Pylonitis and Meyer (2024) include criticality in Pluriliteracies. Dalton-Puffer (2013) operationalises the interplay between content, cognition, and language through CDFs, being the linguistic realisations of cognitive processes about content. It is logical to assume that CDFs such as EXPLORE and EXPLAIN would foster reasoning by supporting hypothesis-building, causal linking, and elaboration. Others, such as COMPARE and EVALUATE, orient learners toward critique, judgment, and perspective-taking, inviting reflection on how knowledge is constructed and valued (see Gerns and Mortimore 2025; Llinares and Nikula 2024). In the same vein, some subjects seem to offer greater affordances for certain CDFs over others, as shown by Dalton-Puffer and Bauer-Marschallinger (2019) who found that the performance of different CDFs were central to achieving different types of historical competences. These functions can thus be seen as conduits for criticality, some opening spaces for questioning what we know, and others for reflection about how ways of knowing are situated within particular traditions and worldviews.

Criticality develops progressively in curricula: younger learners are generally guided to reason with knowledge through problem-solving and inference, while older students are expected to interrogate epistemological assumptions and perspectives. It is also shaped by disciplinary differences (Abrami et al. 2015). Studies in this special issue (Mortimore et al. in progress; Nashaat-Sobhy et al. 2025) show that while CLIL teachers and teacher trainers converge in viewing criticality as integral to learning in general, they frame it differently across disciplines. In science, criticality was seen as inseparable from asking 'why' and 'how' questions, generating predictions, and justifying claims with evidence. In social sciences, it was linked to perspective-taking, judgement, and civic participation, and described as extending beyond school into democratic life. In mathematics, reasoning, problem-solving, and explaining thought processes were underscored as central aims, moving

students beyond calculation toward reflective engagement. Accordingly, the question of whether criticality is generic or discipline-specific can be answered as both: it requires providing learners with broad access to reasoning, and then inducting them into the discipline's own ways of arguing, evidencing, and critiquing (Abrami et al. 2015).

Research in multilingual classrooms demonstrates how these affordances are realised. Translanguaging pedagogy (Cenoz and Gorter 2021), as seen earlier, is both a cognitive tool for reasoning and a social tool for including alternative perspectives, as it opens spaces for critical literacy (Lin 2019), allows learners to challenge dominant representations (Stewart, Hansen-Thomas, and Rupley 2020), and supports identity work and agency, transforming tasks into opportunities for critique (Gomez et al. 2021). The multilingual turn in teacher education has fostered awareness of ethnocentrism and coloniality, broadening the epistemological horizons of applied linguistics and language policy (Levasseur et al. 2022). Classrooms are not ideologically neutral and in CLIL contexts this dynamic is intensified by the interplay of languages and texts, requiring students to navigate multiple representations of knowledge. For example, history students comparing accounts of the same event in different languages are exposed to the perspectival nature of knowledge and develop the ability to evaluate both claims and their epistemological bases. For students to advance in this dimension, they may be encouraged to test how language choice reshapes argument strength and epistemic authority. Encouraging learners to mobilise their linguistic and cultural repertoires supports their capacity to engage in critique, reframing the tasks they engage in for this purpose as opportunities to question assumptions and assert epistemic voice (Stewart, Hansen-Thomas, and Rupley 2020).

Despite these affordances that bi- and multilingual settings provide, criticality remains underdeveloped in curricula and assessment. Implementation often limits critical engagement to factual recall and language scaffolding (Bagalová and Kováčiková 2025), and assessment tasks seem to reward literal comprehension (Alford and Jetnikoff 2016). Goldman et al. (2016) observe that reasoning strategies remain underrepresented in educational standards. Morton et al. (2025), in their comparative analysis of history and biology curricula in Finland, Italy, and Spain, found explicit attention to bias, power, or ideology was absent. This reinforces calls for curriculum and assessment design that integrates both reasoning (critical thinking) and critique (critical literacy) as core elements of BMDLs.

