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Characterizing CLIL teaching: New insights from a lower secondary classroom

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Abstract

As a bilingual teaching method, Content and Language Integrated Learning (CLIL) is growing in popularity in Europe and research has primarily focused on (language) learning outcomes. Few studies have identified what characterizes teaching in the CLIL classroom in terms of content and language integration. Studying how CLIL is practiced is vital to understanding how it works and how students can benefit from it. In this study, we filmed and observed CLIL lessons in science and mathematics in a 9th grade, Norwegian CLIL class offering subjects in English. The present study uses *The Protocol for Language Arts Teaching Observation* (PLATO) to analyze video-recordings of CLIL lessons in science and mathematics, emphasizing a within-CLIL focus, and compared this with the English language teaching in the same class, as a baseline. Our findings indicate content-driven and intellectually challenging CLIL teaching with clear instructional explanations and systematic language support. English was used as frequently in the CLIL teaching as in the English teaching. Content and language were clearly integrated in the observed CLIL lessons, underscoring that the CLIL teachers successfully conveyed their subject in the target language.

Keywords: CLIL teaching, CLIL pedagogy, Content and Language Integrated Learning, teaching practices

Introduction

A central research approach to understanding the Content and Language Integrated Learning (CLIL) methodology is identifying what happens in the CLIL classroom. Despite the growing body of CLIL research in Europe, its focus has primarily been on language outcomes in the form of tests (Brevik and Moe 2012, Coyle 2007, Georgiou 2012, Lasagabaster and Ruiz De Zarobe 2010, Llinares 2015). While recent years have shown a growing number of studies that focus on the interplay between content and language learning (e.g. Llinares, Morton, and Whittaker 2012, Nikula, Dafouz, et al. 2016), researchers have argued that large areas of CLIL teaching remain uninvestigated, especially content (cf. Cenoz, Genesee, and Gorter 2014, Fernández-Sanjurjo, Fernández-Costales, and Arias Blanco 2017). Studies on CLIL classrooms have mainly focused on language use (Dalton-Puffer 2007, Dalton-Puffer, Nikula, and Smit 2010, De Graaff et al. 2007, Escobar Urmeneta 2013, Nikula 2010, 2015, Tavares 2015).

Recent research on CLIL has emphasized that integration should be a practical implementation as well as a theoretical lens (Llinares 2015, Ruiz de Zarobe and Cenoz 2015). Researchers therefore need to describe CLIL teaching practices to address 'the significant gap between CLIL theory and CLIL practice'. To close this gap, two areas in need of further research have been suggested, namely how CLIL is practiced, and how content is approached by the CLIL teachers (Admiraal, Westhoff, and De Bot 2006, Dalton-Puffer 2011). The present study addresses these issues by analyzing actions captured by video observations of naturalistic CLIL teaching in science and mathematics. The aim is *to identify what characterizes CLIL teaching in science and mathematics in terms of content and language when taught in English as a second language.* Our approach is pedagogical and holistic, focusing on the nature of the content subjects as well.

Reviewing research on the CLIL classroom

One of the underlying justifications of CLIL is that students will benefit from it. This is referred to as the 'added value' of CLIL, understood as what CLIL contributes to the classroom that language and content subjects separately do not (Ball, Kelly, and Clegg 2016, Coyle, Hood, and Marsh 2010, Dalton-Puffer 2007, Marsh 2002). The most commonly cited advantage is the added opportunities to speak a foreign or second language (L2) in another subject. Research indicates that some skills seem to be positively affected by CLIL teaching (listening and reading) (Admiraal, Westhoff, and De Bot 2006, Brevik and Moe 2012, Dalton-Puffer 2007, Lasagabaster and Ruiz De Zarobe 2010, Vollmer 2008). However, CLIL's added value has not been argued on the basis of classroom observations. Observational studies have largely used video and audio data from CLIL classrooms to describe patterns of discourse (see Dalton-Puffer 2007, Evnitskaya and Morton 2011, Llinares and Whittaker 2007, Moore 2009, Morton and Llinares 2016, Nikula 2010, 2005, 2015, Relaño Pastor 2015). We argue that observation can additionally be used to describe the 'range and practices by CLIL teachers,' which Van Kampen et al. (2016) refer to as CLIL pedagogy.

Van Kampen, Admiraal, and Berry (2016) analyzed survey data and interviews among CLIL and non-CLIL teachers, and argue that CLIL teaching is more interactive and dialogue-based than non-CLIL teaching, which corroborates findings from discourse analysis (Dalton-Puffer 2007, Dalton-Puffer, Nikula, and Smit 2010). Van Kampen, Admiraal, and Berry (2016) note that the weakest point of CLIL teachers' self-reported practices is their awareness and use of subject-specific literacies.

Another study concerns classroom observations of CLIL practices (De Graaff et al. (2007). To the best of our knowledge, this is the only CLIL study using an observation manual to determine successful practices. The study uncovered that CLIL teachers use a range of effective language teaching tools, including authentic materials and visual aids. In accordance with Van Kampen, Admiraal, and Berry (2016), neither CLIL teachers nor English teachers focused on correcting students' use of English. Instead, content subject teachers offered implicit language support (De Graaff et al. 2007, 620).

The 'disparate nature' of CLIL research combined with the many varieties of CLIL makes it difficult to characterize CLIL teaching, particularly since each content subject has its own needs and traditions (Van Kampen, Admiraal, and Berry 2016). Studies suggest that students who study science in their first language (L1) perform slightly better in the content subject than their CLIL counterparts (Fernández-Sanjurjo, Fernández-Costales, and Arias Blanco 2017), while CLIL science students largely improve their reading, writing, and grammar compared to non-CLIL science students (Pérez-Vidal and Roquet (2015). Although teachers who teach science in L1 have a wider repertoire of meaning-making, which gives nuances in instructional explanations (Nikula 2010), using L2 can facilitate science learning because CLIL teachers feel the need to plan lessons in greater detail (Grandinetti, Langellotti, and Ting 2013, Nikula 2010).

