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Implementing Scientific Experiments in the Content and Language Integrated Learning (CLIL) Methodology

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Abstract

This paper strives to answer the following research question: “How can language appropriate, pupil-centered scientific experiments be implemented in the CLIL-methodology?”. Based on various studies, educational practices that can facilitate this implementation were combined as to guarantee the quality. These educational practices were translated to a framework that can support teachers to integrate pupil-centered scientific experiments in their CLIL lessons. Exploratory surveys were conducted to determine the difficulties in the practice which were taken into account when developing a workshop for teachers. The workshop presented the framework in a learner-centered manner with exemplary exercises to demonstrate possible ways of implementation. All attendants confirmed the practical use of the framework and the workshop in general. They believe it will help teachers in creating powerful learning environments in which pupils can learn in a pupil-centered, collaborative manner that allows them to gain more insight in their own learning processes. More workshops should be given to validate the framework and its efficiency. Therefore, the workshop will be submitted to the educational consultant service to allow more fine-tuning and guarantee a certain reach. The latter proved to be difficult due to the innovative character of CLIL in Flanders.

“When you go to school, the trauma is that you must stop learning and you must now accept being taught”
Dr. Seymour Papert

Foreword

I would like to take the opportunity to thank all the teachers that were able to inspire me during my own school career. Despite all my teachers' efforts, only the occasional passionate teacher that enabled me to learn and explore autonomously, at least to a certain extent, was able to motivate me intrinsically. In this respect I also express my gratitude towards Els Schoubs who never stopped believing, Liesbeth Martens and Joris De Roy for sharing their CLIL enthusiasm and my supervisors John Arnold and Beatrijs Bossuyt who were able to guide me through the process of writing this paper in the same constructive fashion and provided me with feedback and critical suggestions.

Last but not least, I would like to thank my family and especially my girlfriend for their support and patience during my somewhat turbulent educational career.

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Introduction

When comparing literature concerning Content and Language Integrated Learning (CLIL) and science education, a gap between the research and practice can be noted. Due to the innovative character of CLIL in Flanders, educational tools to aid teachers with the practical implementation of CLIL in their classes are lacking. Therefore, the aim of this paper is to start building a bridge between the research and the practice to contribute to the professionalism of teachers and their ability to implement CLIL in a well thought-out manner. This aim has led to the following research question: "How can language appropriate, pupil-centered scientific experiments be implemented in the CLIL-methodology?".

Based on a literature review, the author's own experiences and exploratory research surveys, a workshop was devised. The workshop is based on a framework that supports teachers in designing their CLIL lessons, accompanied by exemplary exercises and presented in a learner-centered manner. Ideally, the workshop should provide science CLIL teachers with an increased understanding of the core principles of CLIL, if not yet present, and how to realize them in their lessons.

To ensure the quality of the workshop, a trial was organized in which qualitative feedback was gathered through both discussion and feedback surveys. The prototype was then adjusted based on this feedback. On top of that, the workshop will be submitted to the educational consultant service to continue the fine-tuning of the workshop and thus its quality. Furthermore, a wider reach can be obtained through the educational consultant service which makes the educational product more durable thanks to the 'trickle-down' principle.

The first part of the paper is the literature review in which the core principles are elaborated: Content and Language Integrated Learning (CLIL), learner-centered learning and cooperative learning, and the natural sciences research method and the 5E's learning cycle. Secondly, methods and results are explained together in one chapter due to the chronologic nature of the different phases of the research. Finally, strengths and weaknesses are presented in the discussion section, as well as possible future research.

Literature review

1. What is CLIL? The four C's

Learning through other languages is not new in itself. As J. Cenoz and Y. Ruiz de Zarobe (2015) state, it goes back to at least the classical era where Greek was learnt by privileged Roman students. Their goal was not necessarily to speak Greek, but to study other content which was only accessible through the Greek language. From the 13th until the 15th century in several regions in Asia most of the study materials were in Chinese, since there were close to none available in their native languages. Promising Vietnamese and Korean pupils were even sent off to China to continue their studies there. This of course required them to master Chinese. In Europe, starting from the dark ages, the Lingua Franca in established education was Latin. The researchers of those days published in Latin as well (De Roy, 2015b).

However, people seldom studied foreign languages for the sake of the language itself. This is a relatively new concept and to fully comprehend the ideas behind CLIL we need to take a look at today's society. "Contemporary multilingualism is no longer limited to particular trades, social classes or geographical locations as was the case with historical multilingualism. In fact, the interest in programs that use a second or additional language as the language of instruction can best be understood if we take into consideration the demands of today's social and economic forces" (Cenoz & Ruiz de Zarobe, 2015, p. 2). The above is also propagated by the European Union to meet the growing need for multilingualism in a globalized world. "One of the EU's multilingualism goals is for every European to speak two languages in addition to their mother tongue. They claim that the best way to achieve this would be to introduce children to two foreign languages from an early age. Evidence suggests this may speed up language learning and boost mother tongue skills too" (European Union, 2017).

Introducing children to foreign languages has been done before and in many forms. Gambineri (2014) states that bilingual education can be distinguished in three types. The first type of bilingual education is immersion and its primary goal is to increase the language proficiency of pupils' other official or regional language. Examples are Belgium, Switzerland and Canada. The second type, submersion, is a kind of bilingual education installed for language minority pupils. These pupils are subjected to high-intensity language courses with the aim to quickly raise their proficiency in the language of the majority group. This way they should be able to integrate in the regular educational system and develop the skills necessary to follow the curriculum as well as get along in daily life. The third kind is Content and Language Integrated Learning, also known as CLIL, or Content Based Instruction, referred to as CBI. The latter is mainly used in the USA, whilst the former is used in Europe, hence CLIL will be used in this review.

In Flanders CLIL is defined as a didactical method that uses French, English or German as the language of instruction (De Roy, 2015b). But CLIL is more than just a course with another target language as medium of instruction, otherwise it would not differ from the other two types of bilingual education. Therefore, the concepts of CLIL will be further elaborated since the Flemish definition is rather vague. The CLIL-methodology does not have a specific target pupil, whereas immersion and submersion are often installed based on socio-political motives concerning equality or preservation of official or regional languages and the education of language minority groups respectively. To say that the propagation of CLIL by the European Union has no socio-political motive would be untrue, but it’s far from the only reason as it transcends the borders of individual countries and their socio-linguistic situations.

Apart from that, research has shown that the specific CLIL-methodology guarantees equal, if not better, results than most conservative teaching methodologies in multiple aspects of the development of pupils. There are, however, conditions that must be met to reach these results. The CLIL-teacher must be qualified to teach both the content and the target language, whereas Dalton-Puffer defines immersion and submersion teachers as native speakers of this language who otherwise possess exactly the same qualifications as would the mother-tongue teachers of the students concerned (as cited in Gambineri, 2014, p. 3). Theresa Ting (2011) confirms this by stating that “no matter how perfect the teacher’s English, a teacher blabbing about physics in English is not CLIL because CLIL attends to the learners’ ability to use language. CLIL thus shifts classroom dynamics away from teacher-centered lecturing to pupil-centered learning. This alone is reason for any education community to notice CLIL.” (p. 315).

It is clear that CLIL has much to offer but it is of utmost importance that CLIL is thoughtfully implemented in contemporary education to avoid criticism. Therefore, researchers around the globe have started investigating the possibilities and boundaries of CLIL. Surmont, Struys and Somers (2015) confirm that “research into the effects of the CLIL approach has been booming” (p. 30). In figure 1, they refer to the meta-analysis on this ever growing research effort by Van de Craen et al.

Research question	General result	Remarks
CLIL's influence on target language knowledge	Very positive	Especially regarding the pragmatic level, i.e. language use
CLIL's influence on the mother tongue	No negative influence on the development of the mother tongue	If anything the influence is rather positive
CLIL's influence on subject matter knowledge	Positive	Results are slightly better in primary than in secondary schools
CLIL's influence on attitudes and motivation	Very positive	Also positive with adolescents
CLIL's influence on cognitive development	Remarkably positive	The younger the better
CLIL's influence on the brain	Brain organisation differs between bilinguals and monolinguals	By extrapolation this is probably also true for CLIL pupils

Figure 1. Summary of findings on CLIL. Reprinted from "Creating a framework for a large-scale implementation of Content and Language Integrated Learning," By J. Surmont, E. Struys and T. Somers, 2015. *European Journal of Language Policy*, *7*(1), p. 30. Copyright 2015 by the Liverpool University Press.

These results confirm the high expectations of CLIL and disprove most of the claims of CLIL-opponents. However, these results can only be achieved through proper implementation. Therefore, a clear framework and educational tools must be made for and used by educators.

Although researchers have made and are still making efforts to delineate CLIL, numerous definitions can be found. "One of the earliest and probably the best known approaches is the integrative approach of the four C's as proposed by Do Coyle: Content, Communication, Cognition and Culture" (De Roy, 2015b, n.p.). The integration of language and content through the four C's is crucial to the success of CLIL-courses. Ideally a CLIL course should have an element of each of the four C's. This can be challenging sometimes, depending on the subject, but educators should always strive towards this goal. By designing courses and classrooms this way, pupils can learn content through language and language through content, as well as other cognitive and social skills. This dual focus lies at the heart of CLIL. Figure 2 illuminates how the four C's can accommodate this and how they are related. The following sections will each give a more detailed explanation on one of the four C's and their relationships.

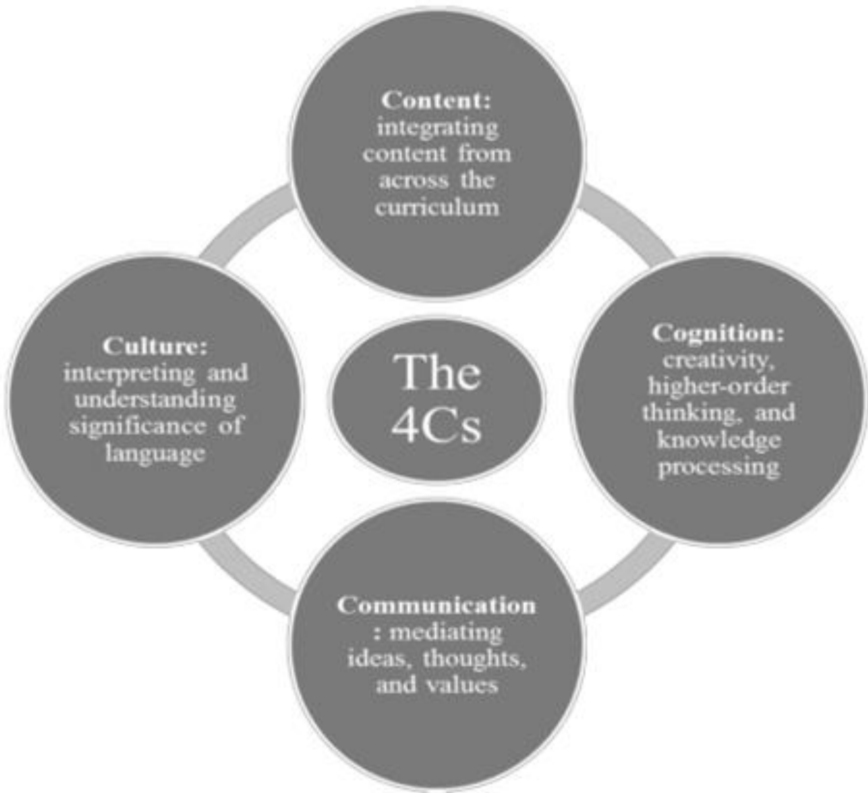

Figure 2. The 4Cs. Reprinted from *Improving the effectiveness of language learning: CLIL and computer assisted language learning* (p.4), by R. Gambineri, 2014, London: ICF Consulting Limited. Copyright 2014 by ICF Consulting Limited.

1.1 Content

Contemporary monolingual language education often receives criticism in that the activities lack a realistic component. In extension, pupils experience these activities as artificial constructions and often question their value. This implies that learning language for the sake of language itself lacks a motivating component, thus not contributing to the involvement of the pupils. Based on multiple studies, Dalton-Puffer and Smit (2007) promote CLIL because of its integrative nature of content and language, which results in meaningful learning activities. "A […] major argument revolves around the purpose and the meaning of language use in the classroom. It is true that learning about geography, science or history in the CLIL classroom gives the use of the foreign language a purpose over and beyond learning the language itself. In this way, learning about subject content is construed as possessing a kind of meaningfulness that is believed to be absent from typical language instruction" (p. 8).

By integrating language in subject courses, the focus of the learner shifts from learning the foreign language to using the foreign language to analyze the content. This results in a more noncommittal approach of language learning that allows room for errors and where the interest is not on language outcomes, but on the process of knowledge construction. Dalton-Dalton-Puffer and Smit (2007) confirm that this noncommittal approach boosts motivation and involvement of pupils and reduces reluctance to express oneself in a foreign language, providing that educators make efforts to design a safe class environment. However, in order for pupils to experience the beneficial effects of CLIL, variation in course activities is paramount. It provides a method of differentiation and also invites pupils to use the target foreign language in different contexts and to different ends (Llinares & Pastrana, 2013).