Taken together, the critical dimension of BMDLs integrates knowledge and epistemology, cognition and socio-cultural critique, and both generic and discipline-specific practices. The aim is not only for learners to comprehend disciplinary knowledge but to develop the criticality needed to reason with evidence, interrogate texts, and participate equitably in shaping disciplinary knowledge.

The technological–digital dimension

The technological–digital dimension of BMDLs affects both knowledge-making and presenting knowledge. Thus, digital tools are used as communication partners for learners to find, synthesise, translate, mediate or (re)produce disciplinary information in terms of accessing knowledge and as editors and designers in the production of texts, including visual representations. The possibilities emerging from Large-Language Models (LLM) to quickly create texts with the help of digital tools is especially relevant in professional or disciplinary texts, either just based on information or through translation programmes. The explicit guidance offered in an increasing number of academic journals on how (not) to use AI shows that the integration of such digital support is becoming more widespread.

Given this trend and the more established prevalence of digital texts (in the widest sense) in our societies, it is not surprising that BMDLs both require and benefit from an engagement with a technological-digital dimension. Within the classroom, technology largely has a facilitative and supportive role, rather than being a goal in itself as reported by CLIL teachers (Nashaat-Sobhy et al., 2025) and teacher educators (Mortimore et al., in progress). There appears, nevertheless, to be a growing

awareness of the need for digital competence to be developed more systematically to support teaching, learning and assessment, with the EU Digital Education Plan laying out actions to unlock quality and inclusive digital learning (European Commission 2020). Further initiatives include EU's DigiComp 2.2 (Vuorikari, Kluzer, and Punie 2022) and the forthcoming and updated DigiComp3 to aid the integration of digital tools for both educational and professional use.

A key consideration in approaching BMDLs from a technological and digital perspective is the access and use of digital tools. Importantly, this dimension covers two learning environments where digitality comes in; firstly, the teacher-guided classroom context, where digital tools, both hardware and software-based, are introduced and used in teaching and learning. Secondly, the learner-driven use of technology, frequently outside the classroom context, with an overt focus on learning or where learning is a by-product of other activities. The latter has been explicitly addressed in terms of language learning under the label of Extramural English (Sundqvist and Sylvén 2016). Both access to and use of digital tools have grown exponentially, but there is a very clear digital divide in terms of resources and user skills. In 2024, CLILNetLE Working Group 4 conducted surveys among teachers ($N = 557$) and students ($N = 4,229$) across 11 European countries on their use and evaluation of digital tools (Ghamarian et al. 2024). Analysis shows that the mobile phone is the most popular device to access information for students, while teachers favour both mobiles and laptops, indicating that portable devices integrated into daily life are favoured by both groups. Students were found to engage frequently in digital activities in their CLIL target language and rated their use of social media, instant messaging, phone apps and online video sharing as most relevant in supporting their CLIL learning. Although teachers also recognised the influence of these tools on the development of their students' DLs, they generally provided much lower estimates regarding their students' engagement with digital media in the CLIL target language, while expressing a desire to better understand their students' extramural activities.

These surveys are the largest and most recent on the use of digital media by CLIL learners and teachers. Nonetheless, with generative AI described as not merely a tool but a catalyst for transforming learning experiences (Aad and Hardey 2025), it is reasonable to assume that any repetition of the survey would find greater use of AI-based applications. The fast pace of introduction and uptake of new digital and AI-based tools, especially LLM (e.g. Co-Pilot, Gemini, Meta AI, ChatGPT), is being driven by their increased availability and accessibility not just in education, but also for recreational and professional purposes.

In this regard, the 2024 TALIS report noted that 68% of teachers say they use AI to efficiently learn about and summarise a topic, and 64% to generate lesson plans, with 50% agreeing that AI can help improve a lesson plan. In line with the view that digital literacy often supports teaching and learning, 40% of teachers in this survey agreed that AI helps them support students individually (OECD 2025). These figures are likely to show a very significant yearly increase in subsequent editions.

