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Building Scientific Knowledge in English: Integrating Content, Cognition and Communication in Secondary School CLIL Biology

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ABSTRACT

Background: The focus of this paper is on Dalton-Puffer's construct of the Cognitive Discourse Function (CDF) (2013), which offers CLIL teachers a practical framework through which they can more easily understand the complex idea of integrating the content, cognition, and language required for their subject. These functions have mainly been addressed from classroom observations or task prompts, and little is known about their teachability and effectiveness on students' content knowledge.

Purpose: This paper explores whether the CDF of 'comparing' (a subcategory of 'classify') can be taught to Spanish seventh-grade CLIL biology students (N = 37) and examines the effect of teaching it explicitly on their written performance.

Method: An operational framework was developed to define this CDF and an exploratory study was performed in which students were asked to hand in written comparisons. Quantitative and qualitative pre-and post-tests were applied.

Results: Significant results were obtained for the experimental groups, which improved in both content and language learning, scoring higher on inclusion of content points, justification of their scientific claims, concept formation and use of lexico-grammatical forms.

Conclusion: These findings add to our understanding of the importance of integrating cognition and language in teaching and learning natural sciences, within which CDFs can be a useful starting point.

KEYWORDS

Content and Language Integrated Learning (CLIL), Cognitive Discourse Function (CDF), secondary school science education, knowledge construction

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INTRODUCTION

Across Europe and many other parts of the world where English is not the vehicular language, school subjects are now being taught in English. In European countries, this approach is generally understood within the paradigm of Content and Language Integrated Learning (CLIL): when suitable didactic techniques are used, students can learn scientific content at the same time as they improve their English language skills and begin to develop scientific literacy in what is effectively the world language of science. However, the actual process of integrating content and language in CLIL classrooms still remains a challenge (Breeze et al., 2014; Llinares, 2015; Villabona & Cenoz, 2021), not least because CLIL teachers seem to continue giving their classes relying on their previous, traditional didactics, where content and language are taught separately. This suggests that the idea of integrated learning has not yet fully reached the classroom. There is a need to bring existing research into CLIL classroom practice (Llinares et. al., 2012, 2015; Nikula et al., 2016) and provide CLIL teachers with concrete, pedagogical tools they can use to foster integrated learning, that is, co-development of the cognitive, content-oriented demands of the subject and the language that students need to express their emergent knowledge effectively (Nikula, 2017; Morton, 2020).

Various European research initiatives address the question of integrating content and language learning in classroom practice. These include the Council of Europe subject language descriptors (Vollmer, 2011), the genre-based approach (Llinares et al., 2012; Lorenzo, 2017) and the Graz-group *Pluriliteracy Teaching for Learning* (PTL) model (Meyer et al., 2015; Coyle & Meyer, 2021; Coyle et al., 2023). One promising departure in this area is the construct of the Cognitive Discourse Function (CDF), proposed by Dalton-Puffer (2013), which offers CLIL teachers a practical conceptual framework they can use in their CLIL planning, teaching, and assessment (Morton, 2020).

The novelty of this approach lies in its interdisciplinary nature, which offers content and language teachers a shared pedagogical tool that unites contributions from both disciplines, namely the notions of thinking skills in science and other subject education and the notion of discourse function in applied linguistics (Dalton-Puffer, 2013; Bauer-Marschallinger, 2022). Dalton-Puffer essentially identifies a 'zone of convergence' between content and language learning objectives, recognising that learning in school tends to occur through a limited set of cognitive operations (such as 'explain' or 'define'), which are expressed using a finite set of verbs. The cognitive demands of content courses can thus be linked to specific linguistic patterns, which allow to them be identified and taught (Dalton-Puffer, 2013). The CDF can thus be considered an 'entry point' for students that introduces them to subject-specific ways of thinking and communicating, which are an integral component of subject literacies (Veel, 1997; Rose & Martin, 2012; Zwiers, 2014; Polias, 2015).

In one landmark paper, Dalton-Puffer (2013) presents an operational framework of the most important CDFs *in* and *for* school learning, bringing together 50 different functions from different curricula and learning frameworks, which are then systematized according to their communicative intentions yielding seven main types, as shown in Table 1. These are: categorise, define, describe, evaluate, explain, explore, and report.

The idea is basically that when students are asked to perform a CDF-task, such as to 'explain' the process of photosynthesis, they have to process the subject contents cognitively and verbalize this process through some corresponding linguistic forms. If properly scaffolded, the effort to express the newly learned knowledge in English will foster students' subject learning, leading them over time to more intertwined, deeper learning (Vollmer, 2011; Meyer et al., 2015, 2018; Morton, 2020).

Research on CDFs so far has mainly been conducted from descriptive classroom observations or by eliciting students' CDF use through concrete tasks, analysing whether and how CLIL users acquire these discursive forms without explicitly teaching them (see Lose, 2007; Breeze & Dafouz, 2017; Lorenzo, 2017; Dalton-Puffer et al., 2018; Evnitskaya & Dalton-Puffer, 2020; Doiz & Lasagabaster, 2021; Llinares & Nashaat-Sobhy, 2021; Salvador-Garcia & Chiva-Bartoll, 2022; Whittaker & McCabe, 2023; Llinares & Nikula, 2023). The results of these studies show that CDFs do occur in the course of ordinary CLIL classes, regardless of the school subjects and students' age. However, they also pinpoint the fact that almost no explicit CDF teaching and learning takes place and that, in general, little attention is paid to the functional side of subject-specific language in CLIL contexts. The data present low incidences of explicit metatalk and few output opportunities for students, who thus fail to develop a pro-

Table 1

Cognitive Discourse Functions

Type	Members	Communicative Intention
categorise	categorise, classify, compare, contrast, exemplify, match, structure, 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 specialised 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, judge	I tell you what my position is vis a vis X.
explain	explain, reason, express cause/effect	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.

Note. From *"Cognitive Discourse Functions in Austrian CLIL Lessons,"* by C. Dalton-Puffer, S. Bauer-Marschallinger, K. Brückl, V. Hofmann, J. Hopf, L. Kröss, & L. Lechner, 2018, European Journal of Applied Linguistics, 6(1), pp. 5–29 (https://doi.org/10.1515/eujal-2017-0028). Copyright 2018 by the De Gruer.

ductive command of CDFs. As natural acquisition of these academic functions seems not to occur automatically when teaching CLIL, research has stressed the need for more explicit teaching and practice of CDF forms (Dalton-Puffer, 2007; 2017; Meyer et al., 2018; Morton, 2020; Nashaat- Sobhy, 2020; Coyle et al., 2023).

Some first steps have already been taken in this direction by working on the conceptual and linguistic framework of the different CDFs using predominantly a Systemic Functional Linguistics (SFL) approach to make them operable. Such is the case for 'categorize' (Evnitskaya & Dalton-Puffer, 2020), 'define' (Nashaat- Sobhy, 2020; Llinares & Nashaat- Sobhy, 2021), 'describe' (Dalton-Puffer, 2004), 'evaluate' (Llinares & Dalton-Puffer, 2015; Whittaker & McCabe, 2023; Hasenberger, ongoing), 'explain' (Dalton-Puffer, 2004; Lose, 2007; Connolly, 2019), and 'predict' (a subcategory of 'explore') (Dalton-Puffer, 2007), though only a few have been validated in terms of usefulness by developing explicit teaching programmes. Work in this direction includes a study by Breeze and Gerns (2019) in a secondary-level CLIL history class, where some general CDF-related features were explicitly taught for 'describing' and 'explaining', four doctoral theses (Connolly, 2019; Gerns, 2021; Bauer-Marschallinger, 2022; Hasenberger, ongoing) and Nashaat-Sobhy's (2020) validated framework for working with the CDF 'defining' in the university setting. Classroom materials are now being developed to teach, scaffold and assess these CDFs in the CLIL classroom[1] (see Coetzee-Lachmann, 2019; DeBoer & Leontjev, 2020; Del Pozo & Llinares, 2021; Coyle et al., 2023). However, more research is clearly needed to clarify the cognitive and linguistic parameters of the various CDFs across school subjects and test their practical applicability, in particular, in secondary L2 education, where the students' content, cognitive and language skills are undergoing intense development.

This study aims to contribute to this ongoing research by first defining the CDF of 'comparing' (a subcategory of 'categorise') in the context of science, where it constitutes a fundamental method and offers a good starting point to introduce students to scientific working culture and its specific modes of thinking and communicating, which are a key component of scientific literacy (Lemke, 1990; Roberts & Bybee, 2014). By enabling students to articulate their own scientific knowledge in a much clearer, more organised and professional way, teachers thus empower them to develop the necessary cognitive and linguistic skills to take part in society's wider scientific debates in and beyond school (Mercer, 1995; Norris & Phillips, 2009; Oliveira & Weinburgh, 2017; Coyle & Meyer, 2021).