Last, but not least, a pragmatic argument circulates that through the integration of language and content, pupils' exposure to the target foreign language dramatically increases whilst not requiring extra time. "If two things can be learned in the slot otherwise taken up by only one, this clearly saves time. Also, especially in foreign language contexts, attending CLIL classes means a substantial increase in the amount of target language exposure for the learners. In such settings CLIL education tends to multiply the hours spent with the target language compared to traditional language classes." (Dalton-Puffer & Smit, 2007, pp. 8–9). In his report on CLIL, issued by the European Commission, Gambineri (2014) presents this benefit as an argument on how CLIL can cost effectively improve foreign language competences. "CLIL increases the opportunities for language learning and practice without increasing the curriculum time and specialist language teacher time allocated to language learning" (p. 3).

By integrating language and content, the increase in learning profit manifests itself in multiple ways. First, pupils learn on a higher level as they construct their knowledge through the use of the target foreign language. Second, pupils can spend more time studying and using the target foreign language without schools having to abolish other subjects in the curriculum. Last, due to the fact that pupils are forced to use academic language to engage in conversation about the content, they automatically get familiar with the specific jargon of the subject.

1.2 Communication

Learning often involves the transfer of information from one party to another. To facilitate this transfer in class, communication is essential. This takes place both passively and actively. Passive skills are reading and listening, whereas active skills are speaking and writing. In the early sixties Vygotsky propagated that knowledge is constructed rather than 'absorbed'. "The influence of Vygotskian socio-cultural perspectives on learning promoted the value to learning of fostering dialectical relationships between the learner, language and context" (Watters & Diezmann, 2015, p. 28).

Good teaching practice implies that the communication itself is an aspect of learning. "Individuals are seen to learn language through the participation in social events, where they co-construct together with other participants the social practices through which learning can take place" (Dalton-Puffer & Smit, 2007, p. 10). This entails that pupils need to have the opportunity to practice these communicative skills. As mentioned before, educators should organize a wide variety of activities in which pupils can practice both their active and passive skills. Lave and Wenger put it as follows: "CLIL classrooms are seen (at least potentially) as communities of practice in which learning is a process of negotiation of meaning and identity formation" (as cited in Evnitskaya & Morton, 2011, p. 110). With the aim being to facilitate pupils' communication, a pupil-centered approach is required. There should not be only a wide variety of activities, but these activities should be designed as to evoke the use of language in multiple ways, allowing the pupils' communication to serve varying ends.

1.3 Cognition

In her review of integration of theory and practice in CLIL, Khan (2014) summarizes that CLIL is not only beneficial for language learning but also makes students better all-round learners. Multilinguals are better learners as their linguistic skills are more automatized in their long term memory, freeing up working space in their short term memory. Apart from that, the explicit and implicit learning involved in CLIL is closer to the natural way of learning due to the integration of language and content, thus making the learning more effective. This is due to the fact that learning in another language forces learners to utilize Higher Order Thinking Skills (HOTS), as propagated by Bloom and show in figure 3. Constructivism states that learning is more effective if knowledge can be constructed through the use of these skills, whereas a behaviorist approach primarily makes use of Lower Order Thinking Skills (LOTS) such as rote learning, repeatedly practicing for good performance, copying notes etc. (Huitt, 2011).

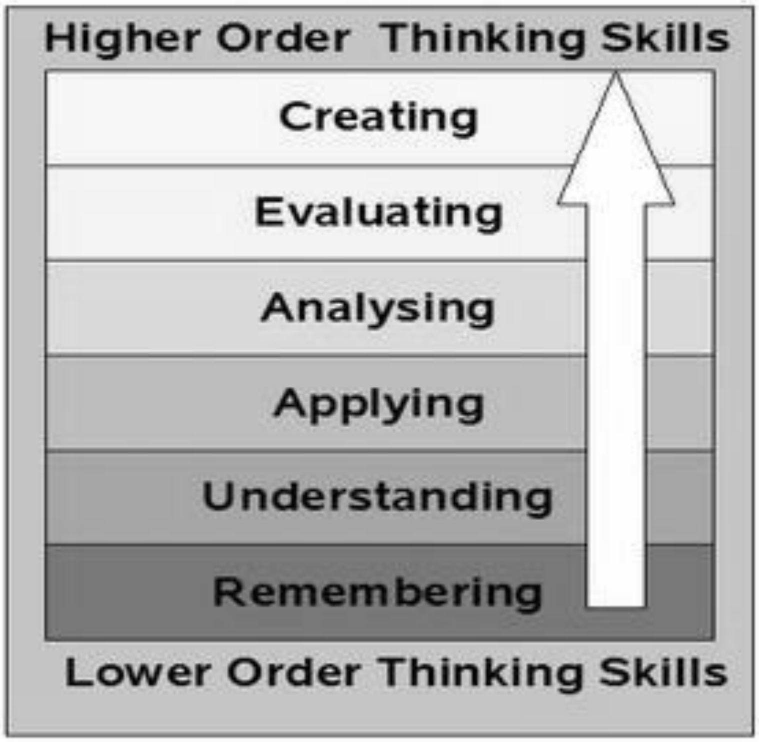

Figure 3. Bloom's taxonomy of learning. Reprinted from "HOTS and LOTS", 2011, Retrieved January 9, 2017, from https://learningcommunity3250.wikispaces.com/HOTS+and+LOTS

Examples of activities for which HOTS are required are comparing data (analyzing), giving a personal opinion (evaluating) or writing a story (creating). Swain was the first to claim that "the production of output is as relevant to language learning processes as is input, because having to produce rather than merely understand meaningful utterances stimulates lexico-grammatical rather than purely semantic processing and leads to deeper learning on the level of linguistic competence per se" (as cited in Dalton-Puffer & Smit, 2007, p. 10). Through both the written and oral communication in CLIL, more complicated cognitive strategies are stimulated and cultivated, resulting in a more profound understanding of both language and content.

1.4 Culture

In a world that grows smaller every day, the need to understand other cultures grows increasingly. Because of the continuous globalization people of different cultures are bound to encounter each other more often. People tend to fear or reject things that they do not know, do not understand or perceive as odd. Therefore it is paramount that education promotes an open mind and stimulates positive interaction with the unknown. There is a Chinese proverb stating that with every extra language you speak, you have an extra window on the world.

Being able to speak another language than one's mother tongue does not only grant a person the ability to express himself in that language, it also renders the speaker able to peer into the collective mind of that culture. The reason for this is twofold. First, languages have spontaneously evolved throughout history to meet the needs of society. The cultural heritage of a society shapes the language evolution, in addition the culture and social identity is preserved by the language at the same time. Claire Kramsch states that "it is widely believed that there is a natural connection between the language spoken by members of a social group and that group's identity. [… Results of this membership are] personal strength and pride, as well as a sense of social importance and historical continuity" (as cited in De Roy, 2015a, p. 10).

Second, language is a cultural divider. Proficiency in a language automatically makes you a member of the group who speaks this language. Through language traditions, moral values and adequate behavior are passed on. As Gibson puts it "language does not only represent 'who we are' but is also a way for others to project their own suppositions of the way 'we must be' " (as cited in Surmont et al., 2015, p. 32). By extension, people tend to drop their guard more easily when a stranger addresses them in their own language, whereas not knowing 'the code' forms an obstacle in communication and, as a result, lowers trustworthiness. In his 'Origins of language' James Hurford puts it as follows: "The truthful cooperative nature of typical language use is consistent with the cheapness of speech and the reciprocal trust characteristics of human groups. The trust is not so easily bought, requiring years of apprenticeship while young in learning the code of the group. Research shows that humans are more trusting of, and likely to cooperate with, people who speak the same language, and especially with the same accent. […] To some extent the complexity of language is a signal of group membership, bringing with it an assurance that a speaker has gone through the appropriate initiation processes of the group. To be sure, some of the complexity is simultaneously useful for complex messages, but any receiver of a complex message needs to assess whether the sender is trustworthy" (as cited in De Roy, 2015a, p. 7).

If people are able to look past each other's differences and understand each other's motives, they will soon discover that we are all very much alike, even though it may not seem so in the first place. By using foreign languages in class, CLIL can facilitate this, thus cultivating pupil's insights in human nature. Dalton-Puffer and Smit (2007) acknowledge this need for mutual understanding on both interpersonal and intercultural levels of our globalized society: "The hub of the question in both cases is how an education system can endow learners with the language skills necessary first to profit from the education on offer, and second to participate in social and economic life in ways that are advantageous for the individual and society at large" (p. 7).

1.5 Conclusion

When reviewing literature about CLIL, it soon becomes clear that none of the 4C's ever stands on its own. It is through the integration of language and content in a pupil-centered way that thinking processes are automatically stimulated and knowledge is constructed through the interaction with others. This does not only result in a deeper understanding of the content and increased target foreign language proficiency, but can also account for an increased consciousness concerning oneself and others. Therefore, culture is present in every interaction in CLIL and lies rightfully at the center of the 4C's Framework which is depicted in figure 4.

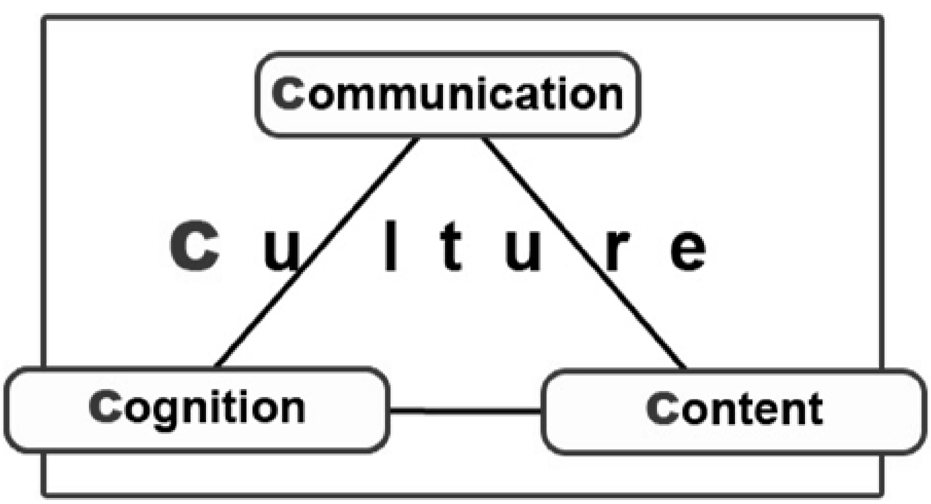

Figure 4. Relations between The 4C's. Reprinted from "Bilingual learning", by Thüringer Institut für Lehrerfortbildung Lehrplanentwicklung und Medien, n.d., retrieved from http://www.schulportal-thueringen.de/bilinguales_lernen

Do Coyle puts it as follows: “The 4Cs Framework holds that it is through progression in knowledge, skills and understanding of the subject matter, engagement in associated cognitive processing, interaction in a communicative context, developing appropriate language knowledge and skills as well as acquiring a deepening intercultural awareness through the positioning of self and ‘otherness’, that effective CLIL takes place whatever the model. From this perspective, CLIL involves learning to use language appropriately whilst using language to learn effectively.” (as cited in Gierlinger, n.d.). The high amount of interaction in CLIL allows for pupils to actively engage with each other and the teacher.

When pupil-centered activities result in pupils supporting pupils, the role of educators shifts from lecturer to ‘guardian’ of learning processes, if the course is properly designed. The fact that every pupil can support others, instead of solely the educator, makes sure that no pupil is left behind. This is closely related to learner-centered learning and cooperative learning, which will be described in the section two.

2. Learner-centered learning

2.1 What is learner-centered learning?

For millennia education has been a one way interaction between teacher and students, where the teacher is continuously dictating what is learnt and how it is learnt. Since the 1960’s Vygotsky’s constructivist theories, influenced by Piaget’s work, triggered a fundamental change of view on how knowledge is acquired. Thompson (2013) summarizes it as follows: “Constructivism claims that we learn and acquire knowledge through active engagement, inquiry, problem solving, and collaboration with others. This theory of learning sees the teacher less as a transmitter of knowledge and more as a guide or facilitator who encourages learners to formulate their own ideas through questioning and challenge. The constructivist approach argues that transmissive or didactic models of knowledge acquisition are unlikely to lead to the effective internalization of new ideas because they are not always well integrated with a learner’s prior knowledge.

If classrooms were to remain organized in the conservative ways of the past, learners will have fewer opportunities to construct their knowledge by employing higher order thinking skills and interacting with their peers. Therefore the classroom activities should shift from a teacher-centered to a more learner-centered manner.

To accomplish this, it is mandatory to keep the constructivist ideas in mind. If children are to become learners for life, they require sufficient motivation and learning tools to facilitate them in their growth. Based on evidence from multiple studies Schweisfurth (2015) formulates a strong argument to put motivation as one of the core conditions required for effective self-regulated learning: "Literature from educational psychology on motivation, theoretical literature in the constructivist tradition, and evidence from empirical studies […] all highlight the centrality of motivation, and so any understanding of quality education needs to include it. It feeds a virtuous interactive cycle of positive outcomes for individual learners, since successful learning is motivating in itself" (p. 263). Educators have the potential to guide their learners into that virtuous interactive cycle of positive outcomes, but to do this profound knowledge of the learning sciences is mandatory. Enabling students in experiencing successful learning requires teachers to regulate their students' learning processes as well as helping them to understand these processes. Failing to accomplish this, due to poor knowledge of the learning sciences, can result in demotivation (Turner, 2011).