Despite this accelerated uptake of, especially LLM-based, AI, training in digital literacy appears not to have followed the same rate of growth. This is true both for established teaching staff and for current student teachers. A 2024 report by the British Council found a major skills gap between training and practice, specifically in English language education: while 70% of teachers reported using AI, just 20% noted having received any training (Edmett et al. 2023). Similarly, the TALIS report found that three out of every four teachers mentioned a lack of knowledge or skills to teach using AI (OECD 2025). This is unsurprising when we take into account that only seven countries worldwide had developed AI frameworks for teachers by 2022 (UNESCO 2024). In response, UNESCO has produced its own AI competency framework (2024), and the EU, the first legal framework, EU Regulation 2024/1689 of the European Parliament (European Union 2024). For teaching and teacher education, a better understanding of the use of digital tools to foster learning appears crucially important. In terms of potentially transforming an individual student's learning process, AI is set apart from other educational technologies regarding its capability to match educational content to that individual student's needs and requests, communicate with

and respond to that student, model their learning process, decide what information to provide, and make decisions about that student's level of understanding and educational progression (Güneyli et al. 2024). However, while generative AI may (artificially) augment language competence, or language production, for example, in a text, this may counteract developing L2 users' confidence in their own foreign language skills. Chat GPT or Co-Pilot routinely offer more 'refined' or 'polished' alternatives, even when the original text is perfectly acceptable.

The current situation can thus be described as CLIL teachers underestimating the use of digital tools by their students outside of school, lacking guidance and knowledge of how to fruitfully integrate these practices into disciplinary learning, and being largely unaware of the need to develop critical digital literacy (Ghamarian et al. 2024). The pace at which LLM-based AI develops to include further functionalities increases this challenge, for CLIL and all other teachers. This highlights the need for focused teacher education, including clear guidance and materials, as well as targeted interventions to highlight the role of digital literacy in building and presenting knowledge.

On the interconnectedness of the dimensions

At the outset, we highlighted the intertwined nature of the BMDL dimensions as a key aspect of our revised conceptualisation. In our view, the lack of clear-cut divisions captures the malleable and context-sensitive nature of DLs more effectively than static categorisations. Such connections take several forms. As space constraints preclude a fuller exploration of the interconnections, we provide below some illustrative examples.

The bi-, multi-, and translingual dimension plays a foundational role in the construct, subtly shaping and supporting the functioning of all other dimensions through its integrative nature. Whether learners are engaging with multisemiotic resources, navigating functional-textual structures, adopting critical stances, or interacting with digital tools, their ability to do so is shaped by the linguistic repertoires they bring, and the communicative demands of the disciplinary context. The bi-, multi- and translingual dimension thus serves as the connective tissue that enables DLs to emerge, adapt and thrive across diverse settings.

Another example of interconnections is the interplay between the functional–textual and critical dimensions. This involves learners reflecting on whose voices and discourses are privileged in disciplinary genres, and questioning textual conventions that may obscure complexity, bias, or positionality. The connection is also at play when students take informed decisions about the forms in which to represent knowledge, with the potential to act upon and transform existing practices. Interconnectedness of the functional-textual and multisemiotic dimensions is evident in texts incorporating non-linguistic resources, which contribute to how knowledge is structured and interpreted (Ting, Rieder-Marschallinger, and Dalton-Puffer 2024). The use of images in combination with text can be particularly relevant for equity in CLIL, providing more flexible and varied means to express meanings.

As regards the technological–digital dimension, it links to the multi-semiotic and bi-, multi- and translingual dimensions in that digital means offer novel affordances for the creation of multisemiotic and multilingual information formats. A connection to the textual-functional dimension shows in AI tools mediating and transforming what it means to produce 'disciplinary texts'. It also links to the critical dimension in that criticality can help ensure that users fully understand the potential limitations of digital tools (such as the trustworthiness of information and linguistic or cultural biases), particularly those based on AI.