Second, this paper aims to examine the effect of explicitly teaching the CDF of 'comparing' on students' subject-based written performance in a secondary school (7 grade) CLIL science class. To this end, some quantitative and qualitative pre-and post-test results will be shown from an empirical study in which the CDF of 'comparing' was explicitly taught to a group of Spanish CLIL biology students.

Defining the CDF of 'Comparing' in CLIL

To determine whether explicit teaching of the CDF of comparing promotes integrated learning between contents and language, an interdisciplinary approach was adopted, which integrates contributions made by the natural, educational, and linguistic sciences. This is briefly presented below.

'Comparing' in Natural Sciences

The act of comparing constitutes one of our first and most natural forms of human thought. From childhood onwards, we interact with the world by making comparisons, grouping things into pairs, and examining their shared and unshared features, that is, their similarities and differences. These comparison-based discoveries are nothing other than our epistemic way of making the world understandable and operational.

However, comparing does not only present a natural human way of thinking – it is also a fundamental method of scientific inquiry, integral to our modern sciences (Darian, 2003; Martinez, 2018). The idea of studying the living word through a comparative approach dates back to the Ancient Greeks, when Aristotle was one of the first to analyse the physiology of dissected animals and plants by identifying patterns of similarity and difference (Carpi & Egger, 2008). This method has developed since and constitutes an essential, distinctive methodology for biological science, being used to classify plants and animals into taxonomies, or to investigate comparative anatomy in the study of evolution, heredity, and adaptation to environmental pressures (Flannery, 2010). It is thus a core cognitive skill in biology, and an essential prerequisite for disciplinary literacy. In fact, comparing is frequently used in biology classes, for example, when viruses are taught together with bacteria, or the concept of warm-blooded with that of cold-blooded. Teaching students how to compare can be a good starting point to introduce them to comparative methods and help them think like scientists.

'Comparing' in Education

In education and cognitive psychology, comparing is understood to be an important component in terms of lower-or-

[1] LongAd-CLIL project (2019-2021). A longitudinal corpus-based analysis of advancedness in CLIL. https://uam-CLIL.org/longad-CLIL/

der thinking skills (Bloom, 1956). It is defined as one of the most basic analytical lower-order thinking skills, grouped together with others (such as 'matching', 'classifying', 'error analysis', 'generalizing' and 'specifying'), which are essential to carry out more advanced and complex operations (such as 'define', 'predict', or 'classify'). Furthermore, different taxonomies (see Anderson & Krathwohl, 2001; Marzano, 2001; Biggs & Tang, 2011) situate comparing at the crossroads between the cognitive dimensions of 'understand' and 'analyse' and the knowledge dimension of concepts. The reason is that comparing consists of identifying commonalities between at least two items, which often requires moving from a surface, experiential-driven understanding towards a more abstract and deconstructive one.

Studies have shown that teaching how to compare properly in content areas seems to have positive effects on students' learning (Hammann & Stevens, 2003; Silver, 2007; Goldstone, 2010; MacArthur & Philippakos, 2010; Clark et al., 2020). For example, it helps to develop: (1) a structured and orderly way of thinking, (2) abstract and relational ways of learning, (3) detail-focused, and longer-lasting comprehension, since two things taught together seem to prove more memorable than one, and ultimately (4) advanced literacy skills.

'Comparing' in Linguistics

According to the Oxford English Dictionary (OED) (1989), the verb 'compare' is a late Middle English word, derived from the old French word 'comparer' and the Latin 'compara-re' ('com'- with + 'par'- equal; 'compar'-like), meaning literate to 'pair' or 'match together'. The transitive verb 'to compare' and its corresponding noun form 'comparison' can be defined in either one of the following ways:

(1) 'to speak of or represent as similar'; 'to make like'; 'to liken'.

(2) 'to place together so as to point out the similarities and differences of (two or more things)'.

Based on these definitions, 'comparing' seems to be characterized by 'matching' or 'bringing' at least two relatable items together, that is, 'likening' them, and analysing them on some shared and unshared features, i.e., on their similarities and differences.

Academic discourse functions have been studied in the context of L2 teaching, in particular, by researchers from English for Specific Purposes (ESP) and Halliday's Systemic Functional Linguistics (SFL) tradition (Halliday & Matthiessen, 2004), which address the importance of such functions in academic writing (Polias, 2015; Smith, 2019). 'Compare' is considered one of the most common discourse functions in expository text, alongside others such as sequencing, classification, explanation, cause-effect, and problem-solution (De La Paz & McCutchen, 2010). This can also be regarded as an aspect of Cognitive Academic Language Proficiency (CALP) (Cummins, 2008), which is crucial for students' academic development (Llinares et al., 2012; Morton, 2020).

It is clear that cognitive functions (such as 'comparing') are tied to specific lexico-grammatical structures (such as 'is like', 'different to' or 'unlike') which allow teaching and learning through them. Considerable research has been conducted to clarify the analytical patterns of these discourse functions (see Cheong, 1978; Widdowson, 1979; Darian, 2003; Dixon; 2005; Huddleston, 2017; Evnitskaya & Dalton-Puffer, 2020).

Five-Point Framework for 'Comparing'

Based on the previous literature, I developed an operational framework that brings these contributions together. As a result, the act of comparing can be defined through at least five elements, shown in Table 2, each of which can be triggered by a corresponding question. This framework relies, in particular, on the work of Raphael and Kirschner (1985),

Table 2

Five-Point Framework for the CDF of 'Comparing'

Components	Questions
Items being compared: "topic" (X) + "target" (Y)	What two items are compared? What is the "topic" and what is the "target"?
Points of comparison: "criteria"	What (points) can these items be compared on? Can you name the criteria explicitly? Can you use the same criteria for both groups?
Types of comparisons: general, specific comparison; similarities, differences.	What type of comparison will be performed? Are the items being compared 1. in a general/ specific way or 2. in terms of similarities and differences. Are these points reasoned?
Language *of* and *for* comparing: "comparitor"	How do we express a comparative relationship? What lexico-grammatical forms are used?
Comparative structure: parallel organization	How do we structure the comparative points? In a block-method, or a point-by-point one?

Widdowson (1979), Cheong (1978), Darian (2003), Dixon (2005), Polias (2015) and Huddleston (2017), as they present some concrete analytical descriptions of how to make a scientific comparison.

The first element addresses the question of what two items will be compared, referred to as 'topic' and 'target' (Cheong, 1978). The second element consists of establishing the criteria on which these items can be compared on, which are variously known as the 'parameter' or 'basis' of a comparison (Widdowson, 1979; Dixon, 2005). These points are usually abstract concepts. Then, the third element refers to the conceptual categories a comparison can adopt, which include Halliday and Hasan's (1976) general and specific comparison and a comparison in terms of similarities, differences and matters of degree (Cheong, 1978; Darian, 2003; Halliday & Matthiessen, 2014; Polias, 2015). Fourth is the language *of* and *for* comparing, which are the specific lexico-grammatical forms and structures (such as 'similar to', 'different') through which comparative relationships can be expressed, known as the comparitor. Significant research has been done in ESP and SFL to clarify these forms. Finally, a comparison is also characterised by its parallel structure, according to which items can be compared and contrasted in a systematic way. See Gerns (2023) for further analysis of these aspects.

Exploratory Classroom Study

Rationale and Research Questions

Given the importance of validating explicit CDF-based teaching tools and verifying their effect not only on students' language but also on their content and cognitive learning (Badertscher & Bieri, 2009; Bauer-Marschallinger, 2022), the present paper aims to validate the CDF framework for comparing and establish whether explicitly teaching it in a CLIL science context can have a positive effect on students' subject knowledge. To do this, a classroom-based study was designed and executed with secondary CLIL biology students (7^{th} grade, age 12-13), who were previously divided into a study and a control group. They were asked to hand in three written comparisons, which served as pre-and post-tests. The idea was to compare the results obtained before and after the instruction to examine whether the study group students displayed their content knowledge significantly better after the instruction phase than the control group.

The following research questions were addressed:

Can explicit CDF-based teaching (CDF 'compare') have a significant effect on students' written subject performance, considering:

(1) *the number of content points (inclusion of differences and similarities)?*

(2) *the number of reasoned content points (using linguistic devices, i.e., explicatory or defining forms, to support scientific claims)?*

(3) *the number of content points related to comparative concepts (criteria) (looking at nominalisations, abstract nouns, topic sentences and superordinated concepts)?*

(4) *the number of lexico-grammatical comparative forms (comparitors)?*

These questions align with the framework's core points for comparing (points 2 to 4). The study thus investigates how students co-develop the cognitive, content-oriented and linguistic skills needed to express their emergent knowledge more effectively.