Demotivated pupils are a result of the educational system as it is, since every young child has an innate curiosity and is driven to explore the world and for some this is lost somewhere along the road. Learner-centered learning has the potential to prevent demotivation. Therefore it is paramount to create powerful learning environments in which learners are invited to actively engage with the subject and their peers, whilst maintaining control over their own learning process. Although this can be very challenging, getting demotivated learners back into the virtuous cycle of successful learning still poses a greater challenge. Based on several studies Turner (2011) states that educators' insights in the learning sciences can greatly benefit their ability to create these powerful learning environments: "Educators with an understanding of the learning sciences are able to skillfully monitor and manage the developmental, emotional, social, and motivational influences on students' learning as well as provide students with meaningful opportunities to use newly acquired knowledge in practice" (p. 124).

It has to be said though, that traditional teacher-centered teaching can be effective and sometimes even the most ideal way to reach a certain goal. But when it comes to preparing children for their future life, learner-centered strategies have more value. Since choice is abundant in the contemporary society and guidance is not always available, adolescents who have grown to become life-long learners are armed with the tools to make well-considered decisions. On top of that, they are more likely to be motivated to pursue their aspirations than their demotivated counterparts.

Another aspect of institutionalized learning that can have a big influence on motivation is the type of assessment used. Although summative assessment can produce useful overviews of learners' progress, it is still not more than one of many tools to facilitate learning and the ultimate goal of evaluation should never be forgotten. "It is not necessarily measurement and metrics per se that are problematic. It is how these in interaction with the classroom level become ends in themselves and creating unintended backwash effects. Their perceived importance also tends to relegate that which is not readily measurable to a secondary place on the agenda" (Schweisfurth, 2015, p. 260). Keeping the former in mind, it can be said that the main focus of evaluation should be on formative assessment, as the learning process is more important than the product when looking at learning on a long-term perspective. This aligns with the idea that learner-centered learning allows pupils to be in control of their own learning process. Therefore, it is paramount that educators offer frequent and differentiated feedback to facilitate pupils in keeping their own learning process on track (Turner, 2011). To conclude, shifting to a more learner-centered pedagogy poses several challenges like extra workload and changing attitudes of teachers, but the potential outcome is well worth it thanks to the promise of more engaged students, with higher learning profits and better cultivated higher-order thinking skills (Csapo & Smart, 2007).

One of the ways to design learner-centered activities is cooperative learning. Since CLIL should be taught in a pupil-centered manner and communication is mandatory, cooperative learning lies at the heart of CLIL. Cooperative learning and its link with CLIL will be further discussed in sections 2.3 and 2.4 but first difficulties of shifting the average classroom practice from teacher-centered to learner-centered will be addressed below.

2.2 Difficulties of implementing learner-centered practices

Researchers often claim that there is a gap between the research and the practice in the educational context. As a result, innovative pedagogical principles often require decades to find their way to the average classroom and in reality many educators still employ a teacher-centered approach. Apart from the research gap, other teacher and curriculum based factors influence this transitional delay.

First, many teachers feel that the curriculum pressure hinders them to experiment with classroom activities that are unfamiliar to them as this can be time-consuming. On top of that, the curriculum often does not run parallel with the learners' level of development, as it is based on what pupils averagely should be able to process at a certain age. "National curricula are not always realistic in themselves, and the assumption that cohorts pass fully ready from each stage to the next in a systematic manner is flawed. Traditional learner-centered education often situates the existing baseline within each individual learner, prescribing individualized learning plans and teacher attention to scaffolding for each learner, in the constructivist tradition" (Schweisfurth, 2015). Secondly, although learner centered-learning can bring along many benefits because it contributes to the emancipation of the self through empowerment, it is that same shift in power that instills reluctance (Thompson, 2013). Educators need a firm grasp on their learners, not in an authoritative way that is, to ensure that the participatory aspect of learner-centered learning does not lead to power abuse by the learners. Finally, students who enroll in a teacher training program already have an elaborate view on education and their own future classroom practices. During their teacher training students continue to develop these notions by assimilating the theory presented, and implicitly the way it is taught, with their own secondary school experiences.
While teacher-centered classroom activities can have their use and should not be purged, educators should strive for a better balance between teacher-centered and pupil-centered activities, keeping the goal of the activity in mind.

2.3 Cooperative Learning

Johnson et al. define cooperative learning (CL) as follows: "Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning" (as cited in Herreid, 1998, p. 553). Slavin further elaborates how cooperative learning differs from traditional lecturing: "In CL classrooms, the pupils are expected to help, discuss and argue with each other; assess each other's current knowledge; and fill any gaps in each other's understanding. CL often replaces individual seatwork, study and individual practice but not direct instruction by the teacher. When properly organized, pupils in CL groups make sure that everyone in the group has mastered the concepts being taught" (as cited in Veenman, Benthum, Bootsma, & Van, 2002, p. 87). "There is tremendous power in having students learn from their experiences rather than from our words. Good teaching is student-centered and focused on learning, not teaching" (Kagan & Kagan, 2009, p. 6.1).

Assigning random pupils without a shared goal or assignment to small groups will not have much impact on learning processes, as pupils generally need more delineated guidance to learn from each other. According to Johnson et al. cooperative learning should be implemented thoughtfully by including five mandatory aspects: "(1) positive interdependence, (2) individual accountability, (3) face-to-face promotive interaction, (4) social skills and (5) group processing" (as cited in Herreid, 1998, p. 554; Veenman et al., 2002, p. 89).

Four key components are also propagated by Kagan Cooperative Learning. "The method has four basic principles, called the PIES principles. PIES is an acronym, what the letters stand for is explained below:

- Positive interdependence creates mutual support among students, creates peer norms favoring achievement, and increases the frequency and quality of peer tutoring.
- Individual accountability dramatically increases student participation and motivation to achieve.
- Equal participation: Students who otherwise would not participate or who would participate very little become engaged when we equalize participation.
- Simultaneous interaction: The amount of participation per student and our efficiency in teaching and managing the classroom are increased enormously when we use simultaneous rather than sequential structures" (Van Horen, 2015, p. 12). Kagan Cooperative Learning has developed to a legit educational trademark in the USA and is finding entrance in Europe as well. It is based on the same principles as classic cooperative learning, although it differs in that it makes use of structures that are very strictly delineated in both time and pupil-activities. Kagan and Kagan (2009) claim that different structures serve different learning purposes, albeit that they are not tied to the curriculum as they are content-free and repeatable. "Without many structures, a teacher is ill-equipped to construct a wide range of cooperative learning experiences for students. Each structure is good for building some types of learning, but no single structure works for all types of learners and learning objectives" (p. 6.2).

2.4 Link between cooperative learning and CLIL

When comparing literature concerning cooperative learning and Kagan cooperative learning, it can be said that it shares many similarities with CLIL, as the underlying principles are often based on the same constructivist approach of learning and its relation to interaction with others. Therefore, positive results of both Kagan and classic cooperative learning will be linked to the 4C's Framework. It is worthy to note that these cooperative learning benefits cannot be delineated in an absolute manner. However, in order to point out the similarities an attempt is made to classify different aspects of cooperative, integrative learning under the 4C's, which is a contradiction in itself.

CONTENT

Acquiring knowledge of the subject through meaningful interaction is crucial to both CLIL and CL. Veenman et al. (2002) put it as follows: "research provides convincing evidence of the positive effects of CL on academic achievement and the development of social skills" (p. 90). Kagan and Kagan (2009) acknowledge this: "As students with different points of view interact, they challenge each other's assumptions and bring different data to the argument. This pushes each student to a higher-level synthesis than if they worked alone"(p. 1.12). The latter can also account for Cognition.

COMMUNICATION

To facilitate meaningful interaction in which knowledge is constructed, communication is mandatory. If course activities are designed properly, communication shifts the support capacity for pupils from a teacher-only to a classroom-wide platform. The process of this communication can also relate to the Culture component of the 4C's Framework. According to Kagan and Kagan (2009) "students become part of a community of learners; they experience joy in working and learning together. They see the teacher as someone who coaches and assists them, someone on their side, not someone who stands back and evaluates them" (p. 4.1). On top of that, the learner-centered nature of both cooperative learning and CLIL allows for pupils to be in the driver's seat of their own learning process. This is reflected in the different usage of language when learning through interaction with others. Thompson (2013) confirms this: "My central argument continued to be that students' reading abilities are more likely to be developed through active comprehension strategies, during which textual meaning is collaboratively interrogated and reconstructed on the basis of students' own questions, than through the linear question-and-answer comprehension format which is more traditionally employed in many English classrooms where questions are framed by a teacher or examiner" (p. 51).

COGNITION

Cooperative learning lacks the target foreign language component and thus cannot facilitate increased learning profits in the same way CLIL does. However, it contains the interaction element that allows pupils to employ Higher Order Thinking Skills, since they have to produce their construct of the subject in order to explain it to others. "Research has shown effective CL groups to include high-, medium- and low-ability pupils working together. Low- and medium-ability pupils clearly benefit from working cooperatively with high-ability peers. There is also evidence that the high-ability pupils are better off academically when cooperating with medium- and low-ability peers as opposed to working alone. Working in heterogeneous groups may benefit low-ability pupils by allowing them to observe the strategies of high-ability pupils. Similarly, high-ability pupils may learn new strategies by teaching other pupils in the group" (Veenman et al., 2002, p. 88).

CULTURE

Interaction promotes awareness of oneself and others, boosting interpersonal and intercultural competences. Although the target foreign language component is absent once more, Kagan and Kagan (2009) claim that cooperative learning can have similar effects. "Cooperative learning improves the range of social skills, including listening, taking the perspective of others, leadership, problem solving, conflict resolution, and helping" (p. 1.12). Furthermore, "when schooling is competitive or students have little interaction with their classmates, who are they most likely to band with at recess and after school? It is only natural for them to be attracted to those who are most like themselves. There are strong biological and sociological forces that oppose harmonious integration in school and in our society. But with cooperative learning in classrooms, students interact freely on equal-status footing, making true integration a reality in our schools. In the cooperative classroom, students work together and get to know each other for their individual nuances. They develop a more accurate and differentiated view of others" (Kagan & Kagan, 2009,

p. 3.5). This cooperation in turn can facilitate the construction of powerful learning environments. Based on an increasing number of studies, Turner (2011) puts it as follows: "To be successful, learning environments need to support the belief that every class member matters and norms are established in the classroom that value learning, high academic standards, and positive behavioural expectations" (p. 127).

2.5 Conclusion

Looking at the possible benefits of CLIL and cooperative learning for science, promising expectations can be made as the discussed methodologies possess all the tools for teaching science in a visualized, pupil-centered and integrated manner. Van Horen (2015) used Kagan cooperative structures in an attempt to increase the limited interactions between boys and girls in Sri Lankan secondary education. "Generally the use of Kagan cooperative learning was a success since the interaction between boys and girls improved. The children were also very enthusiastic when I combined a cooperative learning structure with a scientific experiment with everyday life materials" (p. 28). Herreid (1998) confirms this in an argument to implement cooperative learning into contemporary education: "Cooperative learning works extraordinarily well in science, math, and engineering courses" (p. 554).

It is safe to state that all discussed methods can be viable and capable of achieving learning increase, as long as the underlying principles are respected. According to Van Horen (2015) "the interaction between boys and girls […] can be increased, if an open class atmosphere is created and many interactive activities are organized. Kagan cooperative learning methods can be a good tool to do this, but other methods are definitely possible as well" (p. 29).

In fact, the underlying principles are more important than the individual methodologies themselves. Based on the assumption that they have more in common than not, conclusions can be made that respecting these core ideas is key to designing strong educational environments. Veenman et al. (2002) advocate the same thought as a result of their research on cooperative learning: "Group goals and individual accountability stimulate pupils to help each other and encourage maximum effort. Studies of CL methods incorporating group goals and individual accountability show a much higher median effect size than for other methods" (p. 88).

It is striking to notice the reluctance of many educators to master the principles of CLIL and cooperative learning as they combine good educational practices in general. One of the reasons for this is that there is a lack of didactical equipment. Especially educators of age may find it hard to 'think outside of their box', whereas young educators seem to show persistence and determination to develop their own course materials more easily. Fortunately, research indicates that many efforts are being made to implement CLIL and other forms of cooperative and integrative educational methods on a larger scale (Veenman et al., 2002; Gillies & Boyle, 2008, 2010; Kagan & Kagan, 2009; Surmont et al., 2015).

3. The science of teaching science

3.1 The natural sciences research method

Research has shown that the amount of scientific knowledge is doubled nearly every five years. Growing up in a society that is dominated by science, children and youngsters' insight and understanding in how scientific research takes place must be cultivated in order to allow them to critically analyze and interpret the translation of research to reality. This translation does not only materialize in technology, but also in institutions and governments that base their policies on research. On top of that, the neo-liberal market tends to use pseudo-scientific arguments to brand their products. "Science literacy subsequently benefits individuals throughout their lives, from forming opinions about proposed government policies to making health-care decisions" (Packard, Hartmann, Adger, Barnett, & Dabelko, 2013, p. 171). By extension, quality science education should be implemented in a manner in which pupils can experience natural phenomena for themselves and in relation to others, thus increasing their potential of proper knowledge construction. Striving for this goal does not require every learner to become a full-fledged scientist, but a basic understanding of science and the nature of scientific research is recommended. To avoid misconceptions about the nature of scientific inquiry, educators should make sure to implement the scientific research method properly in classroom activities (Karsai & Kampis, 2010).