CLIL mathematics research has primarily focused on the relationship between content and language, and results are mixed. Studies have suggested that mathematics students at the university level do not understand lectures or how to 'talk in math' in L2, CLIL students who are provided contextual language clues in arithmetic problems outscore students who do not (Miqdadi and Al-Jamal 2013, Van Rinsveld et al. 2016), and language scaffolding in CLIL mathematics unfolds similarly as in language teaching (Tavares 2015). These studies suggest that language is crucial to mathematics teaching, with a need to clarify the relationship between mathematics and language.

We conclude that CLIL teachers and students use many linguistic resources, but there needs to be a more systematic focus on how to scaffold content learning through language (Dalton-Puffer 2007, Dalton-Puffer, Nikula, and Smit 2010, Miqdadi and Al-Jamal 2013, Van Rinsveld et al. 2016). Furthermore, research needs to clarify how content is taught in CLIL teaching, with focus on subject-specific features (Meyer et al. 2015, Van Kampen, Admiraal, and Berry 2016). By observing how CLIL is taught in terms of content and language integration, our study aims to shed light on how CLIL science and mathematics teachers teach their respective subjects in L2. Bearing the aforementioned research gaps in mind, our study poses the following research question: *What characterizes CLIL teaching in science and mathematics in terms of content and language when taught in English as a second language?* In order to examine this research question, we observe classroom teaching for the same students in both CLIL subjects. We have also decided to include observations of English lessons for this class, to use their L2 teaching as a baseline to understand how English functions in their language subject, as done in other research (Nikula 2010).

Conceptualizing integration in CLIL

According to Vygotsky, learning is a social activity (Vygotsky et al. 1978, Wertsch 1985). There is an intricate relationship between mental processes and communication, meaning learning is heavily imbued in social interaction (Hickmann 1985, Mercer 2004). In line with Vygotsky, 'the most significant moment in the course of intellectual development […] occurs when speech and practical activity, two previously completely independent lines of development, converge' (Vygotsky et al. 1978, 24). Classroom talk, in this sense, becomes the 'chief locus of knowledge construction,' as subjects are 'talked into being' (Dalton-Puffer 2016, 29). Integration theories that operate on a local level (i.e., the classroom) are therefore often situated within a sociocultural framing (e.g., Evnitskaya and Morton 2011, Morton and Llinares 2016, Llinares and Whittaker 2010, Nikula 2010).

Following Vygotsky's thought, learning a subject is the process of becoming a member of a certain community (Sfard 1998, 6). In this view, 'content' and 'language' are complex processes that one cannot simply acquire, but rather participate in. Students must not only know and understand concepts in, for instance, science, but also be able to think, speak and write scientifically. Subjects are considered the result of historical processes, in which researchers and teachers are 'socialized in specific discourses and practices' (Nikula, Dalton-Puffer, et al. 2016, 7-8). The use of language depends on the content subject, which can vary in its structure of discourse and vocabulary (Shanahan and Shanahan 2012). Concepts which are gaining foothold in this direction include pluriliteracies (Meyer et al. 2015, Meyer and Coyle 2017) and disciplinary literacy (Airey 2015, Shanahan and Shanahan 2012). These concepts resist language as generalized skills that can be applied across the curriculum, instead focusing on language skills necessary to understand the individual content subject.

Many CLIL scholars have attempted to clarify the integration between content and language (e.g., Berger 2016, Gajo 2007, Llinares 2015, Lorenzo 2007). Content is considered the antithesis of language, defined as 'any topic, theme, or non-language issue' (Genesee 1994, 3). Language, on the other hand, has often been perceived as developing 'skills in speaking, reading and writing, which are readily transferable to other areas of the curriculum' (Davison 2005, 221). CLIL scholars argue that what separates CLIL from other types of bilingual education is its preoccupation with integrating the two; seeing content and language as 'emergent synergies' that create a whole (Coyle, Hood, and Marsh 2010, 27). In our view, integration's goal is to draw on aspects of content and language teaching optimally in the classroom to foster learning.

However, there are some problems in conceptualizing and realizing the potential of integration (Gajo and Serra 2002, Llinares 2015). For example, integration might entail ‘mapping the characteristics and interplay of content and language,’ (De Graaff (2016, xiii). In this sense, integration is not about simply adding content and language to a sum or applying language goals and methods to content subjects. Instead, it involves establishing the role and needs of content and language for each subject, as ‘an integrated perspective on content and language is not the same in history as in physics teaching’ (De Graaff 2016, xv).

It is acknowledged that literacy, in the fundamental and derived senses, is a crucial part of science (Norris and Phillips 2003). The fundamental sense is based on the essential role of text in science and involves reading, writing, and being fluid in the discourse patterns and communication systems of science. The derived sense involves being knowledgeable and educated in science, and being able to take a critical stance on information (Norris and Phillips 2003, Ødegaard et al. 2014). Mathematics requires a different approach. On the one hand, mathematical language has long been considered a language in its own right (Pimm 1987). Berger (2016) argues that although there are symbols and terminology unique to mathematics, ‘mathematical content or understanding is inconceivable without the flexibility of everyday language’ (Berger 2016, 75). Barwell (2005) concurs, emphasizing the need to understanding mathematics classroom problem genres (e.g., how to solve tasks), as well as solving them using subject-specific terminology. These understandings point to the importance of subject-specific literacies. In our study, we have used subject-specific literacies as a lens for understanding how the CLIL teachers teach the subjects within the context of its tradition. This has also aided us in understanding the use and role of language in science and mathematics.

CLIL in Norway

In Norway, CLIL is defined as teaching 30% or more of the curriculum in content subjects in a language other than L1 (Brevik and Moe 2012, Hellekjær 2005). The first CLIL initiative was sponsored by the Norwegian Ministry of Education and Research in 1993 (Svenhard et al. 2007). Since then, CLIL has been a grassroots initiative. Implementing CLIL is the responsibility of the individual county, school, or teacher. CLIL teaching varies between schools, including the number of CLIL subjects offered and the languages used. Although most CLIL initiatives use English as the teaching language, some at primary and lower secondary level have used French and German (Svenhard et al. 2007). The majority of CLIL classes in Norway are at the upper secondary school level, and a survey in 2004 indicated that 4–7% of upper secondary schools offered some form of CLIL teaching (Svenhard et al. 2007). To the best of our knowledge, few lower secondary schools offer CLIL teaching in in Norway, and only one of these has done so consistently over time (since 2011). Little prior research has been conducted in these classrooms, which is why we do so in the present study.

