

“The science of it ...”: designing and teaching a CLIL curriculum

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- introduces a CLIL science subject (*English for the Natural Sciences*) at upper-secondary level
- shows the use of cognitive discourse functions for planning a content- and language-integrated curriculum
- illustrates the use of design-based research methodology
- gives examples of activities used in teaching practice

1. Overview

Developing CLIL programmes requires educational professionals to consider a multitude of aspects in order to design a successful curriculum that furthers both content knowledge and language skills. Coyle et al.'s (2010) “4Cs Framework” and Richards' (2013) model of different curriculum design processes may serve as initial anchor points when devising the general and theoretical concepts behind a CLIL curriculum; however, the practical side also needs to be taken into account – not only when adapting the curriculum to current needs, topical developments or educational reforms, but also – and even more so – if two or more teachers collaborate in a CLIL programme.

This paper will illustrate these issues by introducing an ongoing PhD project about a CLIL science subject at an Austrian upper-secondary school that uses Dalton-Puffer's (2013) construct of cognitive discourse functions (CDFs) as a planning principle for its language- and content-integrated curriculum. The aim of the project is to show the potential of CDFs in curricular design within CLIL contexts.

2. Introducing *English for the Natural Sciences*

A new CLIL science subject, *English for the Natural Sciences*, was introduced at a grammar school (AHS) in Lower Austria in 2014 as an elective subject (*Alternativer Pflichtgegenstand*),

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This contribution is part of a special focus on upper secondary CLIL. Please see the introductory article “Introducing four papers on upper secondary CLIL. Crossing the divides between language and content subjects” by Dalton-Puffer & Smit (2018) for further information.

i.e. one which students can choose to attend in their final two years of upper-secondary school. *EfNS* is taught collaboratively by a science teacher and an English language teacher in a block of two lessons per week. Students who have attended *EfNS* may also select it as an oral exam subject for their school-leaving diploma.

Before teaching commenced, a number of curricular aims regarding the students' language ability were formulated. Among other objectives, the *EfNS* language component should

- improve students' general and content-specific language skills,
- enable students to follow simple subject discourse,
- enable students to follow university science courses in English.

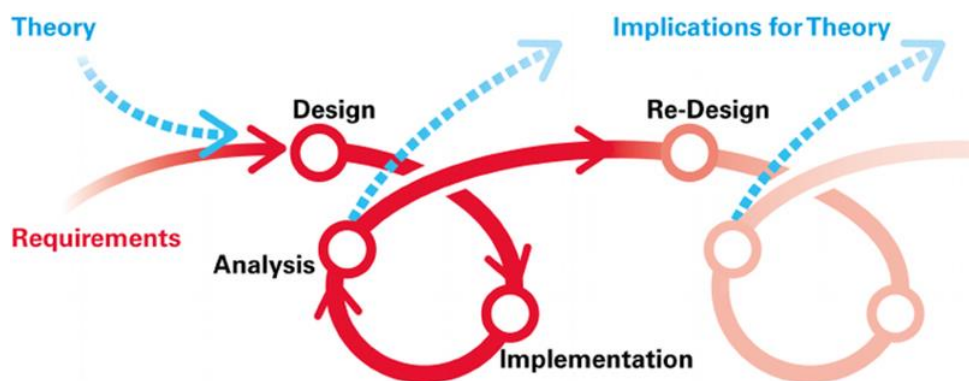
The science content, which is not the focus of the paper at hand, is drawn predominantly from the areas of physics, biology and chemistry. An overview of the topics covered in *EfNS* will follow in section 4 of this paper.

As of September 2017, two full teaching cycles of two academic years each (with two cohorts of students) have been completed. When the subject was first taught in 2014, 11 students registered, with 29 (divided into two groups) in the following year, one group with 13 students in 2016 and 20 students – again in two groups – in 2017.

3. Empirical study

Using the theoretical background of design-based research methodology (Kortland & Klaasen, 2010; McKenney & Reeves, 2013; Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006), the empirical study comprises two research cycles with different cohorts of students, which were conducted from 2015 to 2017. The illustration below shows the principal processes involved in design-based research:

Figure 1: Basic concept of design-based research (Hein, 2017)



The theoretical construct (i.e., in the case of this study, cognitive discourse functions) is combined with both internal (i.e. research-driven) and external (i.e. laws, regulations, etc.) requirements to end in a specific course or lesson design, which is then implemented. Analysis can take place after documenting the relevant lessons. The study at hand uses video-recorded teaching units, transcripts of the spoken language and written assignments. After analysing the implementation phase, implications for the theoretical construct can be drawn, which in

turn lead to a re-design of the course or lesson in question. This cycle may be repeated as often as necessary, but for the empirical study on *EfNS*, two teaching units are analysed in two cycles, resulting in four sets of lessons (each consisting of three to four 100-minute sessions) to be scrutinised.