Next to the aforementioned more obvious reasons to frame natural science classroom activities in the scientific research method, a second argument can be made that it improves children's language and math skills in general because of the interaction with other contexts and peers. Gerde, Schachter and Wasik (2013) elaborate: "Using the scientific method to guide children's thinking during science activities integrates children's language, literacy, math, and science development. Instead of confining science to the science area, the scientific method promotes the incorporation of science exploration across classroom activities including during group sessions, outdoor time, and in all centers. Through this process, experiences inform and build on one another to enhance learning across developmental domains“ (p. 322).

The natural sciences research method consists of multiple phases that are interchangeable depending on the nature of the research and whether it is conducted inductively or deductively. Inductive research starts from reality where a certain phenomenon is observed and a question is formed, whereas deductive research originates from an already existing scientific theory or model of which the validity needs to be verified. Due to the complexity of deductive research, the inductive approach is predominantly used in education. This tendency is often criticized since it may result in an incomplete understanding of the scientific method, but that is beyond the scope of this research.

Gerde et al. (2013) present a list of the various phases of the scientific method:

- Observing
- Asking questions
- Generating hypotheses and predictions
- Experimentation or testing of a hypothesis
- Summarizing or analyzing data to draw a conclusion
- Communicating discovery and process to others: verbally and/or in writing
- Identifying a new question

3.2 A more learner-centered approach: the 5E’s

While the natural sciences research method offers a framework in which scientific research can be conducted in a proper manner, it offers close to none pedagogical support for educators. A useful tool in this regard is the 5E’s learning cycle (OEVUR in Dutch) which is a method to structure science and others lessons, based on the constructivist approach. The 5E’s stands for the five different phases of which the learning cycle exists. These five phases are explained in figure 5. The idea is that teachers should design their scientific experiments in a pupil-centered manner, based on the scientific method and structured with the 5E’s learning cycle. Each phase should give the learners a context in which they can act autonomously and construct their knowledge through experience and interaction with others. The different phases are interchangeable in the same way as the scientific method phases depending on the subject of the course and the goals set by the teacher.

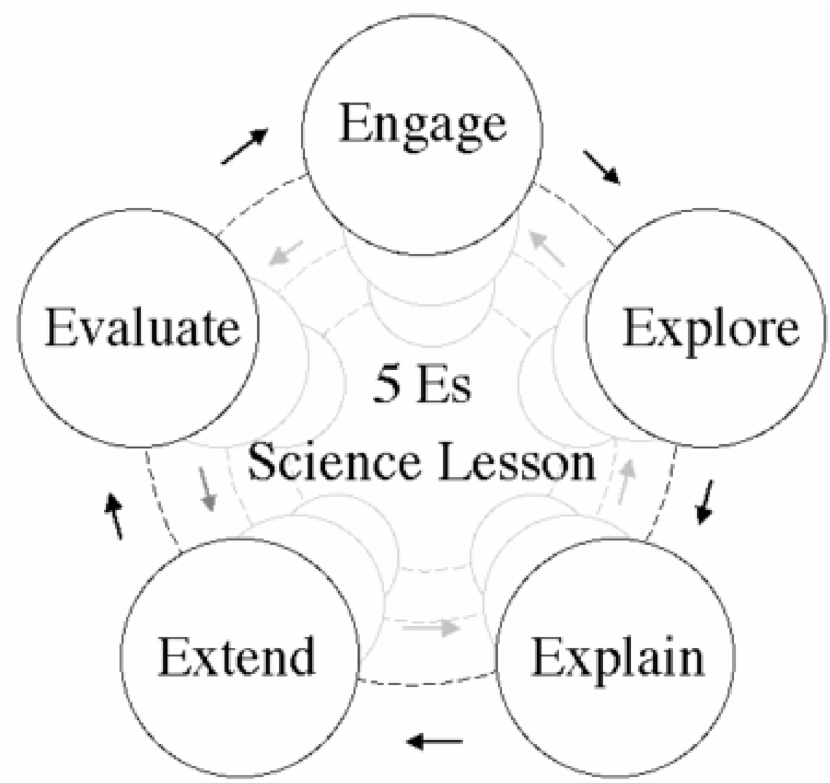

Figure 5. The 5E's learning cycle. Reprinted from "The 5E's science lesson. Inquiry-based instruction" by Lynne Merritt, 2016, retrieved from http://slideplayer.com/slide/7831951/

- Engage: This phase is meant to incite curiosity, activate prior knowledge and identify possible misconceptions.
- Explore: The exploratory phase allows pupils to gather information, data and observations in a preferably instruction-poor environment.
- Explain: During this phase pupils are invited to formulate explanations and definitions, which can then be supported by media presented by the teacher.
- Extend: Newly gained knowledge and insights are applied on real life phenomena. Research and problem-solving should be stimulated in this phase.
- Evaluate: Both the student and the teacher reflect upon the entire process, what went well and what could have been better.

When comparing the natural sciences research method and the 5E's it is noteworthy that the different phases are very similar. The scientific method can be implemented in both a teacher-centered as a learner-centered manner, but it offers fewer suggestions on how to do the latter. Scientific experiments in science courses are therefore often very instruction-based and leave less room for exploratory autonomous learning. The 5E's on the other hand, give a clear overview of the potential that can be attained when designing scientific experiments in a pupil-centered manner. If done properly, it does not only nurture pupils' knowledge and competences but also their attitudes. Therefore, the 5E's are closely related to learner-centered learning and CLIL. The following section will elaborate on the advantages of experiments in the classroom, section 3.4 will treat the more practical aspects of designing pupil-centered scientific experiments as it can be expensive and time-consuming. Sections 3.5 and 3.6 will discuss why experiments are the crossroads between science and language as the latter is an important aspect of CLIL.

3.3 Visualization in science

Letting pupils experience natural phenomena for themselves can be done either in a passive or an active manner. The passive type of visualization uses models and figures for clarification. Educators have been using non-practical visualizing tools for millennia (Eg: geographical maps). A more contemporary example is the periodic table of elements by Mendeleev as presented in figure 6.

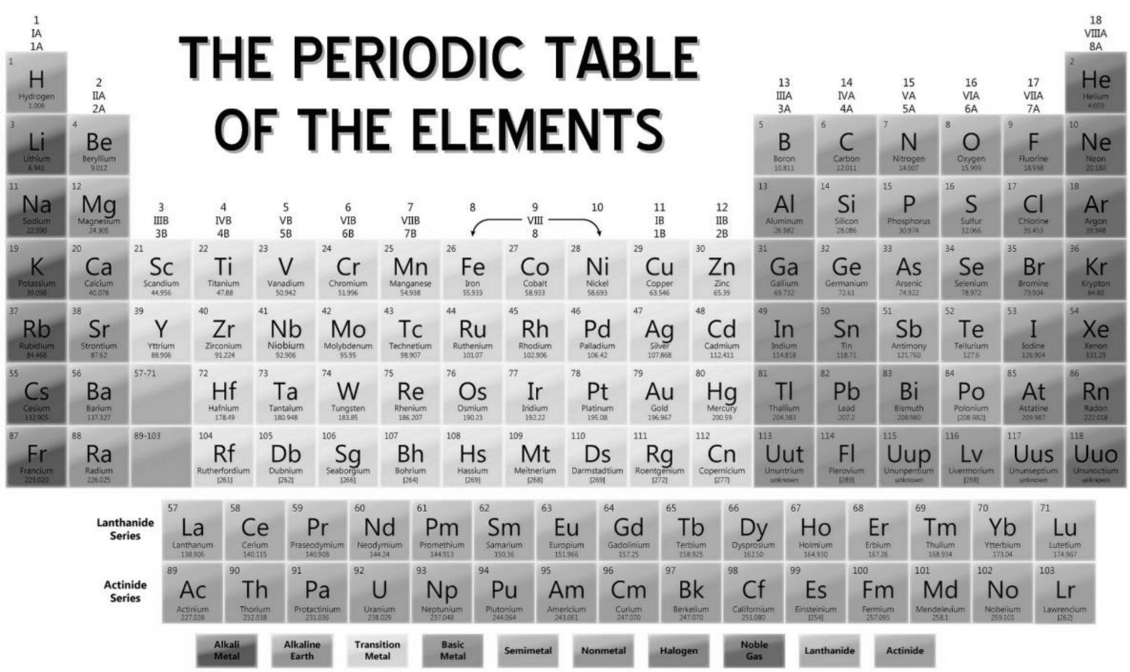

Figure 6. The periodic table of elements by Mendeleev. Reprinted from "Periodic Table Of Elements With Names And Symbols" by Remove and Replace, 2017, retrieved from http://removeandreplace.com/2015/09/09/periodic-table-of-elements-with-names-and-symbols/

It is being used for over a century now. Klerkx, Verbert and Duval (2014) elaborate: “Mendeleev’s periodic table of elements, which encodes several types of data in a small table format, is probably one of the most famous examples of visualization used in educational contexts […]. Mendeleev’s periodic table is known by millions of students all over the world and is a perfect example of how visualization can be effectively used to support understanding of subject matter” (pp. 11-12). It is worthy to note that visualization through models and figures can be extended, especially in CLIL, to pictures, audio and movie clips and other sensory sources as to provide scaffolding for the pupils to construct their knowledge upon.

The active type of visualization consists of bringing as much experiments as possible into the classroom. Experiments offer pupil-centered activities in which abstract concepts are made tangible. This way pupils can relate to their experience rather than a theory in a book. This type of visualization in science courses is relatively new and should not be taken for granted, as it brings along challenges for the educator. Appropriate equipment is necessary, it can be time-consuming and can invoke chaos in the classroom, if organized to loosely.

There are numerous countries where science is still taught strictly through heavy manuals and textbooks with a bit of passive visualization, but none or close to none active visualization. When lecturers and student-teachers of the teacher training in Kabwe, Zambia were asked why they do not perform experiments in class, the common reply was that lab equipment is too expensive. This is not necessarily true and will be clarified below.

3.4 Low-cost lab materials

Many scientific concepts can be visualized with low-cost materials or even objects that are generally referred to as waste. During the author’s experience in giving workshops in Kabwe, Zambia in a teacher training on the conceptualization of scientific concepts through visualization, many of the participants stated to be enthusiastic to employ these experiments in their own courses. The goal of the workshops was to present ample examples of experiments, demonstrations as well as learner-centered experiments, with cheap materials found in the local shops and market of Kabwe and even objects that are perceived as waste. None of the used materials were brought from Belgium, as this would not contribute to the idea that scientific experiments do not have to be expensive per se.

On top of that, there are numerous documents, e.g. Duré's (2010) thesis, treating experiments for natural science courses, in which safe and pupil-centered experiments are presented through the use of daily household objects such as plastic cups; balloons; spoons; stretchers; candles; etc., as well as waste such as empty plastic bottles; pieces of cardboard and wood; etc. It has to be noted though, that educators should always think through their choice of experiments in function of their content goals, the safety of the pupils and the feasibility of the activity in the specific lesson.

3.5 How is visualization beneficial for learning?

Visualization can accommodate learning by rendering abstract concepts tangible. Klerkx et al. (2014) put it as follows: "High quality learning materials such as texts, graphical illustrations, interactive demonstrations, tutorials, and audio and video presentations are essential for students to fully grasp and understand the meaning of a certain topic" (p. 7). Furthermore, Card, Mackinlay and Shneiderman state that "information visualization research is focused on enabling users to control the process of flexibly navigating through information spaces of abstract data, for which there may be no inherent mapping to space or a natural physical reality" (as cited in Klerkx et al., 2014, p. 3).

Concerning the active type of visualization through science experiments, Duré (2010) states that the execution of scientific experiments is a form of active learning. New insights are gained by using observations and prior knowledge. It is even claimed that no foreknowledge of the subject whatsoever is required as long as the subject does not exceed the learners' zone of proximal development and is presented through clear instruction. Windt, Scheuer and Melle (2014) confirm that even pre-school pupils can grasp scientific concepts through active visualization.

To conclude, Klerkx et al. (2014) summarize the aims of visualization in education: "The main intent of information visualization is to represent an abstract information space in a dynamic way, so as to facilitate human interaction for exploration and understanding. It relies on the design of effective and efficient --as well as sometimes playful and aesthetically pleasing-- interactive visual representations that users can manipulate for open-ended exploration or to solve specific tasks" (p. 5). When visualization tools, both passive and active, are designed with a constructivist and integrated approach, they will surely be an added value to any course.

Since this thesis treats the implementation of scientific experiments in the CLIL-methodology, it is notable how active visualization and the integrative CLIL-approach can prove to be a powerful synergy, as visualization can be used as a scaffolding tool for both content and language.

3.6 The language of science

Scientific language differs very much from everyday language as it is very specific and contextual. "Academic Language in Science is the formal, precise terminology used in discipline-or domain-specific ways by those fluent or literate in that discipline" (Benfield & Howard, 2005, p. 2). It is due to this specific nature of academic language that Cummins propagates two kinds of language skills, Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP) (Haynes, 1998). BICS are used to interact socially with others in mundane contexts and do not require a tremendous effort to master. When people are learning a foreign language BICS usually develop rather fast, ranging from six months to two years. CALP on the other hand, refers to language used in subject area content material and is crucial for students to succeed in school. It may take up to 10 years for a child, with no prior schooling, to catch up with its peers (Haynes, 1998). Even children with prior schooling can struggle with academic language, e.g. immigrant children or children whose mothers have a low socio-economic background. As research has pointed out, there is a correlation between language proficiency of the child and socio-economic background of the mother. For the sake of Education for All and effective learning, educators should approach language in the classrooms thoughtfully. "Science teachers, therefore, must become supporters of academic language learning as students navigate these new terms, phrases, symbols, and patterns of discourse while working to gain proficiency in the content area" (Benfield & Howard, 2005, p. 2).

