

CLIL & IBSE METHODOLOGIES IN A CHEMISTRY LEARNING UNIT

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ABSTRACT

In this paper, we have combined CLIL (Content and Language Integrated Learning) with IBSE (Inquiry Based Science Education) methodology. Inquiry is an approach to learning that involves a process of exploration that leads to asking questions and making discoveries in the search for new understandings. This means that in an inquiry, learning process information is not directly offered but it needs to be discovered through investigation activities by learners themselves. Through the "*Chemistry, CLIL and IBSE*" project work, we chose to create a lesson on spectroscopy, to combine CLIL and IBSE methodologies using ITC tools in order to engage and motivate students in both science experiences and foreign language communication.

Keywords: CLIL, IBSE, UV/Visible spectroscopy.

INTRODUCTION

Inquiry-Based Science Education (IBSE) approach [1] encourages young people to engage in science topics to acquire scientific inquiry skills, and to experience the culture of studying science by undertaking active guided experimentation. Graasp platform (www.graasp.eu) allows us to build a learning space based on the inquire cycle, and students to perform personalized scientific experiments with online labs in pedagogically structured and scaffolded learning spaces that are extended by collaboration facilities. The chosen topic has a strong emphasis on content, since content is both very specific and specialized.

For this reason, it also needs methodology such as CLIL [2] that forces non-native students to become involved in an English environment, in which they should use this language for reading, writing and talking. English becomes another support, a further *scaffolding* in addition to ITC (Information and Communication Technology).

METHODOLOGY

First part: how to work with CLIL methodology

We want to explain how to apply CLIL to an Analytical Chemistry unit of the fifth year of Secondary Education. As a matter of fact, in Italy, in the last year of secondary school, it is common to teach a non-linguistic subject using CLIL methodology [3-4].

The unit we are planning is called "Spectroscopy", and it focuses on the components of visible light and the peculiar properties of the *electromagnetic wave*, in order to investigate the relationship between the *concentration* of dyed substances and the *absorption* of light. This unit will be proposed to a group of 19 years-old students who aren't very motivated to study a foreign language and for this reason has Lower-B1 linguistic skills.

During a CLIL lesson, the attention will be gradually moved to the *Content*, which in turn will become the support for learning the *Language*: students learn the language they need for studying and, at the same time, they learn the subject.

The key concepts of CLIL methodology are essentially two:

- *scaffolding*: to make language easier for learners;
- *taxonomy*: to engage learners with different kinds of tasks.

Students might not know the specific vocabulary and expressions used, so it is necessary to provide a suitable scaffold for the use of language, that could be *verbal* (such as writing prompts or definitions, metalinguistic clues, etc.), *procedural* (such as instructional framework, mutual dictation, dictogloss) or *learning tools* (such as graphics organizers, visuals or multimedia). In our topic, we specially use a series of learning tool (above all multimedia) and procedural (instructional framework - that we have called **Key info** - and mutual dictation).

We will also provide students with a series of task, according to new Bloom's Taxonomy [5] (see Figure 1), to promote the acquisition of LOTS (*Lower Order Thinking Skills*) and HOTS (*Higher Order Thinking Skills*) [6].