Each teaching unit consists of a pre-instruction, an instruction and a post-instruction phase. In the pre-input phase, the students' prior knowledge should be activated as they become engaged and acquainted with the topic. The instruction phase is divided into content and language input. Following the principles of direct instruction for lesson design (Kauchak & Eggen, 2012), PowerPoint presentations are used in this phase to show the students what content knowledge and language skills they need in further lessons of the teaching unit in question. The linguistic input comprises information on both grammatical and structural as well as lexical features that are relevant in the context of the content and language aims (i.e. the use of certain CDFs). Post-instruction activities in the teaching units recorded for the empirical study include student presentations and group discussions. In this phase, the students should demonstrate the skills they acquired and improved during the instruction phase.

3.1 Research questions

The PhD project will try to answer a number of research questions, some of which are presented below:

RQ1

How can the subject be defined precisely?

RQ2

Which discourse functions should be developed in *EfNS* and what linguistic forms do they take in science discourse?

RQ3

Based on pre- and post-instruction observation, to what extent do the learners meet the subject's language objectives?

RQ1 refers to the debate as to whether certain educational settings might be understood as CLIL, ESP or a blend of both. RQ2 is concerned with the features of the language of science and consequently asks the question as to which CDFs should be included in the *EfNS* curriculum. Finally, RQ3 investigates the qualitative and quantitative development of CDFs as used by the students before and after instruction.

In my PhD project I will attempt to answer these questions by conducting literature research on various topics associated with CLIL, ESP and CDFs as well as curricular and task design. In addition, I will analyse available teaching materials in order to assess their potential and the need for further or different materials. Finally, the empirical study and the analysis of the pre- and post-instruction phases (i.e. recorded lessons and written assignments) will yield results leading to an answer to RQ3.

4. Course design

In line with the requirements for the new *Matura* exam (i.e. the Austrian school-leaving diploma), 12 science content and 12 corresponding language-content points were selected to be taught in the two years that the subject is offered. The science content was chosen with the help of the upper-secondary curricula for physics, biology, chemistry and geography/economics. The general and didactic part of the *EfNS* curriculum, which is a compulsory section of any Austrian school curriculum, is largely taken from the individual curricula of the abovementioned subjects (BMBWF, 2018), complemented by general aims specific to *EfNS*, i.e. abilities and skills that are expected from students after attending the subject for two years.

The linguistic foci and CDFs selected for the language part of the curriculum were chosen with reference to the context of and current discussions/developments in the various fields of natural sciences. An example for this approach would be the language function of “agreeing & disagreeing” that was combined with the science content of “Atomic & Nuclear Physics”: in debates on the future of nuclear energy, for instance, forming a critical opinion and being able to agree or disagree with the viewpoints of others is a crucial skill.

Table 1: *EfNS* framework curriculum 2014-2017

Topic/Content	Language focus/function
Scientists' Biographies & the Nobel Prize	Writing & nature of biographies
The History & Nature of our Universe	Summarizing
Space Exploration & Extra-terrestrial Life	Describing, speculating
Body, Health & Nutrition	Engaging the audience
The World of Energy	Analysing, evaluating
The Globalization of Science & Technology	Advising, justifying, persuading
Mobility & Motion	Describing motion
Atomic & Nuclear Physics	Agreeing & disagreeing
Communication & Communication Technology	Reporting
Water as the Basis of Life	Classifying
Weather, Climate & Nature	Comparing
The Forces of Nature & Natural Disasters	Sequencing

Similarly, when looking at the more detailed description of one content unit in the curriculum, it becomes clear that another major aim of designing the syllabus was to find somewhat matching linguistic skills. Here, an extract from “The World of Energy” serves as an illustrative example that shows how CDFs can serve as a bridging concept between content and language pedagogies.