While the connections and partial overlaps illustrate that BMDLs is a multilayered construct, recognising different dimensions also provides specific entry points to BMDLs, helping to identify key phenomena relevant to the construct. In this sense, then, the dimensions serve as scaffolds for reflective work on their importance in different disciplinary fields and knowledge domains.

Conclusion

This paper has outlined key dimensions for conceptualising BMDLs, showing the complexities contained within the construct of DLs when enacted in bi- and multilingual settings. The ensuing framework also underlines dynamicity and situatedness, seeking to capture the very essence of DLs as contextually adaptable.

The BMDLs framework, we believe, can serve as a useful thinking tool for both practitioners and researchers. For those engaged in teaching, it may offer useful insights into what aspects of BMDLs are particularly salient and deserving pedagogical attention in their subjects, pinpointing areas to consider when scaffolding learners towards BMDLs. In short, it can support teachers to explicate the often implicit in their pedagogical practice. The view of BMDLs as multidimensional can also benefit pre- and in-service teacher development in a situation where there is still a great deal to be done in terms of systematic and sustained teacher preparation for bi- and multilingual education as shown, for example, by Ballinger, Fielding, and Tedick (2024), Yuan and Lo (2023) and Mortimore et al. (in progress).

Another pedagogically useful aspect of the framework is the conceptualisation of BMDLs as developmental. That is, BMDL is relevant for various educational landscapes from primary to higher education and beyond given that epistemic awareness necessary to make informed decisions is attained through a dynamic process that starts early on in schooling, albeit in more rudimentary forms, and continues through life. To illustrate, the ability to evaluate the scientific and ethical implications of vaccination versus non-vaccination depends on more fundamental forms of knowledge (such as influenza being contagious as viruses spread through droplets, and viruses reproducing, mutating, evolving, and adapting to environmental conditions) that are attained through a process of learning and apprenticeship involving scaffolded experiences.

For those engaged in research, the suggested framework can offer insights for future research openings. For example, empirical investigations across different school subjects are needed to yield more information about the subject-specific nature of the five dimensions and the way they interact with each other. The BMDLs framework can also be used to address variation across educational contexts. As the ongoing work in CLILNetLE has indicated, the applications of CLIL in different contexts are diverse. Therefore, the BMDLs framework could serve as a useful shared perspective for cross-context approaches. Additionally, a fruitful future research avenue could include investigating the role of teachers, teacher educators, and policymakers in the application and development of BMDLs. Finally, the framework may also serve as a useful thinking tool for researchers because its five dimensions offer a perspective from which to interrogate different emphases in existing DLs research (thank you Errol Ertugruloglu for pointing this out) as well as in identifying further caveats besides those noted here that need to be addressed. Portraying the framework as flexible and dynamic thus means that it serves as an invitation for further exploration and specification. We look forward to seeing how the framework is received by practitioners and researchers and how it evolves in the future.

CRediT author statement

Tarja Nikula and Talip Gülle drafted the introduction and conclusion sections, provided the overall structural framework for the paper, and coordinated the team's collaborative writing process. The other authors co-authored individual sections on specific dimensions: Anne Tiermas and Emma

Dafouz (bi-, multi- and translingual dimension), Pilar Gerns and Yasemin Bayyurt (multi- and transsemiotic dimension), Ana Llinares and Silvia Minardi (functional-textual dimension), Nashwa Nashaat-Sobhy and Semih Kaygısız (critical dimension), and Julia Hüttner and Louisa Mortimore (technological-digital dimension). All authors participated in the review, feedback, and editing of the complete manuscript. Talip Gülle created and finalized the figures in Canva with the authors' suggestions. The research was supported by the CLILNetLE COST Action, with funding acquired by Julia Hüttner.

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
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