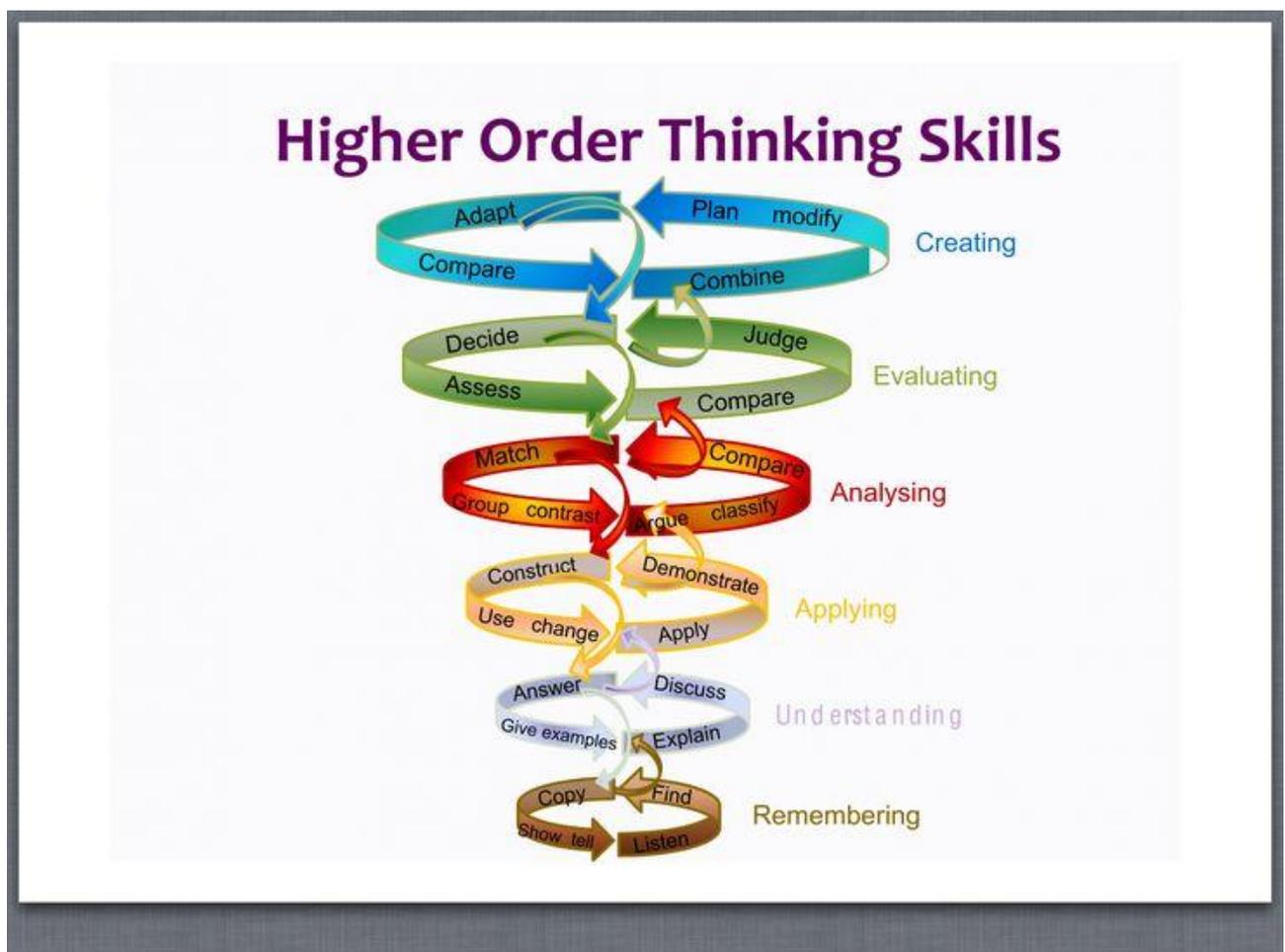


Figure 1. New Bloom's Taxonomy
(from http://cvsdlearning.weebly.com/uploads/1/2/3/8/12388126/41192_orig.jpg)

For these reasons, the first stage should be about the specific lexical phraseology as it is necessary to provide a suitable contextualised language (glossary, sentence structures and use of a dictionary).

In a second stage, tasks should be varied and appropriate to assimilate both content and language. Activities such as pair work are also important to create the right learning environment.

In short, CLIL is a result of the combination of five elements, which are called 5C's [7-8]: Content, Communication, Cognition, Community and Competence. Figure 3 clear up how these elements are related to the contents and skills that students acquire during the unit.

Content includes key concepts:

- EMw and EMspectrum: blu and red radiations, UV, IR., etc.
- Property of EMw: Wavelength, Frequency, Energy.
- Complementary colours.
- Transmittance and absorption.
- Lambert-Beer law: relationship between concentration and absorption.

Cognition involves thinking skills (HOTS & LOTS). This mental process of acquiring knowledge and understanding through thought, experience, and the senses (designed according to a Taxonomy, like Bloom's Wheel), aims at eliciting HOTS as well as LOTS.:

- Relating absorption of different EMws to specific property of matter.
- Predicting the absorption region of coloured substances.
- Describing analytical techniques.
- Performing experiences using of a double-ray UV-Vis spectrophotometer.
- Collecting data to write a lab report.

In order to create our cognition diagram, we used a "Task-oriented question construction wheel" like that in Fig. 2, in which we can see activities and verbs that correspond to each one of the Thinking Skills (remember, understand, apply, analyse, evaluate, and create).