Science education predominantly uses CALP because of its specific nature. Scientific observations and phenomena have to be accurately described with specialized jargon. This kind of words, e.g. osmosis, mean one thing and one thing only. There is no possible way to master academic words like these, other than to conceptualize and understand the process behind it. Therefore interaction has to be brought into the classroom, preferably in a pupil-centered way. "Among the strategies of effective science teaching, practices include rich multilateral discussions among students. The assumption based on social-constructivist frameworks is that when students share and debate multiple perspectives, new sets of correspondences or contradictions to individual understandings can emerge. Students also become encultured into the language and practices of the domain" (Watters & Diezmann, 2015, p. 26).

Considering the 4C's framework, it is safe to say that CLIL should be able to accommodate this. By extension, visualization of scientific concepts is beneficial in several ways. It offers a scaffold for learners to conceptualize abstract content without the necessity of linguistically understanding what the teacher or syllabus explains. In this way the language barrier of CALP can be circumvented, rendering the learners able to construct knowledge in a way that suits them best. Visualization should then be followed by content-assimilating activities in which learners can share their knowledge and understandings. Watters and Diezmann (2015) confirm this in their case study of a teacher focusing on the dialogue in the science classroom: "Students were encouraged to share their knowledge, the teacher then selected key content from the students' communication and shaped it in a way that illustrated the content for the whole class. […] That the students were not always expressing ideas that were acceptable according to the canons of science was, we believe, less important than students were engaging in, and experiencing phenomena that contributed to a richer conceptual profile. In time, with further experiences and refinement their understandings will acquire a richer alignment with acceptable scientific knowledge" (p. 41).

3.7 Conclusion

Science education can clearly offer more than the desired scientific literacy. "Using the scientific method to guide children's thinking during science activities integrates children's language, literacy, math, and science development. Instead of confining science to the science area, the scientific method promotes the incorporation of science exploration across classroom activities including during group sessions, outdoor time, and in all centers. Through this process, experiences inform and build on one another to enhance learning across developmental domains" (Gerde et al., 2013, p. 322).

When science courses are taught in an interactive pupil-centered manner by using the 5E's learning cycle, they have the potential to shape the learner in a holistic way. Especially in combination with CLIL the potential learning outcomes are well-worth the effort required to create such powerful learning environments.

4. Main conclusion

CLIL propagates the entrepreneurship of the self through which pupils can evolve to life-long learners that focus on knowledge and competences as well as attitudes. Learner-centered learning advocates the same ideas and states that this can be achieved by putting the responsibility in the learners' own hands. The attitudes component can be facilitated by interaction with others, thus through cooperative learning.

Science education strives to achieve the same goals in the sense that it should stimulate individuals to discover the systems of the world through curiosity and appreciation for the unknown. The unknown is closely related to the other and by extension related to everything that is 'outside' the learning individual.

In this respect, the ultimate goals of CLIL and science education are very much alike. Concerning this synergy, there is a gap in the literature. Therefore, the aim of this study is to develop a framework to guide science teachers in the implementation of pupil-centered scientific experiments in CLIL courses in a language appropriate way. Thus, this paper strives to answer the following research question: "How can language appropriate, pupil-centered scientific experiments be implemented in the CLIL-methodology?"

Methods and results

1. Exploratory research with CLIL-teachers in the field: surveys

In order to develop a relevant educational product for the practice of teaching sciences in a CLIL-context, exploratory research was required. Since the aim of this paper is to provide a framework upon which CLIL science teachers can fall back to devise pupil-centered scientific experiments with adequate scaffolding for both language and content, information on difficulties in the practice and practical expertise is best gathered from the teachers themselves. An exploratory survey (see appendix 1) was drafted and then presented to science CLIL teachers across Flanders. The exploratory survey focussed on sketching contemporary pioneer practices and identifying common difficulties in the practice in a qualitative manner. Although the response rate was rather low, useful conclusions could still be drawn. The low response rate is due to the fact that CLIL is a relatively new concept in Flanders and participating schools and teachers are scarce, and therefore burdened with a lot of requests to participate in research.

The main topics distilled from the exploratory survey were the challenges and difficulties in the practice and the acknowledgement of the prerequisites to improve science CLIL education. The current tendency in science CLIL education is that teachers design their courses to the best of their ability. The results are diverse due to multiple reasons: the lack of educational means such as textbooks and projects specifically designed for CLIL, the expectation to complete the content-stuffed curriculum and the somewhat lingering conservative teacher-centered view on education. Teachers themselves claimed the pressure of the curriculum did not allow them to organise many pupil-centered experiments. This clearly comes forward in a difficulty in the practice that was mentioned by one of the respondents: “How to complete the curriculum and be able to use active learning methods as much as possible?”. Other challenges mentioned were organizing the class, using the foreign language and giving clear instructions. To summarize, science CLIL courses have many forms due to the innovative character of CLIL in Flanders and, by extension the lack of uniformity about specific science CLIL-methodology. There should not be a uniformity in classroom practices per se, but in order to attain high-quality and uniform science CLIL courses in Flanders the pedagogical principles and concepts on which these activities are based should be the core ideas of CLIL and good educational practices in general.

From these results, several requirements to facilitate this quality increase were identified. Firstly, an increase in didactical means on which teachers can base their educational practice, especially when they have little experience in CLIL. Secondly, an adjusted curriculum that focusses more on the learning sciences and learner-centered learning and less on content. Lastly, extra means to encourage educators to attend more in-service trainings to close the gap between the research and the practice. The common misconception that CLIL and immersion are the same was also present in one of the respondents who teaches sciences both in Dutch and in an English CLIL context: “I don't see any difference in organizing an experiment in Dutch or in English”.

The last two requirements are structural and should be addressed by policy makers. The first prerequisite on the other hand, is the focal point of the educational product of this thesis, a framework that can aid educators in designing language-appropriate pupil-centered scientific experiments in science CLIL courses. The framework should be flexible to facilitate implementation in diverse contexts and should be presented in a workshop in which both the core principles and several practical examples can be offered in a learner-centered and integrative manner.

2. Development of the educational product: framework

Based on the literature review, the findings from the exploratory surveys including the difficulties in the practice, and the author’s own experience during the postgraduate CLIL, a framework was designed with the abovementioned purpose. This framework can be found in pages 16-17 of appendix 2.

Given the potential of the synergy between CLIL and the 5E’s, the framework strives to facilitate the organization of pupil-centered, language-appropriate science experiments. The framework is embedded in the 5E’s learning cycle to create a powerful learning environment in which pupils are challenged to explore and experiment autonomously. This allows them to learn to take control of their own learning process and become life-long learners. On top of that, accountability, common pupil goals and the transparent success-criteria contribute positively towards their engagement. The framework also offers guidelines to increase pupil involvement, language support and scaffolding for both the language and content components.

The different steps of the natural sciences research are present in the 5E’s learning cycle since the curriculum states that pupils should be able to conduct scientific research by using the scientific research method. Since the framework has to be usable in different contexts and courses with different objectives it has to be adjustable to one’s needs. Therefore, the different steps of the framework, based on the scientific research method and the 5 E's, are interchangeable to a certain extent. This way, educators can swap between or leave out certain phases to increase the amount of suiting implementation contexts.

3. Application of the educational product: workshop

When the prototype of the framework was designed, guidelines to apply it were required as well. Given the central position of learner-centered learning in the entire paper, it was logical to present the framework in a similar way. A workshop was produced in which educators could experience an example of how the framework can be used and in which feedback could be gathered as to increase the quality of the final product (see appendix 2).

An example of an answer to the challenge of curriculum pressure is assigning each group to a different experiment and instruct the pupils to explain it to the other groups afterwards. This way all the core principles of CLIL, cooperative learning and the 5E's are respected and sufficient content is covered in one course. The exemplary course in the workshop is not the holy grail, but merely one of the possible ways to interpret the framework. The framework is supposed to be a generic instrument, a guideline for teachers to help them overcome the challenges in the practice and increase the feasibility of designing their own full-fledged CLIL-lessons.

The workshop itself was offered on the 31st of May, 2017 on the campus of UCCL in the Hertogstraat, Heverlee. The class setup consisted of one bench with the materials for each experiment and several isles where four persons could form a group. Each group had to conduct a different scientific experiment by using the instructions in the booklets that were distributed. Afterwards, experts groups were made with one person of each experiment in each group in order to make sure that everyone could be informed about each experiment. Finally, the author and the attendees were enthusiastic and various discussions presented themselves. More feedback was gathered through the use of a feedback survey (see appendix 3). There was a low response rate once more, due to the innovative character of CLIL in Flanders and the high demand for participation in research and the attendance of in-service training. However, the result of the feedback survey, as well as the discussions during the workshop, were extremely helpful as the respondents were veteran educators. Extra difficulties in the practice were acknowledged and implemented in the workshop. Additionally, language support and scaffolding, as well as extra engagement tools were added. The version of the workshop that can be found in appendix 2 is the result of these adjustments.

All attendees confirmed the practical use of the framework and the workshop in general. They believe it will help teachers in creating powerful learning environments in which pupils can learn in a pupil-centered, collaborative manner that allows them to gain more insight in their own learning processes. Due to this feedback, the feedback of the promotors and the enthusiasm of the author, steps might be undertaken to submit the workshop to the educational consultant service for future in-service training.

Discussion

Scientific pupil-centered experiments and CLIL can be powerful allies as they both stimulate collaboration between pupils that allows them to construct their knowledge and competences and cultivates their attitudes. These attitudes are paramount as they allow youngsters to be nurtured into life-long learners. By extension, these educational principles have the potential to pro-actively counter demotivation and school fatigue since the learner is supposed to have more control over his/her own learning process. It is this control and self-regulation that goes hand in hand with intrinsic motivation to learn, as having to do something and making the choice to do something are two different experiences entirely. On top of that, pupils potentially profit more on both the language and content components. Through communication pupils will learn about themselves and others, might gain a broader perspective, and as a result improve their social engagement to positively contribute to the society at large. Lessons have to be designed properly of course, and the framework can facilitate this by giving support to science CLIL teachers. Educational tools in this context are scarce, given the innovative character of CLIL in Flanders. Therefore, this thesis attempts to fill a gap between the research and the practice. If the framework reaches enough teachers it has the potential to enable a durable improvement of the quality of CLIL science courses in Flanders. If CLIL is introduced the way it was introduced to the author, there is a big chance enthusiasm will spread and educators, young and old, might be challenged to rethink their professional self-understanding and subjective educational theory.

Despite the relevance, there were some limitations to the research. Finding sufficient respondents for the surveys and attendees for the workshop was a challenge. Ideally, more exploratory research and workshops should have been conducted. However, the discussions during the workshop were similar to a focus-group interview and provided many useful suggestions and perspectives. Apart from that, if the educational consultant service would approve the authors' offer for in-service training, more teachers can be reached. By extension, more possibilities to continue fine-tuning the framework and workshop will arise. Another limitation is that there is no perfect framework. The framework serves merely as a tool that can support teachers. The most important fact remains that teachers need decent training, otherwise they will not have sufficient knowledge to implement the framework in a constructive manner. Factors such as class and school culture, demographic context, etc. should also be taken into account.

Future research might include testing the efficiency of the framework and workshop, both on the level of teacher skill as the potential learning profit increase for pupils. Should the implementation of the framework become a success, it could encourage other research on the practical implementation of the underlying good educational practices on which CLIL founds itself. Last, studying why there is still such a gap between the literature and the practice might be interesting. Obstacles might be identified and follow-up research could strive to remove these barriers as to allow good educational practices to be implemented more swiftly in contemporary education.

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Appendices

1. Appendix 1: Exploratory survey

Questionnaire for teachers: Implementing scientific experiments in the Content and Language Integrated Learning (CLIL) methodology

The aim of this questionnaire is to gather information concerning the current CLIL science courses: how are they organized, what are the challenges and what has proven to be effective. It's an exploratory research that will help me in developing a workshop. In this workshop I will present a framework that can help experienced and new CLIL-teachers alike in preparing pupil-centered science experiments in the CLIL-context. I would like to share my findings with other CLIL-enthousiatics in this workshop. I can't , however, promise that every interested party can attend my workshop. Therefore your emailadress is required.
This data will be used strictly for the purpose of my bachelor thesis: "Implementing scientific experiments in the Content and Language Integrated Learning (CLIL) methodology". Thank you very much for your cooperation!
Flor Maes

*Vereist

1. **E-mailadres** *

2. **Are you interested in following my workshop in which I will present my framework?** *
Markeer slechts één ovaal.
   - Yes
   - No

3. **In which school are you currently employed?** *

4. **How many years have you been teaching?** *
Markeer slechts één ovaal.
   - Less than two years
   - Between 2 and 5 years
   - Between 5 and 10 years
   - Between 10 and 20 years
   - More than 20 years

5. **How many years have you been teaching science courses?** *
Markeer slechts één ovaal.
   - Less than two years
   - Between 2 and 5 years
   - Between 5 and 10 years
   - Between 10 and 20 years
   - More than 20 years

https://docs.google.com/forms/d/1w5wRsS9J3l0kvrLPlb3c774Q_lteB6hulcgerAzThrc/edit 1/5

6. **How many years have you been teaching using the CLIL-methodology?** *
Markeer slechts één ovaal.