Table 2: Extract from the detailed syllabus for “The World of Energy”

Science	English language
<ul style="list-style-type: none"> • Energy sources, renewable vs. non-renewable • Current and future energy consumption • Future of energy production • Pros and cons of various energy sources • Environmental and sustainability issues 	<ul style="list-style-type: none"> • Describing similarities/differences (words/phrases, sentence patterns) • Describing cause and effect (words/phrases, sentence patterns) • Use of correlative conjunctions • Appropriate use of technical vocabulary (meaning, pronunciation) • Discussion techniques/strategies

5. Sample lessons

Again, the content topic “The World of Energy” serves as an illustrative example of the basic didactic concept behind *EfNS*. It was also used as one of the topics for the teaching cycles in the empirical study.

As already mentioned, each set of lessons begins with a pre-instruction activity that is intended to engage the students and introduce them to the content at hand. “The World of Energy” starts with a worksheet on “A day without energy” (which was later changed to “A day without electricity” due to some confusion in the first teaching cycle), where students have to fill in what they typically use for certain everyday activities and then say what could be used instead using less or no electricity.

Figure 2: Pre-input worksheet (Changing with the climate, 2013)

“A day without energy” Worksheet

type of activity	what is typically used	what can be used instead, using no (or less) energy
waking up		
shower/bath, personal hygiene		
transport, journey to school		
homework, research for school		

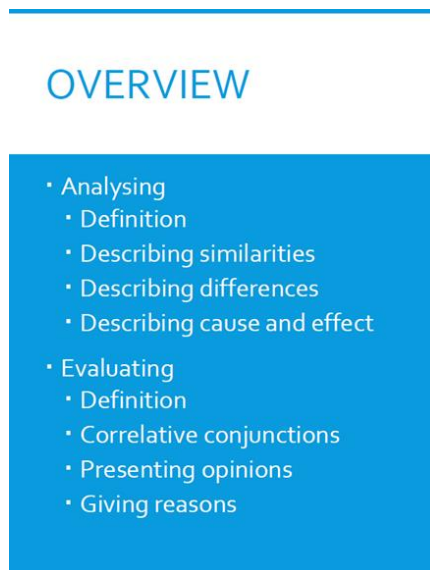
Following the pre-instruction activity, the input phase is divided into content and language instruction, both using PowerPoint presentations and direct-instruction methodology. The science and linguistic knowledge acquired by the students at this point is needed in later stages of the teaching unit. The presentation on “energy” contains a definition of energy and the introduction of various forms of energy as well as current issues and debates.

Figures 3 & 4: Sample slides from the content-instruction presentation



The language input focuses on the CDFs of “analysing” and “evaluating”. With the help of a presentation, certain words, phrases and grammatical features are introduced so that the students should be prepared to use these language patterns when talking about different sources of energy, their advantages/disadvantages and how they could be used sensibly and effectively in the 21st century.

Figure 5: Overview slide from the language-instruction presentation



The post-input activity requires students to use their newly developed skills in an interactive task of some form. In the case of “The World of Energy”, pairs of students have to assume the role of energy company representatives who have to convince an imaginary energy secretary to invest in the energy source that they introduce and argue for. In addition, two students present current and past figures on energy consumption in Austria, the EU and worldwide. To complete this task successfully, students have to resort to both the knowledge from the science input as well as from the language input (i.e. being able to analyse and evaluate).

6. First insights

Since the analysis of the empirical study is still in progress, first insights will be presented instead of concrete results. What can be stated without doubt is that in *EfNS*, students are capable of verbalising complex science content and discussing current issues or problems. In addition, it has become clear to the educators involved in creating and designing the subject that the CDF construct proves to be useful when structuring language curricula within CLIL contexts.

Furthermore, preliminary analysis of the collected data seems to suggest an increased use of appropriate CDFs in post-input activities. In addition, newly acquired CDF structures were also used in the post-instruction phase of the teaching units in question.

Finally, according to the students' feedback, which was collected at least once in each academic year, they claimed a subjective increase in their linguistic and science competence. However, all these findings need to be verified by an in-depth analysis of the data in order to present reliable results.

Application Box

In case you intend to teach CLIL together with a colleague, find someone you can rely on, who shares your views on teaching and learning, who has innovative ideas and who you enjoy working with.

When devising the curriculum, make sure your language aims somehow match your content aims. Considering how content knowledge might be used in professional or academic fields might help to formulate specific language objectives.

The CDF construct proves to be effective when it comes to curricular planning. Finding CDFs that fit to the content points concerned in the curriculum is imperative for your design to make sense in its entirety.

When planning teaching units or individual lessons, think about what kind of activities might be of interest to the students and engage and involve them right from the start.

Be willing to revise your curriculum, specific lessons or individual activities if you feel they do not work or if your students report back to you that they do not. This should be part of every teacher's professional development.

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