Methods

To infer CLIL practices, we sought characteristics of CLIL teaching in mathematics and science in naturalistic video data. During the 2015–16 school year, the Linking Instruction and Student Experiences (LISE) team collected data from one CLIL classroom. Four consecutive lessons in two CLIL subjects (science and mathematics), in addition to English L2 lessons, were filmed in the same class. This totaled 12 lessons (60 minutes each). The data enabled us to identify aspects of integration across CLIL subjects, and use the English lessons as a baseline concerning L2 language use.

Sample

Our sample was a 9th grade CLIL class in a Norwegian public school (ages 14–15). Students must apply for the CLIL program, taking an English reading test and an interview to prove their English level. The participants are the science, mathematics, and English teachers (*n=3*), and the students of the CLIL class (*n=26*). Table 1 offers background information on the teachers, including CLIL experiences.

Table 1. Teacher background information

Subject	**Gender**	**L1**	**Teacher education**	**Education in the subject**	**Teaching experience**	**CLIL teacher**
Science	Female	English	Yes	60 ECTS	6 years	6 years
Mathematics	Female	Norwegian	Yes	30 ECTS	2 years	1 year
English	Male	Norwegian	Yes	300 ECTS (Master's degree)	3 years	1 year

Note. ECTS = European Credit Transfer and Accumulation System.

Video recordings

Video recordings are valuable in classroom analysis due to the possibility of systematically investigating complex educational settings and deconstructing qualities of teaching (Blikstad-Balas 2016; Snell 2011). Our design relied on two cameras: one small, wall-mounted camera at the back of the classroom, facing the teacher; the other at the front, facing the whole classroom. We had two microphones; one on the teacher, the other capturing student conversations.

Data analysis

We analyzed the video data using the *Protocol for Language Arts Teaching Observation* (PLATO) (Grossman et al. 2010). PLATO is particularly relevant, as it is designed to assess content and language aspects of teaching. Despite PLATO's focus on language arts teaching, it has already been used to study mathematics teaching in the US, Finland and Norway (Cohen et al. 2013, Cohen et al. 2016, Kane and Staiger 2012, Klette and Blikstad-Balas 2017, Klette, Blikstad-Balas, and Roe 2017, Luoto, Klette, and Blikstad-Balas under review, Stovner 2018). We applied it to CLIL teaching in mathematics and science.

PLATO consists of 13 elements considered to represent effective teaching (e.g., Klette and Blikstad-Balas 2017). Among these elements, we have chosen six that comply with the CLIL conceptualization of content and language integration. We used these elements in our data analysis to infer CLIL characteristics in the observed lessons, including integration of content and language (see Table 2). PLATO scores on a scale from 1–4, and assigns scores for every 15-minute segment of video data. Each recorded lesson lasted for approximately 60 minutes and was divided into 15-minute segments for analysis. Low-end teaching indicates there is no evidence (score 1) or little evidence (score 2) of the element in question. High-end teaching indicates evidence with some weaknesses (score 3) or strong and consistent evidence (score 4).

Table 2. Content and language features of teaching, based on six PLATO elements (Grossman 2015)

	1: Almost no evidence	**2: Provides limited evidence**	**3: Provides evidence with some weaknesses**	**4. Provides strong and consistent evidence**
PUR	No clear learning goal or unrelated to disciplinary skills	Communicated or inferred goal, as a general disciplinary topic	Communicated, specific goal related to development of disciplinary skills. Activities align with goal	Communicated, specific goal related to development of disciplinary skills. Activities align with goal. Evidence of student awareness. Teacher refers back to goal.
ROC	*Instructional explanations:* Weak or incorrect explanations of disciplinary concepts. *No conceptual richness*	*Instructional explanations*: Incomplete explanations touch on surface-level features of subject content. *Conceptual richness*: Superficial representation, focusing on rules, labels, procedures. Little attention to deeper understanding.	*Instructional explanations*: Accurate but un-nuanced explanations of disciplinary concepts. May address student misunderstandings. *Conceptual richness*: A balance of rules, labels, procedures. Attention to deeper understanding.	*Instructional explanations*: Accurate and clear explanations, addressing student misunderstandings and highlighting nuances. *Conceptual richness*: Conceptual understanding of content beyond the superficial to focus on interpretation or deeper understanding.
IC	Activities are rote/recall	Mostly rote/recall, some analysis/inference	Mostly analysis/inference/ idea generation/interpretation	Mostly sophisticated or high-level analytic and inferential thinking
CD	*Opportunities*: Few or no opportunities for student talk. *Uptake*: Few or no response to students' ideas.	*Opportunities*: Occasional opportunities for student talk. *Uptake*: Brief responses with no elaborative discussion or help to develop.	*Opportunities*: Opportunities for student talk for at least 5 min. Only 2-3 students participate. *Uptake*: Teacher occasionally builds on student ideas (re-voices in academic language, asks for elaboration).	*Opportunities*: Opportunities for student talk for at least 5 min. The majority participates by speaking and/or listening. *Uptake*: A consistent engagement in high-level uptake.
TBI	*Use*: No authentic text present. *Production*: No opportunities for students to engage in writing.	*Use*: Refers to details in authentic text. *Production*: Brief pieces of connected text (at least 3 min).	*Use*: Active use of authentic text to gain understanding. *Production*: Sustained opportunities in a particular genre or structure (at least 7 min).	*Use*: Active use of authentic text for a sustained period of time (at least 7 min). *Production*: Sustained opportunities with attention to issues of writing, style, or genre (at least 7 min).
ALL	*Materials*: No supportive materials. *Academic language*: Teacher does not introduce, define, or prompt use of academic terms.	*Materials*: Teacher provides relevant supportive materials, but are not used. *Academic language*: Teacher rarely introduces, defines, or prompts academic terms.	*Materials*: Teacher provides and prompts use of relevant accessible, supportive materials. *Academic language*: Teacher introduces, defines, and highlights academic language.	*Materials*: Teacher provides and prompts use of relevant materials. Evidence of use. *Academic language*: Teacher consistently introduces, defines, and highlights academic language. Students have multiple opportunities to use them.