- Less than one year
- Between one and two years
- Between two and four years
- More than four years

7. **In which science course do you use the CLIL-methodology?** *

____

8. **How often do you organize pupil-centered experiments in your CLIL-lessons?** *
Markeer slechts één ovaal.

- Once every trimester
- Once every month
- Once every two lessons
- Every lesson
- Anders: _______________________________

9. **What do you experience as most challenging when organizing experiments in CLIL?** *
Markeer slechts één ovaal.

- Time-management
- Organizing the class
- Giving clear instructions
- Using the foreign language
- Completing the curriculum
- Anders: _______________________________

10. **If you were to attend a workshop adressing this topic what would you want to learn from it?** *

____
____
____
____
____

11. **How do you divide your pupils during experiments?** *
Markeer slechts één ovaal.

- They work individually
- They work in pairs
- They work in small groups (3 to 4)
- They work in rather big groups (4 or more)
- They can choose for themselves whether they work individually or together
- Anders: _______________________________

12. **When pupils are allowed to work together, can they choose their partner(s) themselves? ***
Markeer slechts één ovaal.

- Yes
- No

If your previous answer was 'yes', you can skip the next question.

13. **How do you divide your pupils into groups?**
Markeer slechts één ovaal.

- Randomly
- I put stronger and weaker pupils in different groups
- I put stronger and weaker pupils in mixed groups
- I use a rotational system so the pupils always have different partners/groups
- Anders: ____________________

14. **Do you need more time introducing the experiment in the CLIL-context than when you would introduce it in a regular course using Dutch as target language? ***
Markeer slechts één ovaal.

- No
- Yes, but only a couple minutes
- Yes, It takes at least 5 minutes longer
- Anders: ____________________

15. **How do you introduce the experiment? ***
Markeer slechts één ovaal.

- Before the pupils start, I tell them step by step what they should do
- The pupils get work sheets on which everything is explained
- The pupils get both the explanation up front and work sheets
- The pupils have to design their own methodology
- Anders: ____________________

16. **How do you organize your classroom during experiments? ***
Markeer slechts één ovaal.

- Pupils can work where they want
- Pupils work at their desks
- Pupils work at designated working stations
- Anders: ____________________

17. **How do you make sure your pupils are working on the task at hand instead of fooling around? ***

18. **In which way do you offer linguistic support to your pupils? ***
Markeer slechts één ovaal.
- I provide a list with definitions of difficult words
- I provide a list with translations of difficult words
- I provide a list with pictures of difficult words
- I make sure difficult words are introduced in a clear context
- Anders:

19. **What are your expectations concerning the written use of the target language by your pupils? ***
Markeer slechts één ovaal.
- They must write in the target language at all times
- They should try to write in the target language as much as possible
- They may choose to speak Dutch when working on their report
- Anders:

20. **What are your expectations concerning the verbal use of the target language by your pupils? ***
Markeer slechts één ovaal.
- They must speak the target language at all times
- They should try to speak the target language as much as possible
- They may choose to speak Dutch while working on experiments
- Anders:

21. **Which other specific tools or strategies have helped you in organizing expirements in CLIL succesfully? ***

22. **If you have other recommendations or thoughts on this subject, feel free to share them. Thank you!**

☐ Stuur mij een kopie van mijn reacties.

2. Appendix 2: Adjusted workshop

Implementing pupil-centered scientific experiments in the CLIL-methodology

Workshop

THOMAS MORE MECHELEN

May 31, 2017

By Flor Maes

Implementing pupil-centered scientific experiments in the CLIL-methodology

Workshop

Aim of the workshop

The aim of this workshop is to present a set of tools and principles, derived from the 4 C's of CLIL and the scientific research method in the curriculum, which can accommodate setting up pupil-centered scientific experiments in CLIL-context. CLIL courses engage pupils in producing a lot of output, as a result the educational methods used should be learner centered.

Clear solutions won't be given in this section nor will they be given later on, as they don't exist. The key is to use a well thought-out combination of multiple educational principles depending on what you are trying to achieve. When a lesson is organized properly the outcome can transcend the sum of the individual principles used, resulting in a powerful learning environment where pupils are empowered to take their learning process in their own hands. This sounds easier than it is and putting together all the pieces of the CLIL-puzzle can be a challenge. Therefore continuous fine-tuning and innovation are mandatory.

Why scientific experiments? Firstly, experiments allow pupils to learn from their experience rather than from letters in a text book or on a blackboard. Secondly, cooperative learning has been proven to increase learning profit when applied properly. When pupils perform experiments in groups they can share their knowledge and observations, empowering them through their possible prior knowledge as well as giving them the opportunity to communicate in a foreign language without being assessed for their oral skills. And last but not least, learning together with one another and from each other is known to result in deeper learning and enables developing the required social skills to participate in social and economic life.

Core principles

The four C's

1. ***Content:***

   Contemporary monolingual language education often receives criticism in that the activities lack a realistic component. In extension, pupils experience these activities as artificial constructions and often question their value. This implies that learning language for the sake of language itself lacks a motivating component, thus not contributing to the involvement of the pupils. CLIL can offer a valuable alternative because of its integrative nature of content and language, which results in meaningful learning activities.

2. ***Cognition:***

   Research has shown that CLIL is not only beneficial for language learning but also makes students better all-round learners. Multilinguals are better learners as their linguistic skills are more automatized in their long term memory, freeing up working space in their short term memory. Apart from that, the explicit and implicit learning involved in CLIL is closer to the natural way of learning due to the integration of language and content, thus making the learning more effective. Through both the written and oral communication in CLIL, more complicated cognitive strategies, also known as higher-order thinking, are stimulated and cultivated, resulting in a more profound understanding of both language and content. (Bloom's taxonomy provides a clear overview of the different levels of cognition, see p.20)

3. ***Communication:***

   Learning often involves the transfer of information from one party to another. To facilitate this transfer in class, communication is mandatory. This takes place both passively and actively. Pupils need to have the opportunity to practice their communicative skills as to train their cognitive academic language proficiency, also known as CALP. In extension, educators should organize a wide variety of activities in which pupils can practice both their active and passive skills. This way knowledge can be constructed through communication.

4. ***Culture:***

   Being able to speak another language than one's mother tongue does not only grant a person the ability to express himself in that language, it also renders the speaker able to peer into the collective mind of that culture. By using foreign languages in class, CLIL can facilitate this, thus cultivating pupil's insights in human nature. In extension, pupils can develop a deeper understanding of one's self, resulting in more constructive individual growth, and others, allowing them to attribute motivations and aspirations to the actions of those others more precisely. Due to the globalized nature of our society, the need for mutual understanding on both interpersonal and intercultural levels grows daily.

Learner-centered learning

Learner-centered learning is implied in good CLIL practice, but it is still worth mentioning separately as to reflect on the goal of education in general. In the end, learners should grow to become resilient individuals that cultivate their entire self continuously as to have a meaningful life. Allowing your pupils to improve their metacognitive skills can be a huge help in achieving this goal. Learners who have difficulties in school for whatever reason are likely to lose motivation and give up. It is paramount to prevent this, because the behaviour and views on the world at large that teenagers develop during their school career can strongly influence their future place in society.

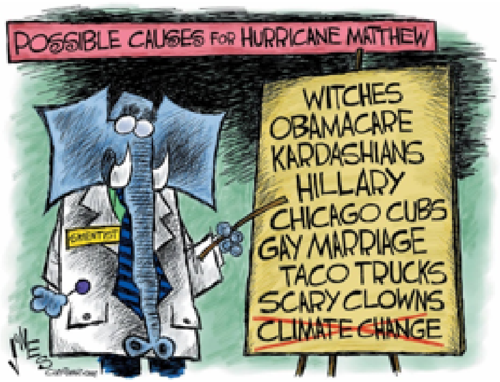
- ***Engages students in the hard, messy work of learning:***
  Pupils can't develop sophisticated learning skills without the chance to practice and in most classrooms the teacher gets far more practice than the students.
- ***Includes explicit skill instruction:***
  Research consistently confirms that learning skills develop faster if they are taught explicitly along with the content.
- ***Encourages learners to reflect on what they are learning and how they are learning it:***
  Teachers should challenge pupil assumptions about learning and encourage them to accept responsibility for decisions they make about learning. The goal is to make students aware of themselves as learners and to make learning skills something students want to develop.
- ***Motivates learners by giving them some control over learning processes:***
  When teachers make all the decisions, the motivation to learn decreases and learners become dependent. Pupil centered teachers search out ethically responsible ways to share power with students.
- ***Encourages collaboration:***
  Pupil centered educators work to develop structures that promote shared commitments to learning.

"I think it's an exaggeration, but that there's a lot of truth in saying that when you go to school, the trauma is that you must stop learning and you must now accept being taught."
— Seymour Papert

The 5 E's learning cycle and the natural sciences research method

The 5 E's learning cycle is a method to structure science and others lessons, based on the constructivist approach. It shows many similarities with the natural sciences research method but offers more pedagogical support and facilitates learner centered learning. The scientific research method is integrated in every science course curriculum and can be defined in the following way: "A set of procedures that scientists follow in order to gain knowledge about the world". Teachers are encouraged in the curriculum to perform pupil centered experiments. This way, pupils can learn how to investigate scientific concepts by using the 5 E's learning cycle, as well as learning the concepts behind the specific experiment.

On top of that, science literacy subsequently benefits individuals throughout their lives, from forming opinions about proposed government policies to making health-care decisions. In extension, a population of critical citizens contributes to the general welfare of society. This, in turn, is advantageous for every individual within that society.



The 5E's stands for the five different phases of which the learning cycle exists.

- Engage: This phase is meant to incite curiosity, activate prior knowledge and identify possible misconceptions.
- Explore: The exploratory phase allows pupils to gather information, data and observations in a preferably instruction-poor environment.
- Explain: During this phase pupils are invited to formulate explanations and definitions, which can then be supported by media presented by the teacher.
- Extend: Newly gained knowledge and insights are applied on real life phenomena. Research and problem-solving should be stimulated in this phase.
- Evaluate: Both the student and the teacher reflect upon the entire process, what went well and what could have been better.

When looking at the different steps it is clear that words like formulate and evaluate are verbs associated with higher-order thinking skills. Given sufficient language support, the pupils can construct their knowledge by experiencing the scientific concepts they are investigating and by interacting with each other while performing the experiment. Taking this into consideration it is safe to say that the scientific research method and especially the 5 E's can be used as an asset when creating a powerful learning environment in the CLIL-methodology.

Difficulties in the practice

Here's a short list of common challenges in the practice. One of the first steps in designing your lesson is identifying the difficulties. Depending on target pupils, setting, course, topic,… these difficulties can be very diverse. Hopefully, by the end of this workshop you will have some ideas to experiment with.

- ***Motivating the pupils to speak the target language:***
  During experiments pupils can get away more easily with speaking their mother tongue deliberately. The pupils need a safe environment where they know trying to speak is more important than speaking flawlessly, especially for classes that are relatively new to CLIL. Apart from that, language support can be given to lower the threshold. It should also be noted that CLIL is not mandatory, meaning that the main reason for this difficulty is insecurity when speaking the target language.
- ***Completing the curriculum:***
  This might be one of the toughest challenges. Even in regular classes with one hour or two hours of sciences a week this can prove to be difficult, especially when you want your pupils to learn actively through experiments. On top of that, CLIL teachers should take the time to cultivate their class atmosphere, especially when it's new to their pupils.
- ***Giving clear instructions:***
  Clear and unambiguous instructions are important as not knowing what to do can demotivate pupils. But even then they will get it wrong from time to time. Cultivating your pupils' persistence will help them in fostering an 'experiment, fail and learn mentality'. Apart from that, clear instructions are also important because the experiment might fail if poorly executed.
- ***Partnership with language teacher:*** While a language teacher will rarely be a science didactics expert, so will a science teacher rarely be a true linguistic. Although science teachers are pretty amazing, there is no shame, on the contrary, in approaching your language colleagues for extra linguistic support for yourself and the pupils.
- ***Language skill of leaners:*** The language proficiency of your pupils can strongly vary. Individual pupil characteristics as well as school, region and other factors can be accounted for this. The potential practical value of the science-CLIL framework, that will be presented later on, is strongly limited by a precise assessment of your pupils' language proficiency.
- ***Class-management:***
  When trying to create a powerful learning environment in which pupils can learn autonomously, it is important to give them enough space to do so. The downside is that it gives them the opportunity to push the boundaries and test your authority. Considering the fact that your pupils are working with expensive and/or dangerous equipment, maintaining order in your class and structure in your lesson is paramount.
- ***Didactical material:*** Since CLIL is relatively new in Flanders there is a shortage of material that offers sufficient language support, scaffolding, and pupil-centered activities and follows the Flemish curriculum.

'Do it yourself' experiments

Since experiencing something oneself is one of the best ways to learn, you will be submerged in a short science CLIL lesson. The following pages are designed as if they would be used in a first grade natural sciences lesson. In addition, tips and tricks on how to design each phase are provided for educators. These tips and tricks are based on the abovementioned core principles. At the end of the workshop, this exemplary lesson will be used to refer to while explaining the framework.

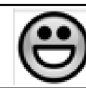
Self-assessment criteria and stimulating participation

Pupils should be encouraged to read the self-assessment criteria up front. This way they can form an idea of what is expected of them and how experiments should be conducted. Make sure to end the experiment in time so the pupils can tidy their desks and fill in an empty grid on the last page of their work sheets. When pupils aren't making any effort during the course it often suffices to remind them of the self-assessment and its criteria. In the beginning of the academic year, pupils could also be allowed to formulate the success criteria together. Since they participated in the creation of these criteria, their motivation to meet them will be increased.