METHOD

Context and Participants

An exploratory study was conducted with 37 lower-secondary (7grade) CLIL biology students (aged 12-13 years), their CLIL biology teacher and their EFL teacher in a charter-like, middle-class school in the north of Spain (Navarra) for three months (January-March 2019). It was decided to work with lower-secondary students, who had just moved from primary to secondary education as this is a decisive stage in students' formal education. The participating school offered biology in three seventh-grade classes with a CLIL modality of 50%, teaching half of its students (approximately 15 per class) in English, who were all included in the study, and half in their L1 (Spanish). These small groups allowed a more personalized teaching approach.

It is a small sample, and cannot be claimed to be representative, but it does offer initial insights into how a group of secondary students learned their science content through a CDF approach. The participants' mother tongue was Spanish (L1), and English was their foreign language (L2), except for three bilingual students (2 Spanish/Chinese and 1 Spanish/Polish). The CLIL biology and EFL teacher ranked the students' English level at a low B1 according to the CEFR.

Design and Method

A class unit was designed in collaboration with the CLIL biology and EFL teacher on the curricular topic of biodiversity, in which the CDF of comparing was integrated into the ordinary science lesson plan, that is, into the class tasks, oral interactions, and materials, providing the students with some CDF-rich lessons. The idea was to integrate the CDF of 'comparing' in a contextualized way so as not to interrupt the regular course of the class or make it look like a subject-external element (see Breeze & Gerns, 2019; Nashaat-Sobhy, 2020; Bauer-Marschallinger, 2022).

We used a pre-and post-test design to measure the possible effects of instruction. Of the three available groups taught by the same CLIL biology and EFL teacher, two were chosen as study groups (S1, S2), and one as control group (CG). The study groups received explicit CDF-based input and output opportunities (see Appendices A-H), while the control group received some lessons only focusing on content aspects without explicit indications or support dedicated to the CDF of 'comparing'; however, as the teacher included comparative expressions in their classroom talk, and as the written texts (see Appendix E) had some comparative lexico-grammatical and structural features, their classes could be regarded as representing an implicit CDF approach.

Intervention

The intervention included several classes during the first two months of the project (January/February 2019), where the teacher progressively explained the five points of the comparing framework. The first step involved raising students' awareness of the role that comparing plays in science (biology) education and jointly defining what makes a good scientific comparison (see Appendix A). Second, work was done on the first three points of the framework (*items being compared*, *comparative concepts* (criteria) and *types of comparison*) practising it with different scientific topics (see Appendix B). In a third step, the language *of* and *for* comparing (*comparitors*) was introduced, encouraging students to formulate some comparative, content-based statements; here language support was aligned with students' scientific knowledge (see Appendices C and D). Last, some structural devices were introduced, such as parallel and paragraph organisation, and the previous points were revised by deconstructing jointly a written comparison (consult text and tasks in Appendices E-G). As in other studies, a step-wise, joint, in-class learning approach was chosen (see Lose, 2007; Bauer-Marschallinger, 2022; Nashaat-Sobhy, 2020), based on the learning cycle idea from the genre tradition (Rose & Martin, 2012), Cummins's four learning quadrants (2008) from the ESL tradition and Vygotsky's (1934) 'collaborative learning' approach, which recommends moving from more supportive to more autonomous learning. Thus, students' receptive skills were first activated, followed by their deconstructive and productive ones. The idea was to draw students' attention to the different dimensions that converge when making a comparison, namely the conceptual, cognitive, and linguistic aspects.

Data Collection

To elicit comparisons, we asked the students to hand in three written comparisons: one before and two after the instruction classes, allowing us to trace better students' learning progress and detect any improvement over time. These served as pre- and post-tests (see Table 3). For the pre-test, the students had to compare between herbivores and carnivores, without receiving any kind of guidance or support. Then, during the instruction, the students were asked to rewrite their first written comparison in order to put what they had learned so far during these lessons into practice (see Appendix H). In the post-instruction phase, the students were asked to hand in two more comparisons to examine their ability to process and present new biological content in a comparative way. This time, they had to compare vertebrates with invertebrates and mammals with reptiles. All three tasks followed a similar design based on the previous analysis of 'comparing' and were reviewed by the participating teachers regarding clarity, content authenticity, curricular demands, and level of difficulty.

Data Analysis

The results were measured in quantitative terms by first counting the number of forms used by the individual students in their writings, and then by calculating average for the groups (S1, S2, CG) in each of the three task collection phases (pre-and post-tests). A paired t-test was run with a p-value at 0.05 (Rasinger, 2008), which indicates whether the students' progress was statistically significant. As the sample is small, caution is recommended. The idea is not to present large-scale representative data but to offer first insights into students' CDF content performance and draw some general conclusions on the effects of explicit CDF-teaching.

RESULTS

Table 3
Study Design

CDF-based tasks	Purpose	Schedule
1. compare herbivores and carnivores.	Pre-test	January 2019
(rewrite first comparison)	Instruction	January/February 2019
2. compare vertebrates and invertebrates.	Post-test (1)	Beginning of March 2019
3. compare reptiles and mammals.	Post-test (2)	End of March 2019

The quantitative results are presented in the following, and a qualitative pre- and post-test example is provided to illustrate students' content performance better.

Inclusion of Content Points

Starting with the results concerning the inclusion of content points (differences and similarities), the students could present up to 7 points per task. The researcher counted the number of task-relevant points presented by each student, identifying 564 points of differences and 155 of similarities, and calculated the average number per group and phase. The points of difference and similarity were analysed separately.

On the one hand, when considering differences, as shown in Figure 1 and Table 4, all three groups learned to include more points from their pre- to their respective post-tests. In the pre-tests the students included an average of 4 points, while in their respective post-tests they included an average of 6 points. Based on the paired t-test results (see Table 4), the gains were highly significant for all groups ($p < 0.05$) except the control group, who improved significantly only when post-test 2 was considered.

On the other hand, regarding students' pre- and post-test inclusion of similarity content points (see Figure 2 and Table 5), at the beginning, the students hardly presented any similarities, whereas after the instructional phase most study-group students (S1, S2) included them, especially in their second post-tests, where they doubled their use (including 2 to 3 forms). This can be considered a significant, delayed improvement ($p<0.05$) (see Table 5). In contrast, the control group's use of similarities declined.

Figure 1

Mean Number of Content Points (Differences) Used per Student

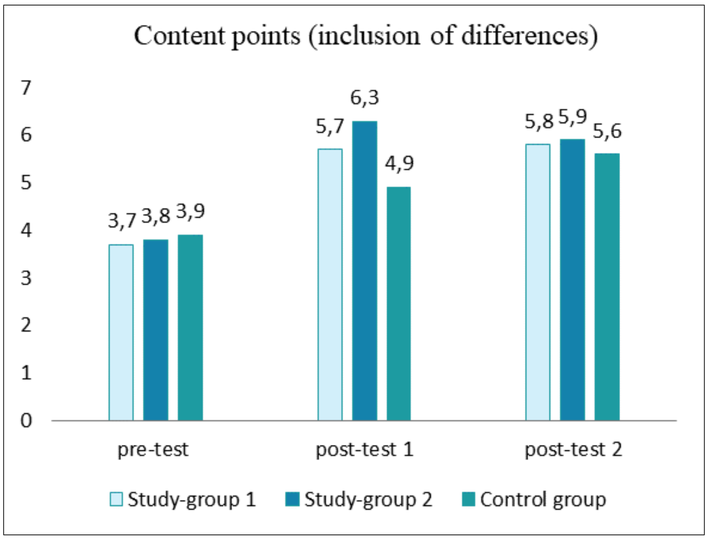

Table 4

Paired T-Test: Mean Number of Content Points (Differences) Used between Pre-Test and Post-Tests

Study Variable	Groups	Pre-Test		Post-Test 1		Post-Test 2		P-Value
		Mean	(Sd)	Mean	(Sd)	Mean	(Sd)	
Mean number of content points (differences)	S1	3.69	(1.58)	5.69	(1.35)			< 0.0007 **
	S2	3.83	(2.21)	6.25	(2.22)			0.0184 *
	CG	3.89	(1.27)	4.89	(2.67)			0.4070
	S1	3.69	(1.58)			5.75	(1.61)	0.0010**
	S2	3.83	(2.21)			5.92	(2.15)	0.0319*
	CG	3.89	(1.27)			5.56	(1.24)	0.0167*