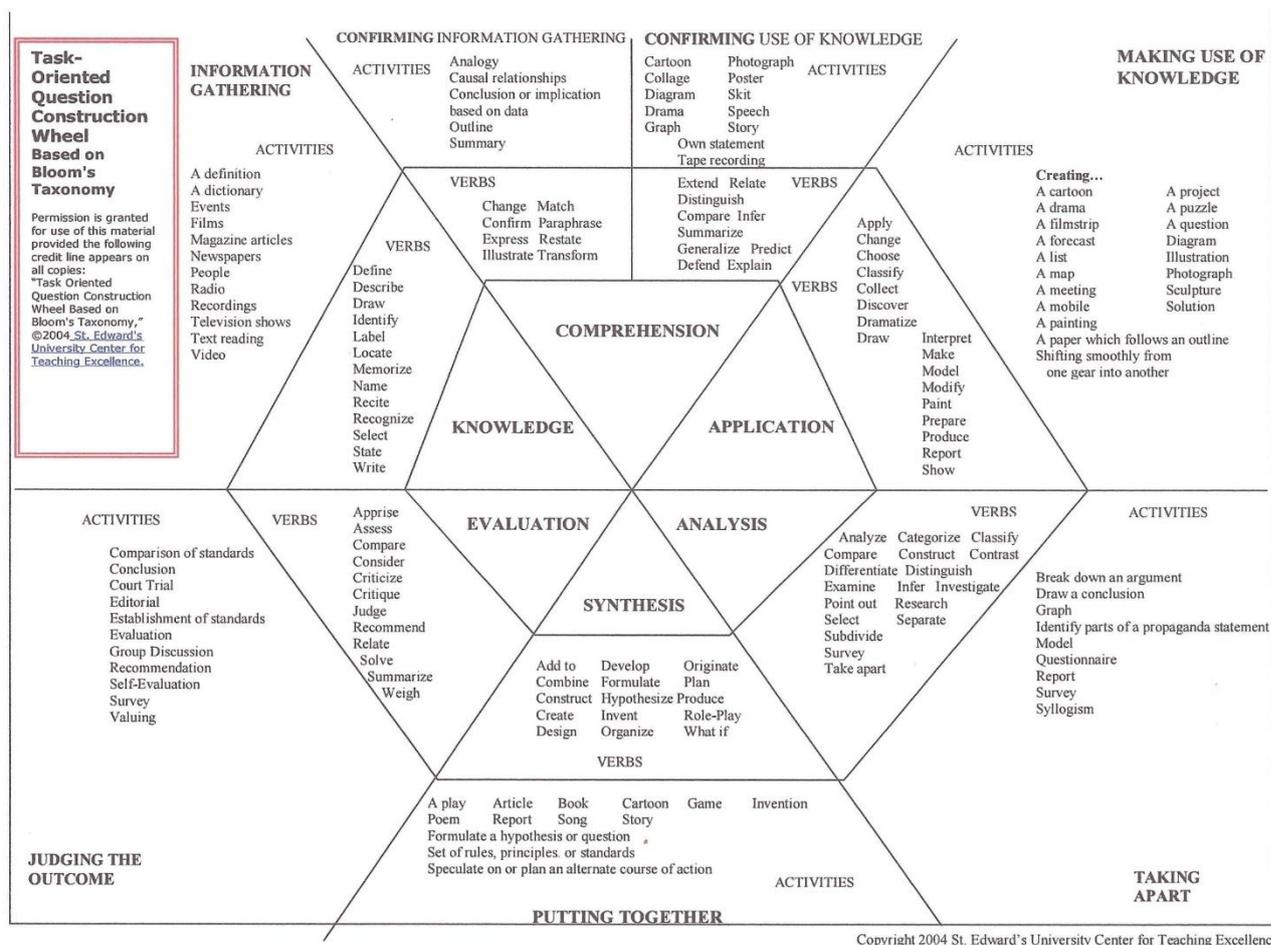


Figure 2. Task-oriented construction wheel (©2004 St. Edward's University Centre for Teaching Excellence)

Community is also called citizenship or culture:

- Working in group, respecting others' ideas.
- Working in the lab in a healthy and safe way.
- Presenting personal lab report in front of peers.
- Peer-to-peer assessment.

Competence: is a list of what the students will be able to do, even using ITC:

- Taking part in discussion.
- Interpreting a diagram.
- Presenting evidence.

Communication: involves CLIL teachers and students in using and developing

- a) Language *of* learning,
- b) Language *for* learning
- c) Language *through* learning [9].

Language of learning: it is the language students need to access basic concepts and skills relating to the subject topic, i.e. the necessary scientific vocabulary during the unit. It includes nouns, adjectives and verbs.