Note. PUR = Purpose. ROC = Representation of content. IC = Intellectual Challenge. CD = Classroom Discourse. TBI = Text Based Instruction. ALL = Accommodations for Language Learning.

Purpose (PUR) examines how the purpose of a lesson is made explicit by the teacher and reflected in student activities (Grossman 2015). We used this element to investigate if the goals of the CLIL teaching were primarily content- or language-driven (Banegas 2016, Lasagabaster 2008, Met 1999).

Representation of content (ROC) denotes the teacher's accuracy in talking about their subject (Grossman 2015). PLATO differentiates between *instructional explanations* (how the teacher explains the content) and *conceptual richness* (the type of explanations offered). Accuracy means that the teacher adequately provides a sufficient level of explanation (score 3), although the explanations are not necessarily nuanced in ways that help students distinguish among different features of related ideas (Grossman, 2015). Conversely, the examples, analogies, and/or explanations are not sufficiently complete to explain the concept, and only touch on surface level features of the content (score 2). As for conceptual richness, we differentiate between explanations that focus on deeper conceptual understanding (score 4), explanations that mainly focus on conceptual understanding (score 3), and superficial explanations that mostly focus on procedures, rules, or labelling terms (score 2). ROC is of relevance, as CLIL teachers often express concerns about talking accurately about their subject through L2 (Maasum et al. 2012, Pérez-Cañado 2016, Šulista 2012).

Intellectual challenge (IC) represents the intellectual rigor of student activities, including student–teacher conversations (Grossman 2015). PLATO differentiates between low-level (rote and recall) and high-level activities (analyzing, synthesizing, and interpreting). IC enables us to observe if content and language are integrated enough for students to understand material and complete tasks (Coyle, Hood, and Marsh 2010).

Classroom discourse (CD) examines what formats and how much speaking time the students are provided (*opportunity*), and how the teacher responds to and builds on student ideas (*uptake*) (Grossman 2015). Opportunities for conversations about subject content is evidence toward low-end (score 2) if the conversations last less than one third of the segment, and evidence toward high-end (score 3 and 4) if the conversations last longer, stay on track, and include open-ended questions. Identifying how teachers and students talk is motivated by research suggesting that CLIL offers student-talking opportunities and high-quality conversations (Dalton-Puffer 2007, De Graaff et al. 2007, Nikula 2010).

Text-based instruction (TBI) relates to how teachers approach reading and writing in the classroom (Grossman 2015). TBI differentiates between use of texts (reading) and production of texts (writing). This establishes the opportunities for student engagement with texts, acknowledging the subject-specific reading and writing conventions. PLATO states that 'authentic texts' comprises published material, student-generated work, pieces of music or art, graphs, tables, or film/video used for teaching. Research indicates that writing opportunities in the CLIL classroom are limited, and often viewed as homework activity (De Graaff et al. 2007).

Accommodations for Language Learning (ALL) refers to strategies teachers use to make lessons available to L2 speakers through *supportive materials* and *academic language* (Grossman 2015). Supportive materials include visual aids that enable students to understand a lesson in L2. Academic language denotes subject-specific terminology related to the content of the lesson at the low end (score 2), including the teacher's strategic use of L1 to explain or prompt terminology. At the high end (scores 3–4), academic language consists of features to describe complex ideas, abstract concepts, and cognitive processes (thinking skills); including the discourse level (communicate, clarify and negotiate meaning), syntactic level (make messages, paragraphs, and sentences clear and correct), and lexical level (choose and use the best terms to convey meaning). In CLIL teaching, academic language instruction is needed for L2 learners who might struggle to understand and use the language of mathematics and science. When CLIL teachers provide language support, the amount may depend on the age or skills of the students (De Graaff et al. 2007, Harvey et al. 2013).

Research credibility and ethics

Several precautions were taken to ensure the trustworthiness of this study (Creswell 2009, Peräkylä 2011). First, following the ethical guidelines of the Norwegian Center for Research Data, written and informed consent was provided by parents, students, and teachers (NESH 2006). Second, using PLATO ensures the research is less prone to personal interpretations and allows for comparability (Klette and Blikstad-Balas 2017). The segments were coded by certified PLATO raters. 25% of the observations in each CLIL subject were double-scored by experts in the respective subjects to ensure high levels of ongoing interrater agreement (≥ 80% exact-score agreement) (Cohen et al. 2016, 8).

A possible limitation of this study is that it will not capture all aspects of CLIL teaching, since the PLATO manual is not designed specifically for CLIL instruction. However, based on its use in the aforementioned prior studies of mathematics teaching in the US, Finland and Norway, and our own analysis, we believe that PLATO is nevertheless a useful tool in our study. The small sample does not allow for generalizability either (Johnson and Christensen 2014). However, the present study is concerned with how CLIL is practiced in a specific setting, with no intention of generalization. Therefore, we believe our design provides valuable data on the characteristics of CLIL teaching.

Results

Results indicate that the CLIL teaching in science and mathematics addressed distinct characteristics relating to the integration of content and language. Both CLIL subjects were taught in English L2. Although the CLIL teachers offered language support and numerous opportunities to speak, there were few opportunities for reading and writing. The CLIL teaching was content-driven, with rich explanations, and intellectually challenging.

Language features of CLIL teaching

In the CLIL lessons, teachers and students spoke L2 90–98% of the time, confirming a systematic L2 presence. Notably, L2 was used as much in the CLIL subjects as in the L2 subject. The CLIL teachers largely used L1 for administrative purposes, and to aid the students in understanding the content subjects.