Note. p<*=significance at 0.05; p<**=significant at 0.001

Figure 2

Mean Number of Content Points (Similarities) Used per Student

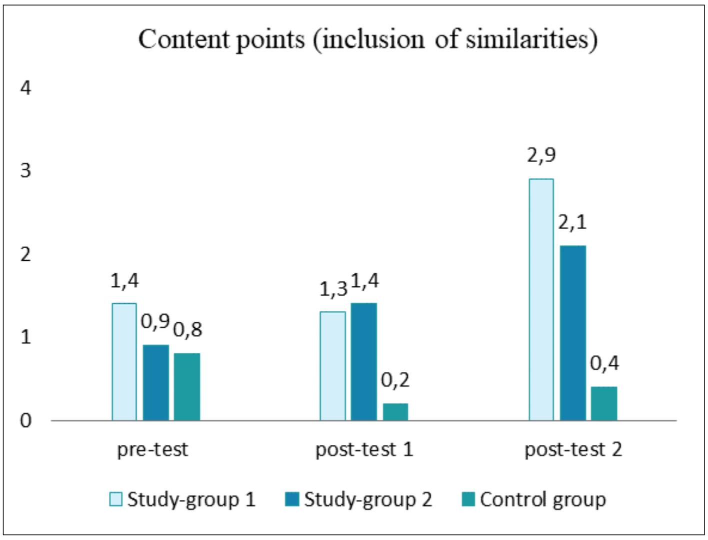

Table 5

Paired T-Test: Mean Number Content Points (Similarities) Used between Pre-Test and Post-Tests

Study Variable	Groups	Pre-Test		Post-Test 1		Post-Test 2		P-Value
		Mean	(Sd)	Mean	(Sd)	Mean	(Sd)	
Mean number of content points (similarities)	S1	1.38	(0.89)	1.31	(1.20)			0.8172
	S2	0.92	(1.31)	1.42	(1.62)			0.2562
	CG	0.78	(0.67)	0.22	(0.44)			0.0509
	S1	1.38	(0.89)			2.94	(1.44)	0.0024 **
	S2	0.92	(1.31)			2.08	(1.38)	0.0413*
	CG	0.78	(0.67)			0.44	(0.73)	0.3466

The following pre and post-test extract (Figure 3, examples 1 and 2) from one study-group student offers a qualitative insight into how most study-group students learned to present the content points in a more integrated, complete, and subject-purposeful way.

As can be seen, in the pre-test (example 1) only one similarity point (*both have a skull*) is included, which offers little relevant information and is presented separately from the other content points. In the post-test (example 2), the point of similarity offers more task-relevant information and is more integrated within the text. The importance of identifying similarities is recognised as a way of establishing class-memberships, seen by the assertion that herbivores and carnivores share the feature of having a backbone to classify them as vertebrates.

Furthermore, most pre-tests presented the differences in a vague and incomplete way, that is, specifying information about one animal group, while omitting this information for the other. Here, the student explains canines in carnivores but fails to provide the corresponding information about herbivores, indicating, for example, that they have a horny pad instead (*herbivores don't have canines and the carnivores have great canines*). Something similar can be seen later in example 5 (*The carnivores have canins and the herbivores not. The herbivores had large incissors to shop grass and canines no*). However, in the post-test most students, like the present one, learned to specify the content points more and analyse the information equally in both groups.

Elaboration of Content Points

Finally, we examined whether the students simply listed or elaborated the content points by providing additional information. The number of content points that were further reasoned, through the use of different linguistic resources (such as synonyms, explanatory/exemplifying forms, conditionals, action verbs, consecutive, relative clauses, etc.), was

Figure 3

Pre- and Post-Test Example: Presenting Content Points (Differences and Similarities)

(1) **PRE-TEST**	(2) **POST-TEST**
Different The herbivores eat plants and the carnivores eat meat (difference) also the herbivores don't have canines and the carnivores have great canines. (difference). Herbivores have broad incisors and the carnivores have pointed incisors. (difference). Common They both have a skull (similarity). (8AM)	Now, I am going to say the differences and the things in common of reptiles and mammals. The first thing in common they have is that both have a backbone; so they are vertebrates (similarity). Now, some differences, reptiles are cold-blooded (ectothermic), on the contrary mammals are warm-blooded (endothermic). (...) (difference) (8AM)

Figure 4

Mean Percentages of Elaborated/Reasoned Content Points per Student

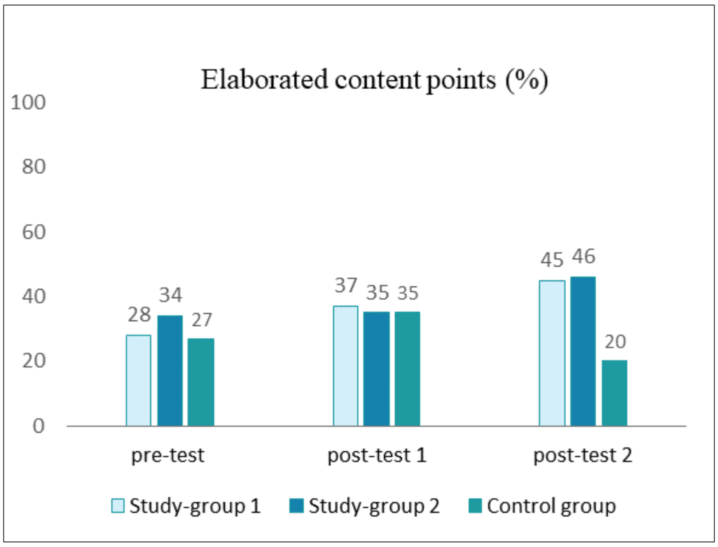

Table 6

Paired T-Test: Mean Value of Elaborated Content Points Between Pre-Test and Post-Tests

Study variable	Groups	Pre-Test		Post-Test 1		Post-Test 2		p-value
		Mean	(SD)	Mean	(SD)	Mean	(SD)	
Mean value of content points related to comparative concepts	S1	1.38	(1.54)	2.56	(2.53)			0.1308
	S2	1.58	(1.56)	2.67	(2.61)			0.2231
	CG	1.22	(1.30)	1.78	(1.56)			0.3251
	S1	1.38	(1.54)			3.50	(2.68)	0.0199*
	S2	1.58	(1.56)			4.17	(2.17)	0.0040**
	CG	1.22	(1.30)			1.69	(0.56)	0.8771

identified and as before, means were calculated in relation to the total number of content points.

Figure 4 and Table 6 show the results of this analysis. When contrasting the pre-test results of all three groups with their respective two post-tests, we see that all three groups improved slightly in developing their content points more. Initially, in the pre-test, the students developed an average of 26-34% of their content points. Then, in the first post-test, these data improved slightly for all, and finally, in the second post-test, the study group learners continued improving significantly on their initial results (see Table 6), whereas the control group decreased the amount of support provided for their content points.

In qualitative terms, the pre-and post-test extracts in examples 3 and 4 (Figure 5) show how especially the study group students learned to elaborate their content points more after the instruction phase.

As the pre-test (example 3) shows, most students presented content points without developing them further or connecting them with theoretical issues. By contrast, in the post-test (example 4), most study-group students improved considerably, clarifying their content points by presenting definitory and explicatory forms. Here, the student explains two biological concepts (cold-blooded and warm-blooded animals) by defining them, using several linguistic resources, such as explanatory and exemplifying forms ('this means'; 'for example'), conditional-if, a consecutive form ('as a result of') and an action verb ('to keep'). The underlying relationship is shown between the different contents (the blood groups, heat regulation mechanism, the environment and eating habits) and there is an attempt to derive a general scientific principle that reptiles are found in warmer climates due to their thermoregulation. This reveals a more complex and interrelated understanding of the contents and of typical scientific ways of proceeding (Schalk et al., 2016).

Figure 5

Pre- and Post-Test Example: Reasoning/Elaborating Students' Comparative Claims

(3) **PRE-TEST**	(4) **POST-TEST**
(...) Herbivores need to **eat a lot** but carnivores don't eat everyday. Herbivores stomach is **large** and has many chambers, but carnivores stomach is **simple**. Herbivores intestine is **big** and very **long** but carnivores intestine is **short and small** (...) (2CF)	(...) The **main difference** between the two groups is that reptiles are **cold-blooded** and **mammals** are **warm-blooded**. **This means that** reptiles' body temperature **depends on** their environment. **If** it is cold, their bodies are cold **too**. **However**, mammals can regulate their heat by themselves. **For example**, they get cooler through sweat. **As a result** of this difference, reptiles **normally** live in warm places, **but** mammals can live in any environment. Reptiles need less food or energy than mammals **to keep** their bodies warm. (...) (2CF)