- **EMws:** Radio waves, Microwaves, Infra-red, Visible light, Ultra-violet rays, X-rays, Gamma rays, Electromagnetic spectrum, photons, nanometers, Hertz;
- **Property of EMw:** Wavelength, Frequency, Energy, speed of light, Colour, Complementary colour, intensity;
- **Analysis techniques:** Transmittance and absorption, lambda max, calibration curve;
- **Lab equipment:** double ray UV-visible spectrophotometer, source, monochromator, slit, prism, beam splitter, reference cell, sample cell, detector;
- **Lab processes:** adding, evaporating, selecting, pouring, filling.

Language **for** learning: it is the language used to operate in a foreign language environment, which includes the following types of expressions.

- How to compare different EMw through their properties: they are similar in that, they are different in that, their similarities are, their differences are, their wavelengths are longer/shorter than, their frequencies are lower/higher;
- How to carry out an experiment to calculate concentration: put the sample in the specific compartment, turn on the light source, report the measure on block-diagram, white light is divided by a prism into a rainbow of colors, it likely to, it consist of, edit data set, drug and drop data for the X/Y axis.

In CLIL settings, this means that the student needs to be supported in developing skills such as those required for pair work, cooperative learning, asking questions, debating, chatting, enquiring, thinking, memorizing and so on. Until students are able to understand and use language, which enables them to learn, to support each other and to be supported, quality learning will not take place.

Language **through** learning: it is the language that supports and improves the students' thinking processes whilst acquiring new knowledge. It is based on the principle that effective learning cannot take place without active involvement of language and thinking. Language through learning means to learn effective language as it is used by students.

- **Expressing opinions:** I think that, in my opinion, from my point of view, I agree with you, I disagree with you, that's a good idea, you are right, you are wrong;
- **Explaining processes:** first, second, then, next, after that, finally, above, below, behind, beyond, across.