Academic language (ALL)

While L2 seemed to be used in effective ways to scaffold content learning in the CLIL subjects, there did not appear to be any explicit focus on L2 apart from consistent use of academic language. Both CLIL teachers used subject-specific terminology throughout their lessons (minimum score 2), but varied the extent to which they defined (score 3) or prompted students to use it (score 4). Using L2 subject as a baseline, Figure 1 shows that in L2 lessons, students only occasionally used academic language (7% high-end, scores 3-4), while they did so frequently in mathematics (58%) and science (79%), to describe complex ideas, abstract concepts, and thinking skills.

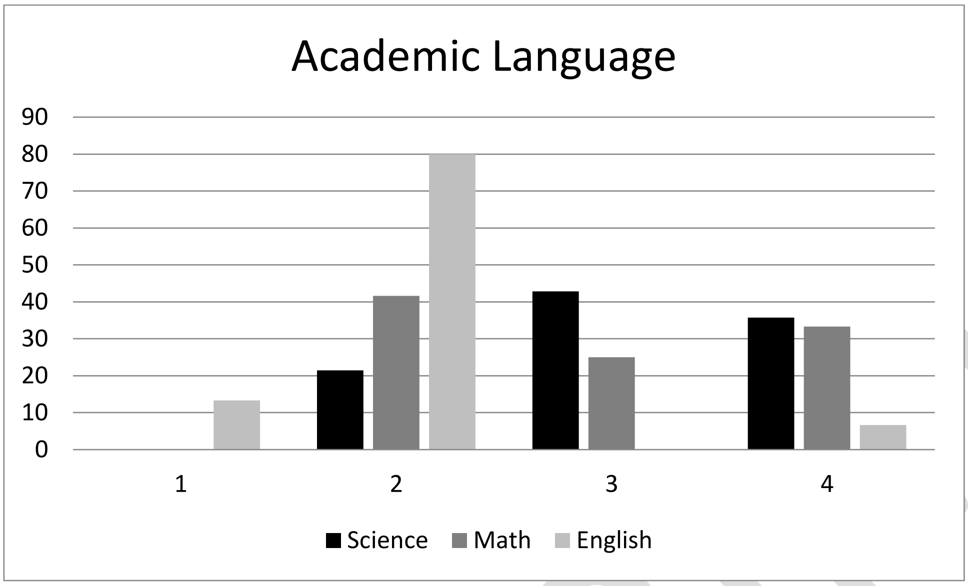

Figure 1. PLATO scores for Academic Language in science, mathematics, and English

The science teacher consistently gave tasks related to subject-specific terminology, offering opportunities to negotiate scientific meaning both in L1 and L2. In Excerpt 1, she uses L1 (underlined) to aid the students in learning subject-specific L2 terminology. It is noteworthy how the teacher uses everyday language to support learning of L2 vocabulary:

Excerpt 1 (Science, Academic Language, Score 4):

Teacher: What does *etsende* mean in English? […] Anybody that would like to give the answer to that? *Etsende*, what's that? Starts with a C? What does it do?

Student: It eats your skin.

Teacher: Yeah, exactly. So, it eats up your skin … can eat your skin. […] Corrosive is the word. Corrosive.

The mathematics teacher also encouraged the students to use L1 and L2 terminology to clarify content meaning. In Excerpt 2, she asks three students to explain how one mathematical function can differ from another, prompting the students to use subject-specific terminology (underlined) and by doing so, negotiating disciplinary meaning:

Excerpt 2 (Mathematics, Academic Language, Score 4):

Teacher: Can you try to explain in mathematical terms? […]

Student 1: So, so, so, that's minus three, right?

Teacher: That's a negative. Minus negative. Slope? Ok, how can you see that?

Student 2: Because it's going that way?

Teacher: It's going the other way. Yeah. Do you want to explain further, […]?

Student 3: *Fordi stigningstallet er ved minus?* [Because the slope is at minus?]

Teacher: In English?

Student 3: Because the *stigningstall* is …

Teacher: What's the *stigningstall* in English?

Student 3: Slope.

Teacher: Yes, thank you.

Student 3: If the slope is minus, means that the Y goes downwards, not upwards, because the slope is downwards, not upwards.

Teacher: Ok. So, what does the 'B' mean here?

Student 3: When the line hits the 'Y'.

Teacher: Yeah. And what do we call that?

Student 3: The Y-intercept.

Here, the mathematics teacher integrates academic language and content by prompting the students to convey subject-specific terminology, with Students 1 and 2 negotiating meaning in L2. Student 3 opts to explain in L1, with the teacher prompting him to use L2.

Supportive materials (ALL)

We also investigated the type of supportive material the teachers provided, and found several instances of visual representations to aid content learning in the CLIL subjects. Again using the L2 subject as baseline, we infrequently found materials offered as language support (20% high-end), quite similar to mathematics (25%). The science teaching used extensively more supportive materials (79% high-end), but both CLIL teachers used these materials to integrate language and content. This included science props (e.g., vegetables) for the students to name, pictures with labels so students could identify certain items, and models of items they were building in the laboratory. An example of supportive materials in mathematics was a drawing of a box with terminology and descriptions, which the students actively used to construct their own boxes and negotiate content meaning during the process.

Opportunities to listen and speak (CD), read and write (TBI)

A third characteristic of language integration in the CLIL lessons concerned opportunities to use L2. We found a striking similarity in the students' opportunities to listen and speak through classroom discourse across both CLIL subjects (86% high-end in science and 83% in mathematics), even to a larger extent than the L2 subject (60%). This suggests that these opportunities are characteristic of CLIL teaching, rather than subject-dependent (Table 3). One reason is the large amount of group work in the CLIL subjects, whereas the L2 subject had more individual work.

Table 3. Percentage of segments showing opportunities to listen, speak, read, and write across the subjects: high-end PLATO scores (3-4)

Subject	Listening and speaking	Reading	Writing
Science	86 %	0 %	14 %
Mathematics	83 %	0 %	0 %
English	60 %	20 %	0 %

Note. Listening and speaking = Classroom Discourse (CD), sub-category Opportunities. Reading = Text-Based Instruction (TBI), sub-category 'Use.' Writing = Text-Based Instruction (TBI), sub-category 'Production' (See Table 3). Each segment can include any aspect of speaking, reading, and writing. Therefore, each category can score up to 100%.