Figure 6

Mean Percentages of Content Points Related to Comparative Concepts per Student

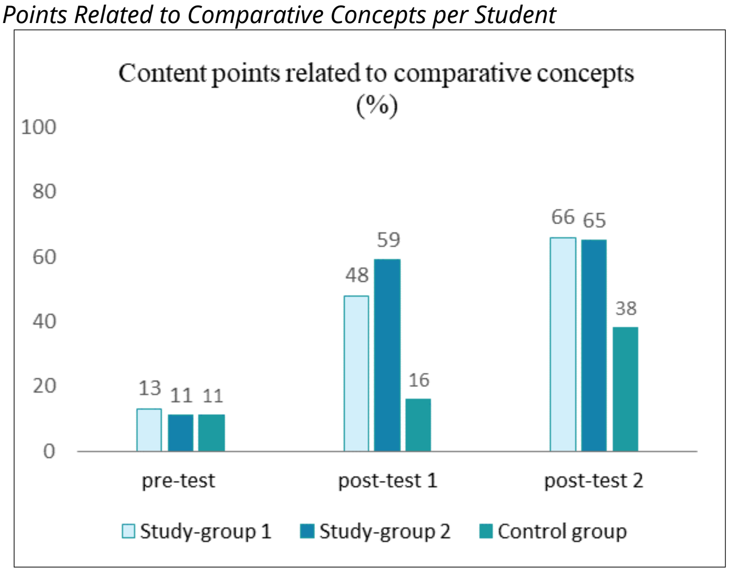

Table 7

Paired T-Test: Mean Value of Content Points Related to Comparative Concepts Between Pre-Test and Post-Tests

Study Variable	Groups	Pre-Test		Post-Test 1		Post-Test 2		P-Value
		Mean	(Sd)	Mean	(Sd)	Mean	(Sd)	
Mean value of elaborated content points	S1	0.50	(0.82)	2.75	(2.44)			0.0051 *
	S2	0.42	(0.90)	3.67	(2.84)			0.0059 *
	CG	0.44	(0.88)	0.67	(0.87)			0.4468
	S1	0.50	(0.82)			3.81	(2.76)	0.0001***
	S2	0.42	(0.90)			3.83	(2.72)	0.0009**
	CG	0.44	(0.88)			1.89	(1.76)	0.0563

Figure 7

Pre- and Post-Test Example: Using Comparative Concepts (Criteria)

(5) PRE-TEST	(6) POST-TEST
The herbivore animals eat plants and the carnivores eat meat, fish and eggs for example. The carnivores have canins and the herbivores not. The herbivores had large incissors to chop grass and carnivores no. (11AF) **(implicit criteria)**	First I'm going to compare the **legs** **(explicit criterion)** that they (reptiles and mammals) have. They can be legless or tetrapodal. Legless mean that they haven't got legs and tetrapodal means that they have 4 legs. Reptiles can be legless or tetrapodal. However mammals are tetrapodal, they have 4 legs. Second I'm going to explain how is their **habitat** **(explicit criterion)**. Both can live in a terrestrial and freshwater ecosystem. In marine ecosystem only can live reptiles. (11AF)

Content Points related to Comparative Concepts (Criteria)

Third, students' writings were examined on their ability to form comparative concepts (criteria) and base their search for similarities and differences on them. To measure this abstract ability, the number of content points that were explicitly related to a comparative concept using nominalisations, abstract nouns or main idea topic sentences was counted per student and phase, and averages were calculated in relation to the total number of content points (previously measured).

As Figure 6 shows, all post-test results from the three groups indicate a significant improvement (especially the second post-test). In the pre-test, the students only subordinated and introduced a few content points (about 12%), while in the two post-tests, this changed significantly, as the two study groups subordinated 35-54% more forms, and the control group learned to subordinate between 5 to 27% more forms. According to the paired t-test results (see Table 7), this improvement was highly significant for the study-group students (S1, S2) in their two respective post-tests ($p<0.05$), while for the control group, the improvement failed to reach significance.

From a qualitative perspective, the following pre- and post-test extracts from a study group student (Figure 7, examples 5 and 6), show the improvement process many study-group students went through, as they learned to relate diffuse content points under some corresponding superordinated concepts (criteria).

In the pre-test (example 5) two animal groups (herbivores, carnivores) are compared on their diet and teeth, but at no point are these two categories explicitly referred to, whereas in the post-test (example 6) the student explicitly names the comparative concepts in a topic sentence ('First I'm going to compare the legs'; 'Second I'm going to explain how is their habitat') and structures his/her comparative analysis on it.

These two examples show that explicit mention of the comparative concept (criterion) in a topic sentence is not an indispensable element when making a comparison, as both the pre-test (example 5) and post-test (example 6) are two valid comparative statements. However, it does show that

Figure 8

Mean Number of Lexico-Grammatical Comparative Forms Used per Student

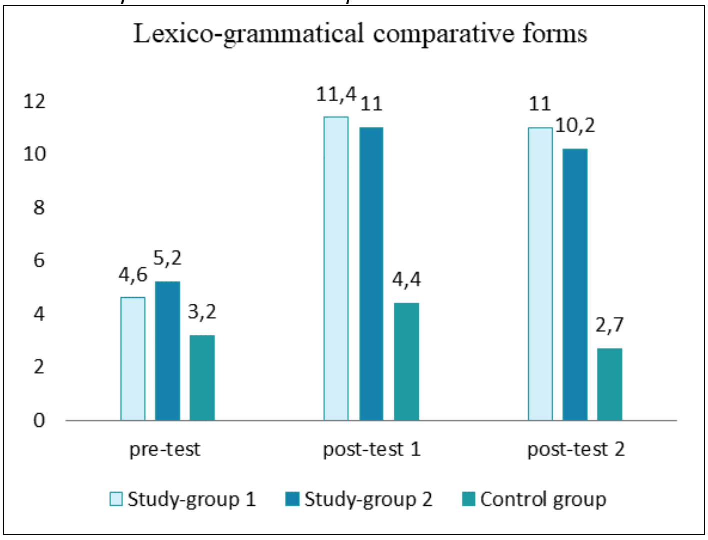

Table 8

Paired T-Test: Mean Number of Lexico-Grammatical Comparative Forms Used between Pre-Test and Post-Tests

Study Variable	Groups	Pre-Test		Post-Test 1		Post-Test 2		P-Value
		Mean	(Sd)	Mean	(Sd)	Mean	(Sd)	
Mean number of lexico-grammatical comparative forms	S1	4.94	(3.21)	11.38	(5.82)			0.0006 **
	S2	4.92	(3.68)	11	(7.38)			0.0145*
	CG	3.56	(2.01)	4.44	(2.79)			0.2495
	S1	4.94	(3.21)			10.81	(5.56)	0.0005***
	S2	4.92	(3.68)			11	(8.05)	0.00981*
	CG	3.56	(2.01)			2.78	(2.17)	0.4097

the comparison must have a common comparative point, because otherwise, it would not be a comparison but a description.

Use of Comparative Language (Comparitor)

In the second step, students' writings were analysed in terms of lexico-grammatical comparative forms, the 'comparitors' (Darian, 2003). There are three main types: contrast forms (such as 'is different', 'unlike'), comparison forms (like 'similar', 'equal to'), and grammatical comparative forms (such as 'less/more than'). In the analysis, all linguistic attempts that somehow indicated a comparative relation were counted, including forms with linguistic errors, as long as their communicative intention was understandable. Average numbers per student, group and phase were calculated. A total of 848 linguistic comparative forms were identified in the whole sample, among which 458 were contrasts, 216 were comparisons, and 174 were grammatical comparative constructions. These numbers can be explained by the fact that most of the content points presented were differences and there were few similarities.

As Figure 8 shows, the study group students learned to include considerably more lexico-grammatical forms after the instruction classes, progressing from using initially an average of 4 to 5 forms per student to including around 11 in their post-tests, which is a significant improvement ($p<0.05$) (see Table 8). On the other hand, the control group students also experienced a slight increase between their first and second writing (passing from 3 to 4 forms), but it quickly declined in their second post-test, where they returned to their initial starting point. It should be noted that from the beginning all groups already used some kind of linguistic comparative forms, which may suggest a certain prior familiarization with these forms acquired in their EFL classes.

The following pre- and post-tests (Figure 9, examples 7 and 8), illustrate how most study group students moved from an initial low and basic use of lexico-grammatical expressions (such as 'common'; 'both', 'different', 'but') towards a more

Figure 9

Pre- and Post-Test Example: Using Lexico-Grammatical Comparative Forms (Comparitor)

(7) PRE-TEST	(8) POST-TEST
Common: • Carnivore animals and herbivore animals, have a skull that protect their brain. • **Both** have a jaw that used to eat. **Different**: • Carnivores have: Incisors, Canines, Premolars and molars **that** used to eat. • Herbivores have: at the beginning they not have teeth, the have large cheving molars and premolars. (10CM)	**I'm gone a talk about** the physical of **both** groups. **Both** have a skin, reptiles' skin is covered by scales, **while** mammals' skin is covered by hair **that is** beneficial **for** heat themselves, **for advertising. Both** kinds of animals are tetrapodal **that means that** they have four legs **but** not always, **some** mammals **like** dolphins have flippers and **some** reptiles **like** snakes have not any legs, **so** they are legless. **So** leaving behind the physical **now can I talk about** their reproduction. **I'm sure** about you know the meaning of oviparous and viviparous. **Well in one hand** mammals are viviparous **that** they born from their mammas body and they are nursed with milk from mother glands, **but in the other hand** reptiles are viviparous, they lay eggs in the land. (10CM)

varied and combined use of advanced forms (such as 'while', 'whereas', 'on the one hand… on the other'), making their comparative claims more explicit.