A second way to stimulate participation is to make the pupils accountable for their work. Accountability can be achieved by allowing every group to distribute certain roles in the beginning of the lesson. Depending on the aim of your lesson, possible roles are reporter, manager, material master, language specialist, google man (should pc's or tablets be present, even smartphones could do the trick if expectations concerning their use are made clear), time-keeper, etc. Both the success criteria and the pupil roles are concepts that can keep coming back, hence they will not remain time-consuming. On the contrary, pupils will get accustomed to it and even make it their own.

Finally, many simple tricks ranging from cards with raised fingers, that the pupils have to get rid of during the lesson by answering or posing questions, to cards with smileys as a reward for good effort can stimulate participation. An agreement with the language teacher could be made to sometimes appoint a random pupil during language class and ask him/her to explain which experiment they conducted. The possibilities here are only limited by your own imagination and creativity. Talk with your colleagues, they might have some tricks up their sleeves as well.

Example of self-assessment criteria for CLIL-science lessons

Attitudes and competences				
Working in own group in a calm manner	I make too much noise or shout and disturb other groups	I walk around and disturb other groups	I talk standing at my desk	I sit at my own desk and discuss with partners
Working together	I don't cooperate and copy notes from others	I work alone and don't want other to help me	I do my best and let others help me	I do my best and help others
Working pace	I work slowly and waste a lot of time	I work rather slowly	I work fast enough, my work is finished right on time	I work fast enough, I have time left
Following instructions	I have no respect for the material and don't follow the instructions	I only respect the material and instructions when the teacher is near.	I always respect the material and instructions	I always respect the material and instructions, I stimulate others to do the same
Safety	I endanger myself and others	I only work safely when the teacher is near	I always work safely	I always work safely, I stimulate others to do the same
Formulating observations	I don't make any effort to formulate observations	I only make an effort to formulate observations with the help of others	I can formulate observations by myself	I can formulate precise and correct observations
Using the CLIL-language as much as possible	I don't make any effort to use the CLIL language	I only make an effort to use the CLIL language when the teacher is near	I always make an effort to use the CLIL language	I always make an effort to use the CLIL language, I stimulate others to do the same

Introduction of subject and jargon

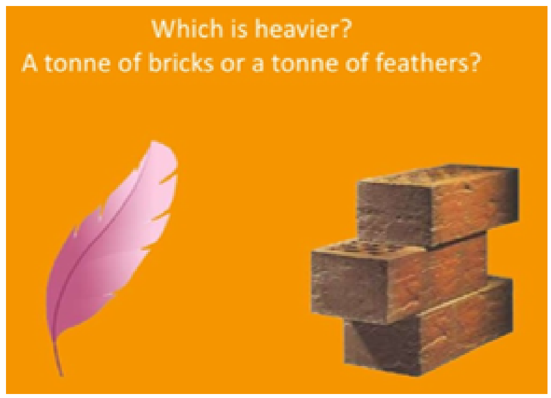
When the pupils have been made aware of the expectations and the conditions for participation have been set, the subject can be introduced, preferably in a way that motivates the pupils by raising their curiosity. You could show them some awe-inspiring footage about the subject and activate their prior knowledge by allowing them to discuss what they know with their neighbour. By discussing the topic up front, the pupils can realize they already know more than they thought, they use the specific jargon while summarizing the previous content, and are positively reinforced by doing so.

When the pupils and their prior knowledge are activated it is time to introduce the new content. Presenting the new content in exercises with plenty of language scaffolding and visualization through pictures enables your pupils to construct new knowledge through communication with their peers. The introduction of new words isn't merely another vocabulary exercise, but a required phase in preparing for the experiment.

What is density?

Synonym for matter = substance

Activity 1: Discuss the statement on the picture with your face partner. Form a conclusion in one minute. Afterwards compare with your shoulder partner.



Conclusion:

____
____
____
____
____
____
____

Activity 2:

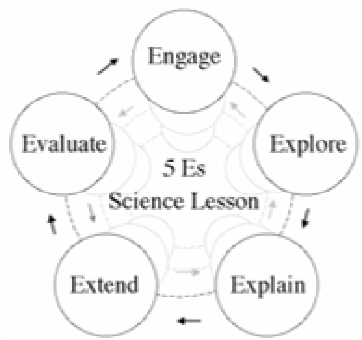
- The material master collects a placemat at the teachers' desk. Next, everyone has one minute to write down what he/she can remember about mass and volume. Write this down in your own space on the placemat.
- Comparing everyone's ideas, form a definition for both mass and volume in the central space in one minute.
- Let the reporter write down the definitions on his whiteboard so they can be discussed classically.

Activity 3: Fill out the grid using the following words. Mass, volume, density, tonne, quantity, unit.

	General word used for concepts such as volume, length, mass, …
	The space that a substance (solid, liquid, or gas) or shape occupies or contains. The basic SI unit is the cubic meter (m^3).
	The amount of matter in an object. The basic SI unit is the kilogram (kg).
	= 1000 kg
	The amount of mass per unit volume or in symbols: $\rho = \frac{m}{V}$ and $\rho = [\frac{kg}{m^3}]$
	The symbol used to describe a quantity.

Activity 4: Now that you have learned more about density, go back to the first activity and check your answer.

Research method and 5 E's learning cycle



Every group of pupils will be performing a different experiment. This way, when conclusions are shared classically, the entire class can benefit from each other's learning. This also provides the possibility to treat more content during one lesson. Pupils should be able to conduct the experiment following the steps of the scientific research method. The research method is implemented in the 5E's learning cycle as the pupils still need to learn the nature of scientific inquiry. The different phases are interchangeable, depending on grade and subject. In this example inductive research is done about density, which is a first grade subject. Extra language scaffolding can be offered when new words are introduced.

Every phase of the scientific research method is present in the overview chart, as well as every experiment. When all experiments have been performed and conclusions have been made, the pupils are mixed up in different groups. The idea is that every group now consists of four pupils who all conducted a different experiment and are 'expert' of that experiment. By sharing their knowledge about the same topic in a different way, content and language are processed together and through each other. Since the pupils are learning together, the teacher doesn't have to do anything special apart from taking the time to make sure every group is on track and providing extra support where needed.

Follow the instruction for each phase accurately and complete the overview chart below. Make sure you are working in the right part of the chart. The titles are in the upper row. Online dictionaries may be used.

1. Question: Read the question and make sure you understand it.
2. Hypothesis: Choose a hypothesis from one of the cards and write it down in the hypothesis box in the chart (see added document p. 18-19).
3. Experiment: Perform your experiment by following the different steps in the chart. Taking notes can help you in the next phase.
4. Observation: Write down your observations. Sentence heads are given to get you going.
5. Analysis: Compare your observations with your hypothesis and discuss them with your group. Do they meet your expectations? Sentence heads are given to get you going.
6. Conclusion: Was your hypothesis correct? Answer the questions from step 1 in a full sentence.

	Swimming eggs	**Wonky water and ordinary oil**	**Which is the densest object?**	**Magic water**
1. Question	Can an egg float in water? Is there a difference in density between fresh water and salt water?	How do water and oil interact with each other? How does solid matter behave when submerged in liquid of the same matter?	Is density substance-specific?	Does temperature influence a substance's density? Does warm water have a different density than cold water?
2. Hypothesis	Write your hypothesis here	Write your hypothesis here	Write your hypothesis here	Write your hypothesis here

3. Experiment	**Material:** an egg, water, salt, spoon, container, water heater 1. Heat sufficient water to fill the container 2. Fill the container with warm water 3. Carefully submerge the egg in the water 4. Add salt while stirring 5. See what happens	**Material:** 2 containers, oil and water, oil and ice cubes 1. Fill the container with water 2. Put in some ice cubes 3. Fill the second container with oil 4. Put in some oil cubes 5. Compare the two containers 6. Put some ice cubes in the oil container 7. Watch what happens when the ice cube melts	**Material:** measuring cup, stone, tea cup, candle holder, calculator, balance, unit conversion grid, water 1. Weigh the first object by using the balance, write down the mass 2. Fill the measuring cup with water high enough to submerge the object 3. Write down the volume before submerging the object 4. Submerge the first object and calculate the volume difference (=object volume) 5. Calculate the density of the object by using the formula $\rho = \frac{m}{V}$ 6. Repeat for the other two objects and compare	**Material:** water heater, water, two glasses, food colouring, laminated paper 1. Heat some water 2. Fill one glass with warm water and the other with cold water 3. Add food colouring to the warm water 4. Place the laminated paper on top of the cold water glass, make sure the circle on the paper is resting on the edge of the glass 5. Press the paper tightly against the edges and put it upside down on top of the warm water glass. Again, make sure the edges are on the circle 6. Carefully remove the laminated paper. Turn the glasses upside down very slowly
4. Observation	- When the egg is put into the fresh water… - When salt is added to the water…	- Ice cubes float in … - Oil cubes sink in … - The water from the melted ice cube in oil…	- ρ_{rock} = - $\rho_{tea\ cup}$ = - ρ_{glass} =	- When the laminated card is removed … - When the glasses are slowly turned upside down …

5. Analysis	- The egg has a higher density than … - The density of water increases …	- The ice cubes float in … because … - The ice cubes sink in … because … - Water sinks in … because …	- When comparing the density of the three substances … - The density of an irregular object can be calculated by …	- The warm water … - Temperature increase in a substance results in …
6. Conclusion				

Activity 5: Now swap groups so the new groups consist of one member from every different experiment. Take turns to explain your experiment and conclusion to your new group in two minutes. Complete the overview grid.

Conclusion and recapitulation

When the exchange of experience and conclusions has come to an end, so does the intake of new content. If the teacher hasn't been able to check all the conclusions before the groups were mixed up, then now is the time to set straight any misunderstandings. Apart from that, a summary or schematized overview, accompanied by visual support, of the newly learnt content is crucial in allowing the pupils to categorize it and to link it to the new language and prior knowledge. New information is not added on top of previously gained knowledge, but rather assimilated with the experience and knowledge already present.

Activity 6: Watch the video fragment (https://www.youtube.com/watch?v=WGFJqTmjz84). Match the density value to the substances: oil, penny, apple, water.

Low density					High density
	$0{,}92\,\frac{g}{ml}$	$0{,}95\,\frac{g}{ml}$	$1{,}0\,\frac{g}{ml}$	$7{,}1\,\frac{g}{ml}$	

Activity 7: Complete the box together with your shoulder partner. Write the words in the right category. Take turns for each word. If your partner makes a mistake, try helping him/her without giving the right answer. "float, higher, lowers, solid, particles, density, water, sink, changed, increases, fluid, volume."

Verb (werkwoord)	Noun (zelfstandig naamwoord)	Adjective (bijvoeglijk naamwoord)

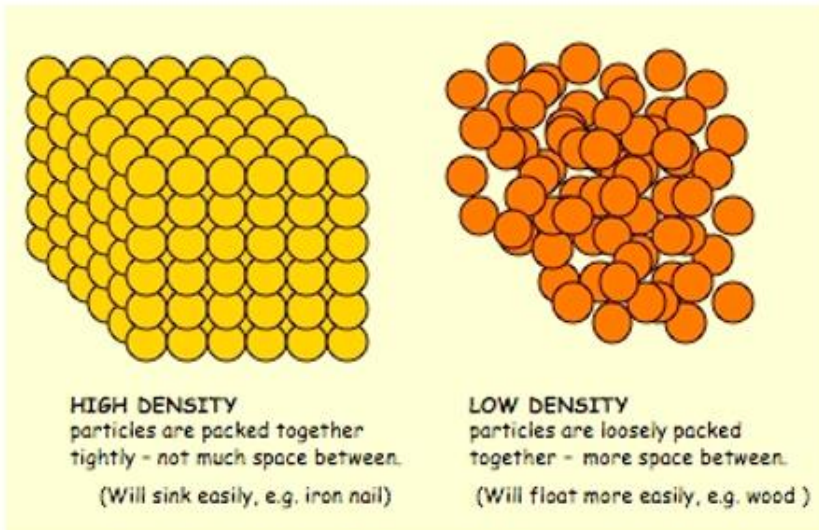
Now, complete the summary in the box by using the same words. Use the grid you just filled in to help you figure out where the words fit.

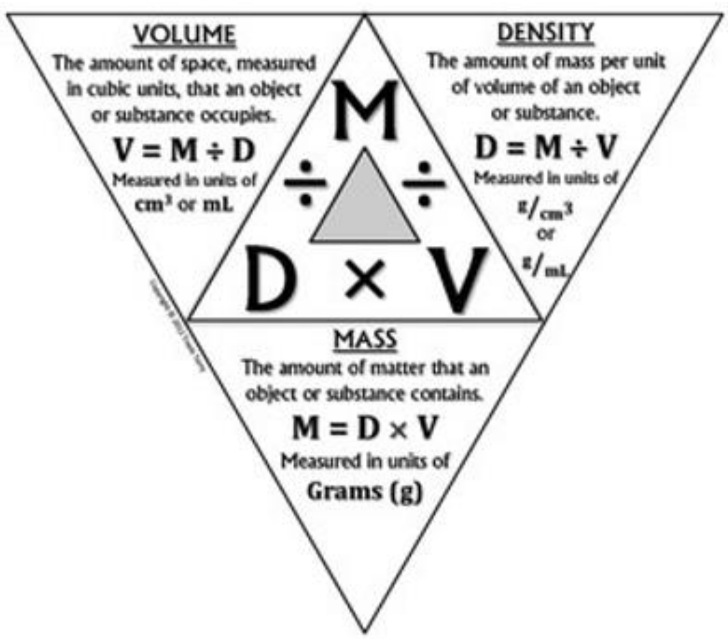
______________________ is a measure for the space between the ________________ of a substance. The less space in between the particles, the ____________ the density. The density value of a substance is typical for that substance.