In addition, we identified the CLIL teachers' consistent uptake of student responses and ideas in classroom discourse, within and across the CLIL lessons. In mathematics and science, the teachers prompted the students to justify their answers during most lessons (science 57% high-end; mathematics 67%). Excerpt 3 shows the mathematics teacher's engagement in high-level uptake, contributing to students' opportunities to negotiate content meaning in L2.

Excerpt 3 (Mathematics, Uptake, Score 4):

Teacher: At what values of x would the volume be zero? So, at zero, here. How could this parenthesis here be zero? Or this parenthesis here be zero.

Student 2: Ok. […]

Teacher: Yeah, but how could … could you have any other values of x that also would be zero? Other than zero. Because the question asks where it intersects the x-axis

Student 2: One hundred!

Teacher: One hundred? So, thirty minus two times one hundred. That's ...

Student 1: Explain *hvor kommer* [where comes] …

Student 2: It's x minus. You can have a minus box.

Teacher: Yeah, that's true. But the volume would be less than zero.

Student 2: So, then it's before. Before one hundred x.

Teacher: Could you ... , could you turn this parenthesis … could you give us an x-value that would make this parenthesis to be zero?

Student 3: Uh. Fifteen?

Teacher: Yep. Because thirty minus two times fifteen is zero. So, then the whole thing would be zero.

Student 1: Oh.

Teacher: Ok. Could you find a value of x here that would make this parenthesis, uh, to zero?

Here, the mathematics teacher asks for elaboration, addresses student ideas, and challenges students to expand on these. These aspects point to L2 integration by high uptake of student responses, and are implemented consistently throughout the mathematics teaching.

A final note concerns the (lack of) CLIL characteristics related to reading and writing. As shown in Table 3, reading and writing had largely perfunctory functions across the subjects, meaning the students read (in the L2 subject only) and wrote (in science only) primarily to solve tasks during group work. Although texts were present during most CLIL lessons, all tasks and materials provided to the students were authored by the teachers. Reading was not addressed in depth. Concerning writing, they largely took notes in the mathematics class. However, in science, the teacher discussed how to write a lab report, providing opportunities for sustained writing. Thus, while listening and speaking seem characteristic both within and across the two CLIL subjects, the opportunities to write rather seems a characteristic of science literacy.

Content-driven

We identified three content-driven features of the CLIL teaching, which entailed how the teachers expressed the purpose of the lessons (PUR), what type of instructional explanations the teachers provided (ROC), and the intellectual challenges (IC) of the tasks and activities the students were provided to fulfill said purpose.

Purpose (PUR)

While the CLIL teachers expressed no language learning goals, content-driven purposes were explicitly stated in both CLIL subjects, as here in Excerpt 4 where the science teacher expresses the goal of a science experiment:

> *Excerpt 4 (Science, Purpose, Score 4):*
> **Teacher:** We're going to be doing a "red cabbage indicator." Right, so we're going to be testing solutions for whether or not they are acids or bases. We're going to see what kind of … what kind of effect the, um, the indicator has. Ok? [Writes: Goals for lab -> finding the pH of different substances using universal indicators] Ok, I'm going to give you your lab [assignment]. Please read it now, for five minutes. Then I want you to figure out what are the goals for the lab. Ok? [Students read assignment] What is the goal, what is the purpose of the lab? Goals? Or goals? [Student], you had an idea?
>
> **Student:** To figure out the pH values of different things by using different indicators.
>
> **Teacher:** Yeah? So. Finding the pH of different substances. Right? Using … [student], yeah?
>
> **Student:** But also, do you think we will be able to find the properties of acids and bases?
>
> **Teacher:** Hmm, good question. I don't know if you can do that. If you think about it, what are you going to see? What are you going to observe?
>
> **Student:** We are going to observe whether the substance or object or whatever we are

testing is acidic or …

Teacher: Yeah, but what are the properties? We're not going to exactly be looking at the properties. No. So, this is all about seeing … learning about the pH scale, right? Um. The pH of different … and then, and you said, the pH scale, so we need to know about what this means.

This example indicates how the goal relates to the development of students' science skills. The teacher prompts students to state the purpose of the lesson, and there is evidence of student awareness. Throughout the segment, the activities aligned with this goal, and towards the end of the segment, the teacher referred back to it. This example is representative of the high-end, content-driven purposes observed in 64% of the science segments. In mathematics, the goal was explicitly communicated in only 17% of the segments, and also content-driven.

Rich explanations (ROC)

Another characteristic of the content-driven teaching we observed concerned instructional explanations and conceptual richness. The explanations of content in both CLIL subjects were rich, lengthy, and accurate (science 71% high-end, mathematics 58%), suggesting integration of content and language as the CLIL teachers conveyed the content of their subjects in L2. A difference though, was the science teacher's focus on conceptual understanding in most of the lessons (79% high-end), whereas the mathematics teacher did so in a few segments only (17% high-end), primarily focusing on explaining rules and procedures. This points to more conceptual richness in the science teaching.

The science teacher focused on representing scientific phenomena and providing clear examples, analogies, and explanations, as in this example where she explains the theory behind the pH-experiment they are going to conduct:

Excerpt 5 (Science, Instructional Explanations and Conceptual Richness, Score 4):

Teacher: What is a pH scale? What is the range on it? What do you think, [student]? The range of the pH scale.

Student: From zero to … fourteen?

Teacher: Yeah. Do you think in this world that we have just that, the … that it's just between … hmm … zero and fourteen? The pH? H stands for? What do you think? So, it's between zero and fourteen, ok, you say that. This one is between zero and fourteen. What I was going to say was that the … there is more. Beyond fourteen and beyond zero. There are substances that are minus twenty-five. But in general, this is our scale. Just know that it is not limited. What does H stand for?

Student: Hydrogen.