The students had no great difficulties in picking up and using these forms; they probably knew them from their EFL class and they seemed to understand their functional purpose as they used them in the right place (to state a contrast and/or similarity). However, they had difficulties using them correctly, that is without making lexico-grammatical or orthographic mistakes. For example, they confused comparatives with superlatives, forgot about the suffix 'than' when using comparative grammatical forms or used incorrect word order or prepositions, which suggests inadequate grammatical, lexical and orthographic knowledge or perhaps lack of attention due to cognitive overload.

Moreover, as shown in example 8, the students were able to combine these forms with other linguistic devices, which had not been explicitly taught, which were probably transferred from their L1 and/or EFL classes. These include, consequence forms ('so'), the English possessive 's', explicative and defining forms (such as 'that means that', 'that is', 'like'), quantifiers ('some', percentages), and they developed some awareness to the need to guide readers and adopt a writerly stance, using future tenses, direct pronouns ('I', 'you'), discourse markers ('well', 'so'), temporal features ('now') and referring to a shared background knowledge ('I am sure about you know the meaning of …'). Their post-tests thus show greater literacy development by decentring (take distance) from the text and establishing a dialogue with the reader.

DISCUSSION

This paper has examined the teachability and effect of explicitly teaching CDFs in CLIL science.

As for the teachability of CDFs, the CLIL science and the English teacher had no difficulty in co-designing and delivering science lessons that integrated the CDF of *comparing*. They quickly understood that language not only refers to English (as L2) but to the language demands specific to science, which goes beyond learning a set of technical terms, but includes using abstract nouns and topic sentences to form concepts, supporting scientific claims through linguistic devices and using discursive structures and specific lexical-grammatical forms to express comparative relationships (Lemke, 1990; Mortimer & Scott, 2003; Evnitskaya & Morton; 2011; Rose & Martin, 2012; Nikula, 2017). A functional rather than formal approach was adopted to the study of language and content, where clarity (communicative intention) was favoured over form. That is why little attention was paid to grammatical and orthographic errors, so as not to overload students with corrections and avoid turning the class into a language class.

The intervention showed that teaching students how to compare from a scientific perspective and in a progressive, explicit and interactive way was extremely useful. A gradual learning path was chosen, which started by first co-defining the importance of *comparing* for learning natural sciences, then moved on to practise some of its constituent components, to review lexico-grammatical forms for expressing the emerging scientific knowledge better and finally to address textual organization in paragraphs and parallel structures. The language and cognitive support were only introduced in so far as they aided subject learning.

As for the effect of explicitly teaching CDFs on students' subject performance, significant results were obtained for the experimental groups, which improved in both content and language learning, when looking at the inclusion of content points, justification of scientific claims, concept formation and use of lexico-grammatical forms.

Based on the results, the study-group students moved from an initial, weak understanding of *comparing* towards a more proficient one as students learned to work harder on content and language. They included a greater number not only of differences but also of similarities and provided more specific, and task-relevant information. They also explained and linked their initially diffuse content points more, relying on linguistic devices (such as linking words, defining and explicatory forms) and clarifying the relationship between content concepts (i.e., blood type, environment and temperature), showing a clearer subject understanding. Moreover, the students also learned to structure their claims and make them more explicit as they related the contents to the superordinate concepts, introduced them with topic sentences and signalled comparative relationships using appropriate lexico-grammatical forms, indicating a more advanced linguistic command and proficiency in abstract reasoning. By and large, the explicit instruction helped students reach better scientific achievement levels as they developed more scientific concepts, practised scientific thinking (i.e., using similarities to establish class membership) and produced more sophisticated writing about science. The students understood that *comparing* in science is an inherent part of studying science, requiring certain cognitive and linguistic forms. The process of writing in science class, which is not frequently used, undoubtedly supported the students' learning process, helping them to plan, organise and visualise their scientific understanding in a linear and logical way (Schleppegrell & Colombi, 2005; Oliveira & Weinburgh, 2017).

Most of the pre-test results coincide with the findings made by other studies, which observed students' natural - that is, not-explicitly-taught - CDF performance in different predominantly secondary-level but also tertiary European CLIL contexts, (see Lose, 2007; Coetzee-Lachmann, 2009; Breeze & Dafouz, 2017; Lorenzo, 2017; Dalton-Puffer et al., 2018; Evnitskaya & Dalton-Puffer, 2020; Whittaker & McCabe, 2023). They show that students have difficulties performing CDFs when left on their own, often presenting them in an incomplete way, without including many concepts or explaining them in depth. Such was the case in the pre-test phase, where students failed to present the contents accurately and completely, doing so in a somewhat superficial way, lacking solid argumentation and supporting information. In addition, the students seem to prefer to focus on concrete, tangible content elements rather than relating them to abstract concepts (i.e., comparative criteria), a phenomenon that Evnitskaya and Dalton-Puffer (2020) have analysed in terms of horizontal and vertical content performance. As Nashaat-Sobhy (2020) explains, vertical performance of this kind is particularly challenging.

Overuse of horizontal content performance may be linked to weak conceptual and procedural knowledge, and an inadequate understanding of how knowledge should be displayed using CDFs (Breeze & Dafouz, 2017; Evnitskaya & Dalton-Puffer, 2020). Clear proof of this is that the students at first only superficially included similarity points, to comply with the task instruction, and failed to name the comparative concepts (criteria). It seems that if students are left on their own without explicit support, they have considerably more difficulty presenting the content points in a subject-purposeful way.

The post-tests are consistent with recent interventional studies (Connolly, 2019; Breeze & Gerns, 2019; Nashaat-Sobhy, 2020; Bauer-Marschallinger, 2022; Hasenberger, ongoing), showing how even general, non-explicitly focused CDF support can be very helpful in equipping students to display their content knowledge better, as was the case with the control group who received implicit CDF-based classes. When contrasting the study and control group's CDF-performance, interestingly, both groups did improve in terms of including differences and building comparative concepts (*criteria*). However, the control group did not progress in adding similarities, using lexico-grammatical forms or justifying their statements on their own. An implicit CDF-teaching approach seems to help students pick up some CDF-related features, probably the more familiar ones. In this sense, Breeze and Gerns (2019) reported improvements in a group of Spanish secondary CLIL history students who worked on academic writing skills involving the CDFs of 'describing' and 'explaining', leading to a higher number of content points and improved structure.

In more explicit studies, where the CDF of 'defining' was taught in Spanish tertiary education (Nashaat-Shobhy, 2020), the CDF of 'explaining' in German bilingual secondary chemistry classes (Connolly, 2019) and all seven CDFs were taught in Austrian CLIL secondary history and science classrooms (Bauer-Marschallinger, 2022; Hasenberger, ongoing), a reciprocal effect could be observed on students' content and language learning. It seems that teaching with CDFs helps students retain their subject knowledge better (Nashaat-Sobhy, 2020), increases their use of CDF-related expressions and linking devices (Bauer-Marschallinger, 2022; Hasenberger, ongoing) and fosters their self-confidence (Connolly, 2019). The present post-test results confirm that an explicit teaching approach has a stronger effect on students' integrated content and language learning, making them focus more on linguistic and structural features (such as comparitors, linking devices/sequential connectors, explanatory and defining forms, topic sentences, paragraph, and parallel organisation among others), which they would most probably not pay attention to if not prompted.

The results also show how teaching science through a CDF approach may require more time and practice since some points of the framework developed over a longer period (see delayed improvement in presenting similarities in the second post-test).

CONCLUSION

The CDFs construct offers content teachers a practical framework to unlock the importance of language and cognition in the teaching and learning of natural sciences, two dimensions that often receive little attention. This integration can be promoted in a natural way, since the content teacher can point out certain linguistic or cognitive aspects from the scientific perspective without resorting to more complex language models from the EFL class. One of the advantages of the CDFs is that they are basic knowledge-building blocks common to all school subjects (Morton, 2020) and thus inherent to science education.

Furthermore, the study demonstrates the integrated learning potential of CDFs, which can equip students to deal better with content, cognitive and language aspects in a CLIL science class. The CDFs help students advance in their conceptual knowledge and its corresponding language, something students are expected to develop during their years of schooling, which they will not learn in their language class or outside school. These functions, therefore, offer teachers a good starting point to introduce students to subject-specific ways of making meaning and communicating it appropriately, enabling them to participate in scientific discourse in and beyond school. It would thus be desirable that content teachers include more of these cognitive functions in their class input and output to help students in their knowledge-building process. For this, a gradual and collaborative learning path is recommended, making the conceptual, cognitive and linguistic demands visible to students, as most require support to notice and use these tools.