The density of a substance can be ________ in two ways. Increasing the temperature _________ the density, while cooling the substance _________ it. When fluids are cooled until their freezing point, they turn ________ . Solid substances have a higher density than the ______ of that same substance. Except for ________ . This substance is an exception that has a _______ increase and thus density increase when turning solid.

Objects and liquids with a higher density will _________ in a fluid with lower density. Objects and liquids with a lower density will _________ in a fluid with lower density.

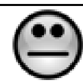
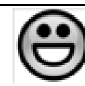
Examples of visual overviews of core principles of the lesson





Self-assessment

The pupils may now assess themselves. This way they can reflect about their attitudes during the course, the things they like or didn't like, what they learned and whether they enjoyed learning it. In the long run it should increase the awareness of their own responsibility towards their learning process.

Attitudes and competences				
Working in own group in a calm manner				
Working together				
Working pace				
Following instructions				
Safety				
Formulating observations				
Using the CLIL-language as much as possible				

CLIL science experiments framework

The framework consists of an extended version of the scientific research method. The basic research method is embedded in a learner centered frame. Each of the steps can be facilitated with different elements that have proven to be effective in the CLIL-methodology. One general principle that should be present in every step is positive reinforcement. It is one of the most powerful tools to create a safe class environment in which pupils drop their reluctance to speak the foreign language. It is paramount to break this barrier since not communicating equals not participating.

1. Engage: transparent success criteria and stimulating participation	- Set clear expectations - Let pupils participate in formulating the criteria - Accountability through 'specialized roles' during entire course - Encourage pupils to help each other, consider making groups of weaker and stronger pupils - Allow pupils to take learning process in their own hands - Hand out little whiteboards or cards with raised fingers that pupils have to get rid of by posing or solving a question - Project count down timers for each activity to set a clear timeframe.
2. Engage: introduction subject and jargon	- Activate prior knowledge - Motivate pupils with awe-inspiring footage of the subject - Scaffold with pictures, lexicons and/or synonyms, fill the gap and linking exercises, associations, … - Organize activities in which the pupils have to discuss the subject using the new jargon - Flipped classroom: let the pupils prepare the subject and jargon at home - Placemat
3. Explore: question	- The question is often given, even in regular science courses - Cards with questions can be used from which the pupils must choose - Questions can be formed by the pupils using sentence heads, key words, synonyms, placemat
4. Explore: hypothesis	- Hypotheses can be formed by the pupils using sentence heads, key words, synonyms, placemat - Cards with statements can be used to introduce different hypotheses - Generic hypothesis structure can be introduced and re-used in following experiments
5. Explore: experiment	- Offer clear instructions with extra scaffolding for the new jargon introduced with pictures, lexicons and/or synonyms, fill the gap and linking exercises, associations, … - Flipped classroom: let the pupils prepare the experiment at home - Let the pupils design their own methodology - Refer to success criteria during the experiment

6. Explore: Observation	- Varies depending on language proficiency and experience in CLIL - observations can be formulated by the pupils using sentence heads, key words, synonyms - Let the pupils take turns to formulate observations, then discuss them
7. Explore: Analysis	- Support the pupils with sentence heads, lexicon and key words, depending on the proficiency of your pupils you can take away some scaffolding. - Pose questions that stimulate higher order thinking skills, charts with verbs associated with these skills are very useful. (see bloom's taxonomy, p.20)
8. Extend: conclusion and recapitulation	- Reformulate questions from step 3, - Jigsaw - Overview charts or summaries with the core of both content and related jargon, preferably visualized in a clear way
9. Evaluate: (self-) assessment	- Stimulates higher-order thinking skills - Makes pupils aware of their own learning process - Let the pupils keep track of their progress in an experiment portfolio. Both scientific and personal growth can be tracked here. - You could give the pupils the opportunity to assess the design of your lesson. This increases the awareness of their own learning styles and can help you improve your future lessons at the same time

Practice

Develop, in group, your own conceptual pupil centered scientific CLIL course using the framework. Write down the key elements on your little whiteboard. In case you needs inspiration concerning specific experiments, booklets are present.

Present your ideas to the other groups in a class discussion, ask feedback.

My own assessment

Thank you all very much for participating in my workshop. I would love your feedback!

With the idea of life-long learning in mind, I realize this framework will never be truly finished. To increase the quality of my workshop in the future, and potentially the durability, I would love your feedback in two ways. Firstly, I would appreciate comments on good aspects as well as suggestions for improvement. Please be so kind to discuss this in group by using a placemat. Secondly, I would be much obliged if the survey, with closed questions and a general personal comment section, could be completed.

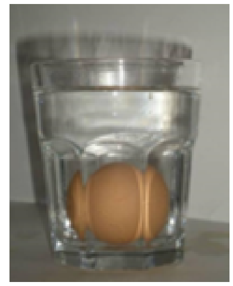
I would also like to thank Liesbeth Martens and Joris De Roy for sharing their knowledge on CLIL, general good educational practices and, especially, their enthusiasm and passion for education with me. It's contagious in a good way and I hope it will linger for a long time…

Swimming eggs: What will happen? Discuss with your group the hypothesis you will choose and write it down in your overview chart. The pictures and words can help you during the experiment phase.

fresh water = zoet water

to submerge = onderdompelen

to float = zweven



- The egg will sink in fresh water and float when enough salt is added.
- The egg will float in fresh water and sink when enough salt is added.
- The egg will sink in fresh and salt water.

Which object has the highest density?: What will happen? Discuss with your group the hypothesis you will choose and write it down in your overview chart. The pictures and words can help you during the experiment phase.

- The tea cup has the highest density.
- The rock has the highest density.
- The glass has the highest density.

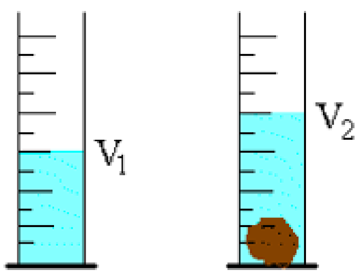
object = voorwerp

to submerge = onderdompelen

irregular = onregelmatig

conversion grid = omzet tabel

balance= weegschaal



Unit conversion grid:
Place the value you want to convert in the box corresponding with the value of the unit.
Example: 5,447 dl = 544,7 cm^3

m^3			dm^3			cm^3			mm^3		
			hl	dal	l	dl	cl	ml			
						5	4	4	7		

Magic water: What will happen? Discuss with your group the hypothesis you will choose and write it down in your overview chart. The pictures and words can help you during the experiment phase.

- When the temperature of a substance is raised, the density stays the same.
- When the temperature of a substance is raised, the density increases.
- When the temperature of a substance is raised, the density lowers.

increase = stijging

to influence = beïnvloeden

laminated = geplastificeerd

edge = rand

Wonky water and ordinary oil: What will happen? Discuss with your group the hypothesis you will choose and write it down in your overview chart. The pictures and words can help you during the experiment phase.

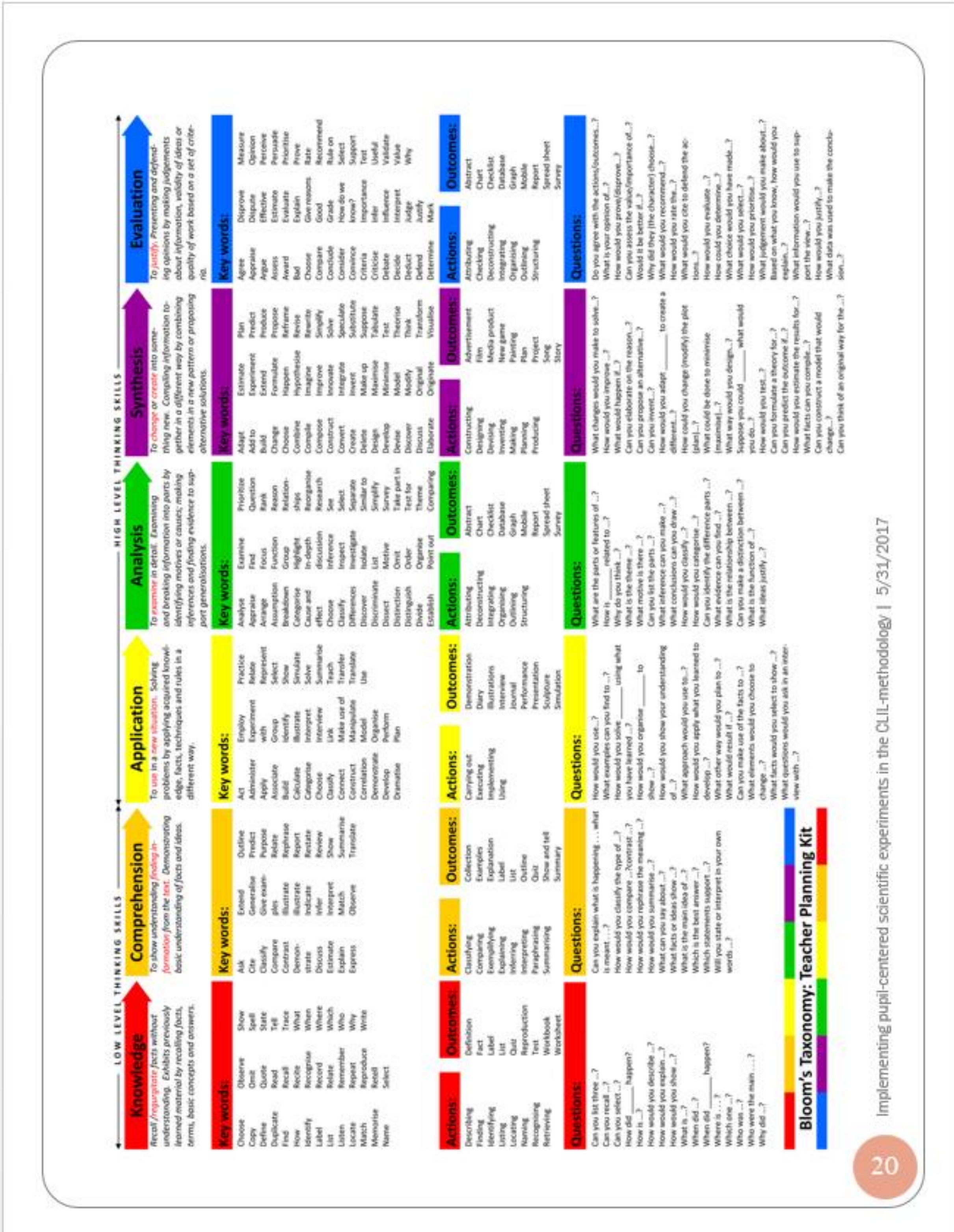
- When submerged in liquid of the same matter, the ice and oil cubes will float.
- When submerged in liquid of the same matter, the ice and oil cubes will sink.
- When submerged in liquid of the same matter, the ice cubes will float and oil cubes will sink.

to float = zweven

to submerge = onderdompelen

to interact with one another = op elkaar inwerken

to behave = zich gedragen


LOW LEVEL THINKING SKILLS
HIGH LEVEL THINKING SKILLS
Knowledge
Comprehension
Application
Analysis
Synthesis
Evaluation
Bloom's Taxonomy: Teacher Planning Kit
Implementing pupil-centered scientific experiments in the CLIL-methodology | 5/31/2017
20

3. Appendix 3: Feedback survey

Feedback workshop: Implementing pupil-centered scientific experiments in the CLIL-methodology

1. How old are you?

___

2. What is your link with education?

___

3. If you have any experience as a teacher, how many years did you teach already?

___

Please rate the following statements with the numbers 1 to 5. (1 = I strongly disagree, 5= I strongly agree)

	1	2	3	4	5
The framework is relevant to the subject of the bachelor thesis.					
The framework provides a comprehensive overview of educational methods that can facilitate a powerful learning environment.					
The framework encourages educators to develop pupil-centered science lessons.					
The framework can help me overcome some of the challenges I face in the practice.					
I believe the difficulty level of the framework suits my skills and knowledge as teacher.					
Using the framework will allow me to organize more pupil-centered scientific experiments.					
CLIL lessons based on the framework will encourage pupils to collaborate and learn from each other.					
A CLIL lesson based on the framework will result in more profound learning on both the content and language aspect.					
I feel I have gained more insight in the way lessons can be organized in a pupil-centered manner.					
After following the workshop, I have more tools to give my pupils the language support they need.					
The exemplary exercises are suitable for my pupils					
After following the workshop, I have more tools to give my pupils the language support they need.					
When giving CLIL lessons based on the framework, pupils will gain more insight in their own learning process.					

1

If you have additional thoughts on the subject of which you didn't have the opportunity to voice yet, feel free to share them with me.

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Your confidentiality as a participant in this study will remain secure. The information gathered will be used strictly for the purpose of my bachelor thesis: Implementing pupil-centered scientific experiments in the CLIL-methodology.

Thank you very much for your cooperation!

Flor Maes