Teacher: Good. So, this is hydrogen. What do you think 'p' stands for? They don't really know, but they assume that it's called the 'power of hydrogen.' How cool is that? It's like a super power of hydrogen. And then you had these things … what is this power of hydrogen? What does it do? Well, it creates different environments. Acidic or basic. Right? So, the hydrogen in it is … it's the hydrogen's fault! The hydrogen is at fault for creating acidity or … basic … basidity as well, I've seen. Ok, so, finding the pH of different substances using a universal indicator, and also testing different indicators.

The science teacher's L2 explanation of the pH scale is long, accurate, and clear, which she ties to an earlier lesson where they talked about hydrogen, and explains how to use the theory during the experiment. The primary focus concerns a conceptual understanding of the pH scale. Although the mathematics teacher rarely explained concepts in depth, the L2 explanations were mostly accurate and addressed student misunderstandings, as in Excerpt 6:

Excerpt 6 (Mathematics, Instructional Explanations, Score 3, Conceptual Richness, Score 2):

Teacher: So, these two [graphs] show the difference for mobile phone subscription. So, this one is more expensive, right?

Student: Yeah?

Teacher: And this one is less expensive, unless you use many megabytes per month. So, if you use any megabyte, this one increases. But this won't increase that much. Since the slope is different. So here, this mobile phone subscription will be more expensive. If you use a lot of megabytes. So, in this point, this one will start to be more expensive when you use more than how many megabytes? Fifty. So, if you use more than fifty megabytes, this subscription will be more expensive. But if you use less than fifty megabytes, this one will be more expensive. That's the answer to this one. So, when it says cheapest to use the subscription, it's f of x. F of x is the first one, right? That's this one.

The mathematics teacher is explaining how to interpret and compare two graphs. The example is accurate and clear to help the students solve the task at hand, although there is no focus on conceptual understanding of the graphs. Both CLIL teachers' representations of content in L2 were not only rich, but also consistently focused on subject-specific content.

Intellectually challenging

The third content-driven characteristic of the CLIL teaching was that it provided high intellectual challenges in terms of analytic/inferential tasks in more than half of both the science segments (57% high-end), and the mathematics segments (58% high-end). Figure 2 gives an overview.

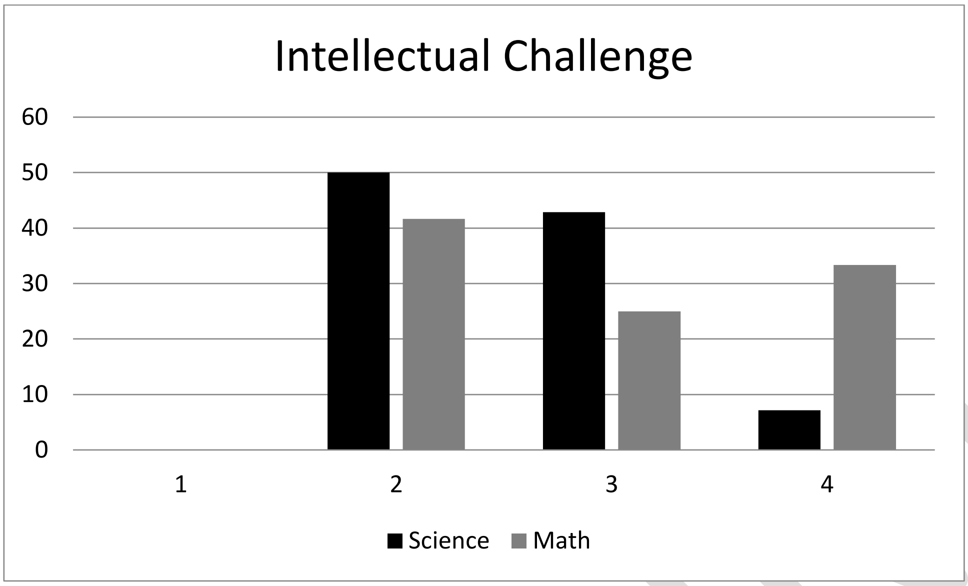

Figure 2. PLATO scores for Intellectual Challenge in science, mathematics, and English

Both CLIL subjects showed a mixture of rote/recall (score 2) and analytic/inference activities (score 3–4). In both subjects, the teachers encouraged the students to think like scientists and mathematicians; formulating hypotheses, observing, testing, and justifying conclusions in science, and interpreting visual representations of numbers in mathematics. Excerpt 7 offers an example:

Excerpt 7 (Mathematics, Intellectual Challenge, Score 3):

Teacher: So, when the graph intersects the x-axis, what will the value of y be then? When it intersects here? For example, if it intersects about here? What is the value of y?

Student 1: Zero.

Teacher: Zero! If it intersects here? What will the value of y be?

Student 1: Fourteen point five?

Student 2: What? No.

Teacher: Zero. Because it's always zero. On this axis. Where it intersects the x-axis, the y will always be zero. Because here, the y is always zero. So, at this point, the coordinate will be twelve point zero. Eleven point zero, ten point zero, nine point zero, eight point zero, seven point zero, zero point zero. And what happen … what do you think the volume is? Here?

Student 1: Zero.

Teacher: Zero.

The first question was inferential, asking the students in L2 to infer based on the axes. When Student 1 answered correctly, the teacher checked by asking a related question. When Student 1 then answered incorrectly, the teacher reformulated it to prompt the students to approach the question differently, instead of reducing the intellectual challenge of the task. However, a lack of student responses to analytic/inference questions reduced the level of intellectual challenge in some instances.

Discussion

In this section, we will discuss our research question: *What characterizes CLIL teaching in science and mathematics in terms of content and language when taught in English as a second language?* We will discuss our findings in light of previous CLIL research and our understanding of integration. One challenge is to discuss potential benefits or pitfalls when using L2 teaching as a baseline for comparison with the use of L2 in CLIL teaching. Another is whether the content-driven features of the science and mathematics teaching are due to CLIL teaching or are usual content features for the subjects.