Some of the limits of the present study were the small sample size and the lack of variety between the different written tasks, which follow a similar task design based on a comparative analysis. It would have also been interesting to analyse teacher's and students' classroom interaction and have taught the CDF of *comparing* in another science class (e.g., chemistry).

Further research is therefore needed to operationalize the different CDFs across school subjects and levels, and to provide practical pedagogical tools to foster students' scientific knowledge in different CLIL contexts.

ETHICS STATEMENT

This study formed part of a research project, which was accepted by the Research Ethics Committee (CEI) of the University of Navarra (approval number 2019.164).

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DECLARATION OF COMPETITING INTEREST

None declared.

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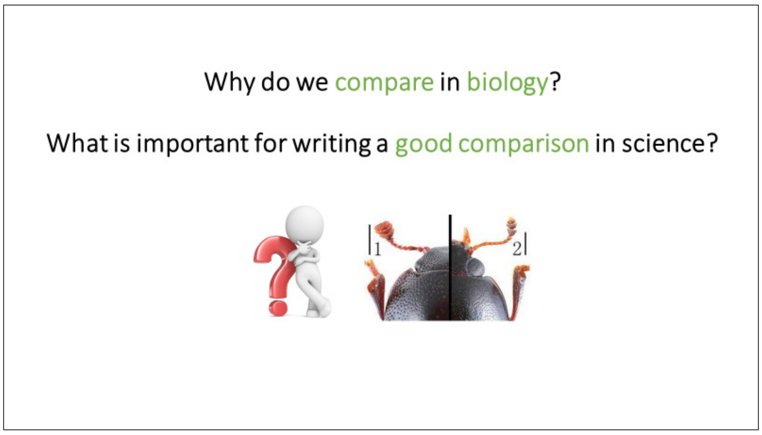
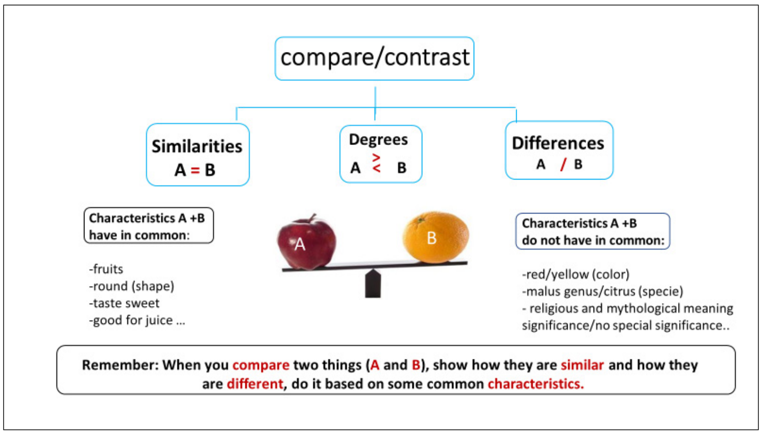
APPENDIX A

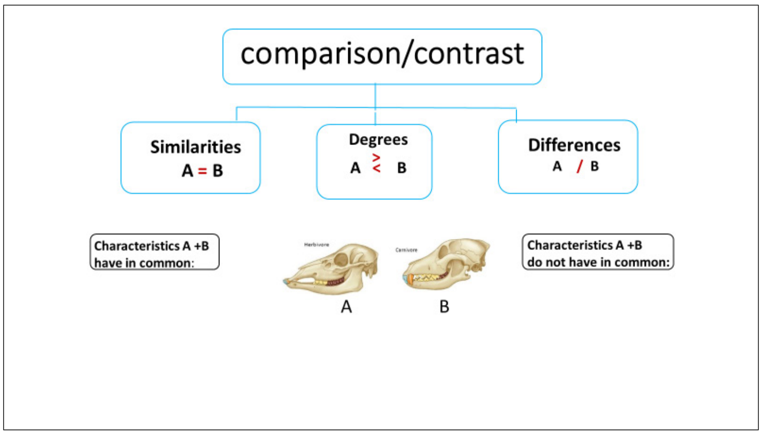
'*Comparing*' in science



APPENDIX B

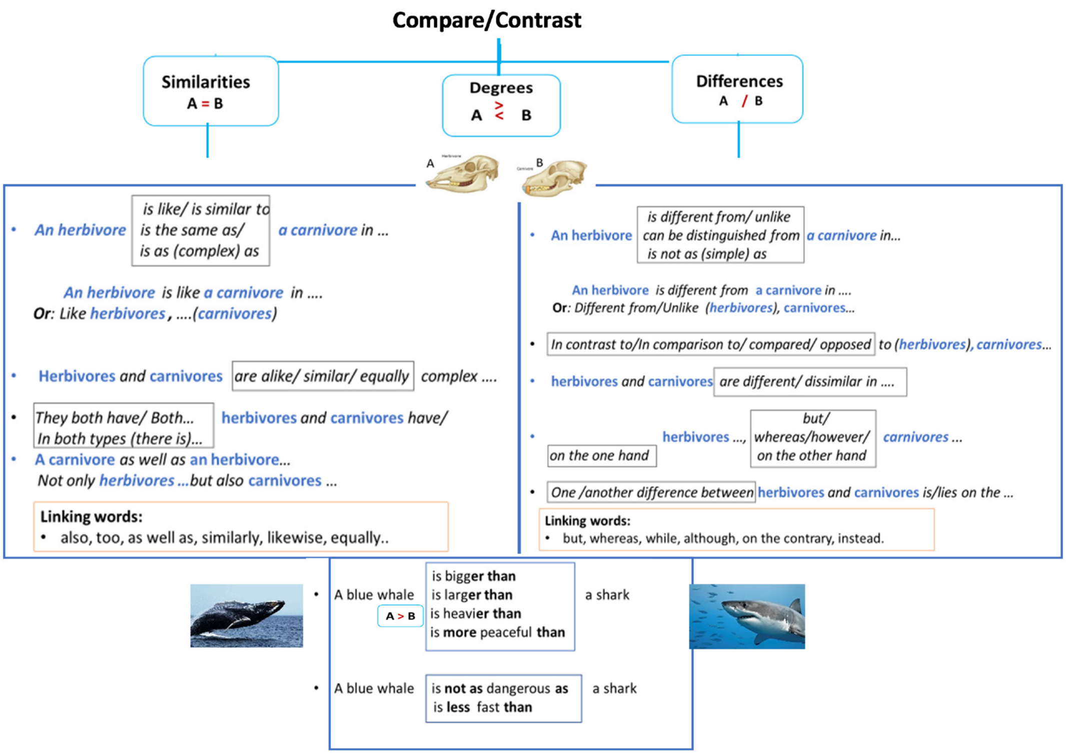
Components of the CDF '*comparing*'





APPENDIX C.

The language *of* and *for* comparing (lexico-grammatical forms; *comparitor*)



APPENDIX D

Individual written tasks

Please form sentences that indicate how herbivores and carnivores are different. To do this, use the contrast forms of the box. Do it as the example indicates.

Example:
***1**. Herbivores are plant eaters, **while** carnivores are meat-eaters.*
***2**. Herbivores have a tooth set that **is very different from** carnivores in…*

3.
4.
5.
6.

Expressions for contrast

- **An herbivore** [*is different from/ unlike* / *can be distinguished from* / *is not as (simple) as*] ***a carnivore** in…*

  An herbivore *is different from* **a carnivore** *in ….*
  Or: *Different from/Unlike (**herbivores**), **carnivores**…*

- [*In contrast to/In comparison to/ compared/ opposed*] *to (**herbivores**), **carnivores**…*
- **herbivores** *and* **carnivores** [*are different/ dissimilar in ….*]
- [*on the one hand*] **herbivores** *…,* [*but/ whereas/however/ on the other hand*] ***carnivores** …*
- [*One /another difference between*] **herbivores** *and* **carnivores** *is/lies on the …*

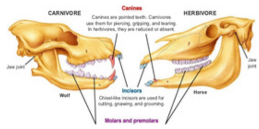
Linking words:
- but, whereas, while, although, on the contrary, instead.

APPENDIX E

Reading and writing tasks

1. Read the following text with your neighbour. Identify comparative **SIGNAL WORDS**. Circle the ones indicating a **similarity in green** and the ones indicating a **difference in red**. Fill these expressions in the table below.

Signal words	
similarity	difference



2. In the text, go paragraph by paragraph and identify the **main idea** on which the two animals (herbivores and carnivores) are compared. In the first paragraph, for example, carnivores and herbivores are compared on their diet. Now try to figure out what these main comparative points are for the other paragraphs.

3. Find out what the text says about the concrete **differences** and **similarity**. What do the two groups have or do not have in common? Include this information in a Venn diagram or a table. Good luck! 😉

Differences and similarities between herbivores and carnivores

In the animal kingdom, two major kinds of animals can be distinguished. These include **herbivores** and **carnivores** that will be compared.

Type of food/ Diet

1.Herbivores, as well as **carnivores**, are similar in being **heterotrophs**. This means both animal groups **depend on others** for food. They require another living thing to live. But, having a closer look at **the concrete type of food** they eat, they differ. **Herbivores** refer to those animals that **consume only plants**. This includes **leaves[1], grains[2]** and **seeds[3]**. In contrast, **carnivores** are those animals that eat **meat** to survive[4].

2.Determining **whether a** particular **animal is** a **herbivore** or a **carnivore** is **not just** limited to merely **observing** what **particular type of food** they eat, but by simply looking at the **skeletal remains**[5]: at their **teeth.** Both groups possess an identifiable tooth set that allows them to eat. On the one hand, **herbivores** have **broad, flat canines**[6], sometimes they are even absent, and with **large, dull incisors[8]**. This helps them to properly **grind**[9] **the fibres** found in plants and **crush seeds and grains**. On the other side, **carnivores** have teeth proper to a hunter with **large, pointed canines** and short**, sharp incisors.** This allows them to **tear[10] through skin** and muscle and **chew**[11] **the meat** from their **prey[12].**

3. Another comparable feature is the **nails**. **Herbivores** have **flattened nails[13]** or blunt **hooves**[14]**.** C**arnivores** have **sharp claws[15]** instead**.** Again, the difference between the **nails** has to do with **the type of food** they eat. **Carnivores** have to **hunt and kill** their **pre**y to eat their **flesh**, and these **claws help** them leave their **prey helpless.**

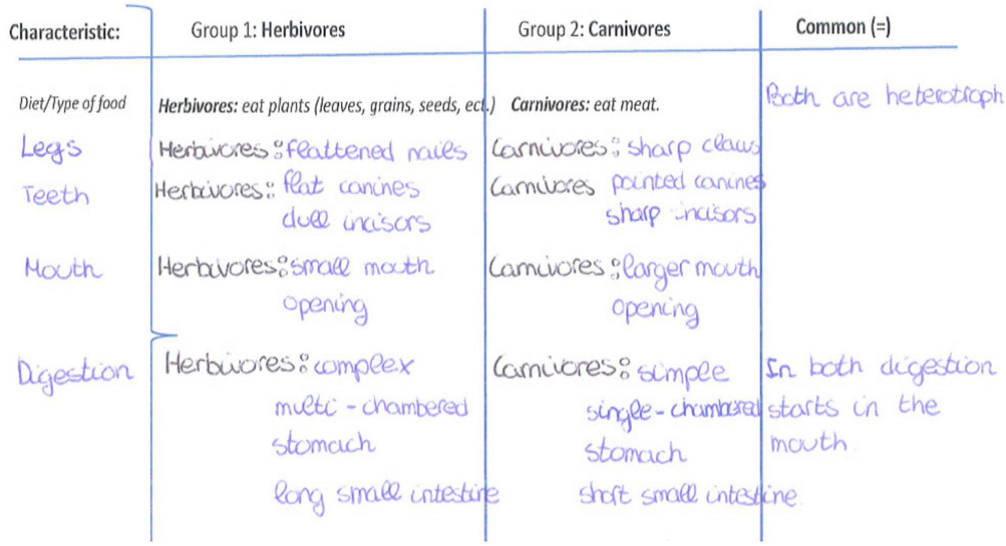
4. In line with this, there is also a difference in the **size[17]** of the **mouth opening** with the **size of** the **skull[18].** As **herbivores** only **eat plants**, their **mouth opening** is relatively **small** compared with their **head size**. In contrast, **carnivores** have **larger** mouth openings. This is because carnivores do **not just use** their **mouths to eat but** utilize their sharp teeth **to attack and kill** their prey.

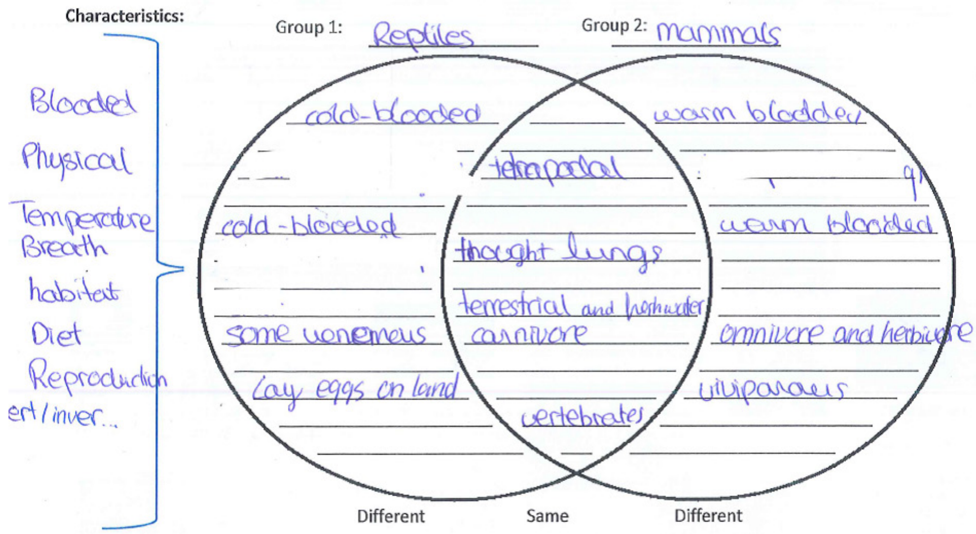
5. A last point to be compared is the **digestive system** of both groups. As digestion starts in the mouth, by breaking down the food into smaller pieces, in both cases, their **teeth are indispensable** for this process. Nevertheless, digestion is not as complex in **carnivores** as in **herbivores**. **Carnivores** have a very **simple, single-chambered stomach** because the **meat** is relatively **easily digested**. Hence[19], their **small intestine** is quite **short** too. On the contrary, **herbivores** that consume high amounts of **plants**, difficult to digest must do **a lot of chewing**. That is why they have a **complex, multi-chambered stomach** and a **long small intestine**.

Concluding, **herbivores** only **utilize** their **flat**-based, dull **teeth for consuming food** (plant leaves, seeds and grains) which is why they **only have small mouth openings**. While **carnivores** **use** their **sharp incisors and canines** as a weapon[20], making it necessary for their **mouth openings** to be relatively **larger**.

APPENDIX F

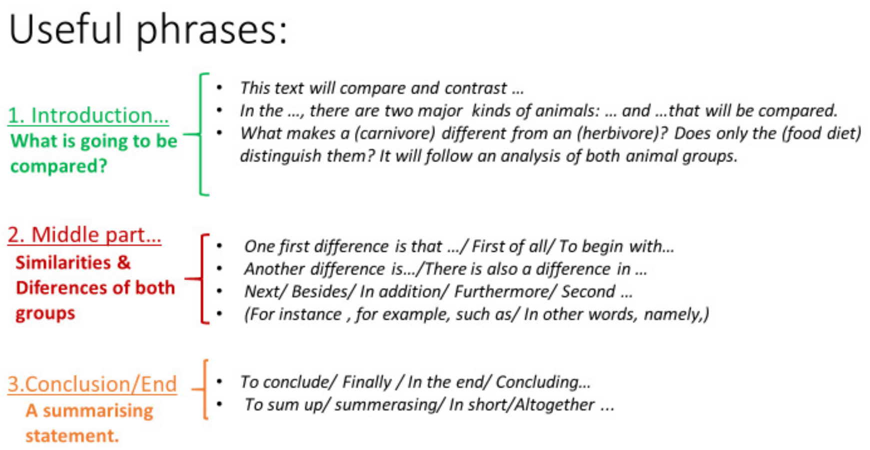
Examples of students' responses





APPENDIX G

General structure of a comparison and useful starting sentences



APPENDIX H

Useful framework to redo your first comparison

Remember!! Steps for writing a scientific comparison:

1. **Identify** the groups, that will be compared.
2. **Make a brainstorming** on **characteristics** both groups have in common (**similar**ities) or not (**differen**ces). (Do not list irrelevant information!) (Note them in a Venn diagram or tablet).
3. **Order the points logically.**
4. **Time for writing.**
   Give your text a structure!
   (1. Introduction,**2.** Middle part (Point-by-point Method), **3.** Conclusion).
   Start with an **introduction.**
5. **Link isolated ideas** and **use signal words** to stress **similarities and differences**.
6. Do not forget a summarising **conclusion**! 😉