Although the differences between CLIL subjects are ultimately more interesting and significant for understanding CLIL than the differences between them and English L2 teaching, using the latter as a baseline contributes to our understanding of the integration of language and content. Specifically, it helps identify CLIL characteristics concerning content learning through L2. Characterizing the oral use of languages of the CLIL classroom, this class spoke primarily in

English L2, both in science and mathematics. Using L2 for 90–98% of the time is extremely high, particularly compared to prior research in Norway with 30% or more L2 use (Brevik and Moe 2012). Language and content integration seemed to be a CLIL characteristic, as realized for example through the use of L1 to aid content understanding (especially translating subject-specific terminology). This concurs with previous research that suggests L1 is often used strategically by CLIL teachers (Gallagher and Colohan 2014, Gierlinger 2015, Martínez Adrián and Gutiérrez Mangado 2015, Tavares 2015).

Both CLIL subjects scored high on use of academic language, illustrating how the teachers used and prompted subject-specific terminology consistently throughout the lessons. This points to process-oriented integration, where the students are becoming members of the subject communities (Sfard 1998). Through prompting them to use terminology, the CLIL teachers push their students toward being able to think and speak scientifically/mathematically in L2. We argue that this is the embodiment of the added value of CLIL – students are not only learning to express themselves in L2, but through integration express themselves in specific disciplinary ways (Berger 2016, Llinares, Morton, and Whittaker 2012, Nikula, Dafouz, et al. 2016, Nikula, Dalton-Puffer, et al. 2016, Norris and Phillips 2003, Ødegaard et al. 2014).

We furthermore revealed that another characteristic of the CLIL teaching was how it offered the students many opportunities to speak. This coincides with theories of learning as social interaction (Mercer 2004; Vygotsky 1987) and previous research that aligns CLIL with a sociocultural framing (Nikula 2010, Dalton-Puffer 2007, Van Kampen, Admiraal, and Berry 2016). Moreover, this refers to speaking in ways that may also scaffold socialization into becoming a member of the field, in other words, not just a matter of speaking more for sake of speaking. Unsurprisingly, the opportunities to speak are also reflected in research on language outcomes that suggests CLIL students primarily improve their oral proficiency (Admiraal, Westhoff, and De Bot 2006, Lasagabaster 2008). However, the CLIL students were provided limited opportunities to read and write. Interestingly, this is echoed in CLIL literature commenting that writing was perceived as a homework activity (Dalton-Puffer 2007). We therefore question if the overt focus on oral communication may draw attention away from reading and writing aspects of the content subjects, particularly as these are considered essential features of scientific/mathematical literacy (Berger 2016, Ødegaard et al. 2014). Other studies of science classrooms show between 17–30% writing (Ødegaard and Arnesen 2010, Ødegaard et al. 2014), where Ødegaard et al. (2014) was an intervention study with a focus on literacy. In mathematics, it is usually around 50% (Bergem 2016).

The within-CLIL analysis further probed the depths of content-driven features of the CLIL teaching in science and mathematics, demonstrating more traces of the integration of content and language. Since both CLIL subjects purely focused on content goals and no tangible language goals, this raises another question of integration: Will CLIL be CLIL without explicit language goals, or is it sufficient to say that CLIL has a dual focus on content and language if there is an implicit focus on language learning? Several researchers have commented on this dichotomy (cf. Dalton-Puffer 2007, Coyle, Hood, and Marsh 2010, Georgiou 2012, Marsh 2002). Nikula, Dalton-Puffer, et al. (2016) propose that our understanding of how language functions in content subjects is underdeveloped and needs to be further explored before we can begin to discuss how CLIL should be taught.

Delving into issues of content, there is also the question of whether content-driven features of the science and mathematics teaching reported above are due to teaching through an L2, or if these are disciplinary features of the subjects. Although Nikula (2010) and Moore (2011) argue that teaching through L2 may cause CLIL teachers to lose some nuances in their instructional explanations, we found the instruction to be rich, lengthy and accurate. In line with disciplinary literacy (Airey 2015, Shanahan and Shanahan 2012, Ødegaard et al. 2014), the science teacher focused on conceptual understanding of scientific phenomena, while the mathematics teacher primarily focused on mathematical rules and procedures. This is an interesting finding, which may relate to the culture of mathematics teaching in Norway (Stigler and Hiebert 1999). Another aspect of language support that might be considered a disciplinary rather than CLIL characteristic, was visual aids. We discovered that the science lessons provided the students with more visual aids than the mathematics lessons; including models, and pictures with labels. We attribute this to the nature of the content subjects (Nikula, Dalton-Puffer, et al. 2016), since science traditionally use many visual representations (Tytler et al. 2013).

Much CLIL literature is preoccupied with intellectual challenge, questioning if learning a content subject through L2 will render the students less capable of completing tasks (Coyle, Hood, and Marsh 2010, Lin 2016, Gibbons 2015). Examining intellectual challenge, we found that approximately half of the time, in science, students were given analytical/high inference tasks, while in mathematics, they were given slightly more rote and recall tasks. The observation of tasks and dialogues between the teachers and students suggest that the students' levels of language and the type of challenges were successfully integrated. Briefly put, the students are still provided complex instructional explanations and intellectually challenging tasks through L2.

In conclusion, the strength with our within-CLIL comparison approach is that the participants are students in the same class. Studies that have compared CLIL students with non-CLIL students have been problematized, since CLIL students are often handpicked from disproportionately higher socioeconomic backgrounds, have higher grade averages and L2 proficiency (see Bruton 2013, 2011, Aro and Mikkilä-Erdmann 2015). This makes for difficult comparisons, as CLIL teachers may teach their subjects differently to high-achieving CLIL students as opposed to non-CLIL students. However, a within-CLIL comparison means that we cannot say for certain if our findings are subject-specific (e.g. typical of science/mathematics) or CLIL-specific (teaching through L2). We acknowledge that our study only provides insight into the workings of one CLIL classroom. However, our design allowed for a systematic and detailed description of CLIL teaching across subjects and adding to the body of much-needed detailed studies of CLIL in practice. We hope these observations can serve as a starting point for further research, particularly into issues of how teachers support their students through scaffolding not only language, but also content.

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