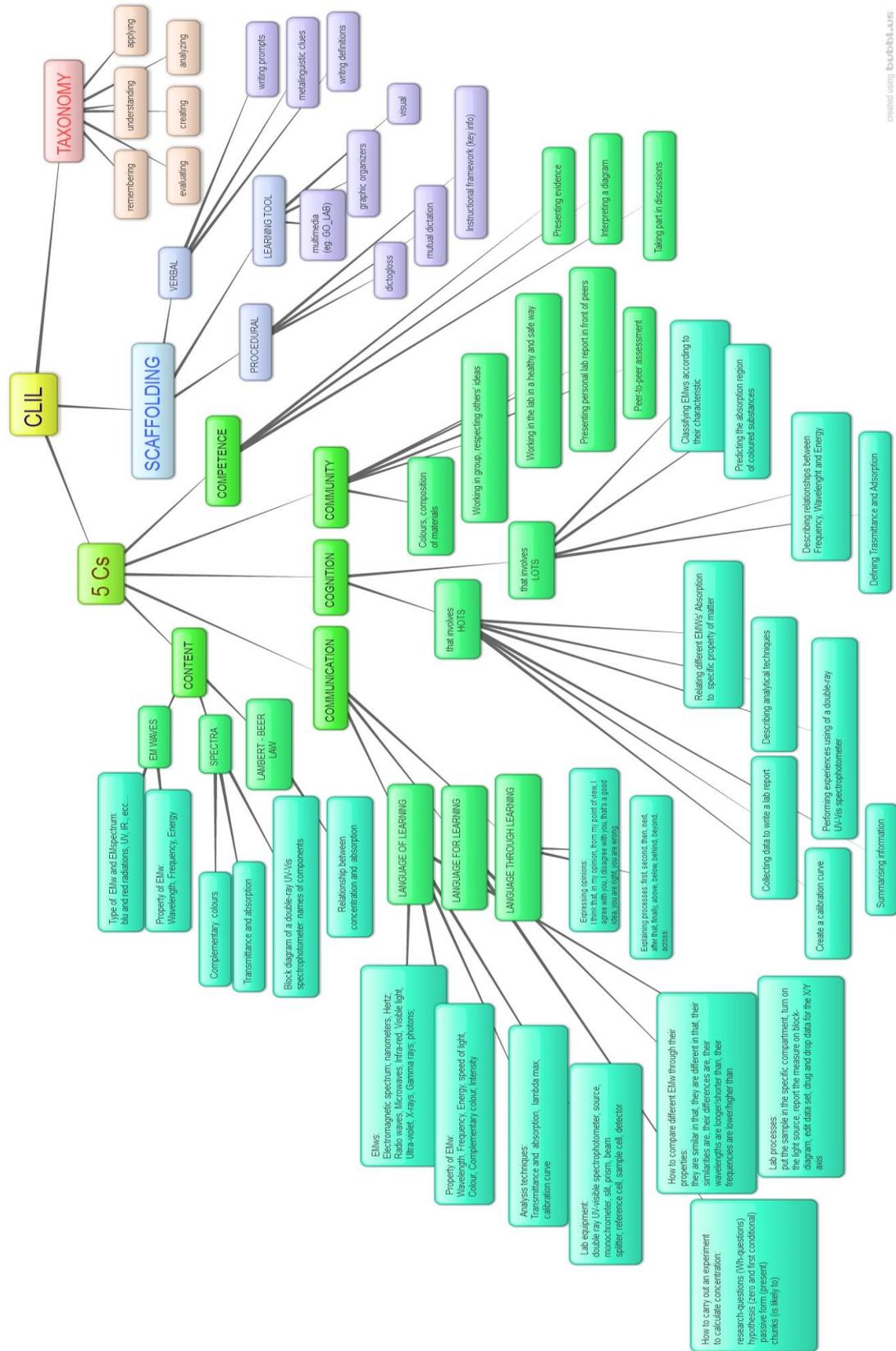


Figure 3. A mind map on UV/Visible spectroscopy

Second part: how to work with IBSE methodology

IBSE is a methodology consisting of five stages [10]: orientation, conceptualization, investigation, conclusion, discussion and evaluation. There are several scenarios of application of this methodology. The scenarios are offered in Graasp Further, the Go-Lab authoring environment [11]. A Go-Lab Scenario [12] describes all activities, materials, and interactions for teachers and learners, that include a complete (online and offline) Go-Lab inquiry learning experience. In any case, each scenario allows students to approach the study of scientific disciplines.

We have chosen the basic scenario. It is apt to achieve two main goals. First, it can be used to understand a particular phenomenon where one or several independent factors have effect on a dependent variable. Secondly, it guides students towards understanding the inquiry approach – its phases, sub-phases and particular tasks. Compared to other Go-Lab scenarios, it is the simplest one and it could be recommended as the first one for novices.

In the **Orientation phase** students not only get an idea about the topic to be investigated, but where they are also introduced to the problem to be solved. Orientation is focused on stimulating students' interest and curiosity towards the problem at hand. The Orientation phase is also used to activate students' prior and new knowledge.

The **Conceptualization** is a process of understanding a concept belonging to the stated problem. This activity is divided in two sub-phases: Research question formulation and Hypothesis generation. In this phase the students will use two apps: the *Question Scratchpad* to formulate research-questions and the *Hypothesis Scratchpad* to formulate hypotheses.

In the **Investigation phase** the students will utilize 3 tools: the *Experiment design*, to facilitate the experimental plan and the experimental design process; the *Observation tool*, to write and remember the laboratorial activity; the *Data viewer*, to facilitate the visualization of data collected during the experiment. Before laboratory activity, the students will use an applet to become familiar with the law of Lambert-Beer.

The **Conclusion phase** is where the outcomes of the Investigation phase are compared with the output of the Conceptualization phase, and conclusions are drawn.

In this phase the students will utilize 2 tools: the *Conclusion tool*, to facilitate the formulation of valid conclusions, and the *Quiz tool*, to answer a final quiz.

The **Discussion phase** is about sharing one's inquiry process and results. It involves the process of describing, criticizing, evaluating and discussing the whole inquiry process or a specific phase. It contains two sub-phases - Communication and Reflection - which help students to communicate their findings to others and prompt them to reflect on their actions in order to learn from their experiences.

RESULTS AND DISCUSSION

The lesson plan was divided in five phases or stages, clarified by five diagrams, each one corresponding to the learning space based on the inquire cycle (see Table 1). The lesson plan was built by developing many aspects such as those we illustrated before, and others like teaching aims, basic competences, evaluation and facilities (see Table 2) [13-17]. In Table 3

we reported only one of the five activities. Activities as well as the whole project can be read at the following link:

<http://graasp.eu/spaces/570208c0c831445e00a04fb7>

Table 1. Phases of inquiry cycle

Plan	Short Description	Activities
Stage 1: Orientation	Warm-up: introduction to <i>EM radiations</i> and <i>spectroscopy</i>	Activity 1
Stage 2: Conceptualisation	Core concepts of <i>transmittance</i> and <i>absorption</i> . Relationship between <i>absorption</i> and <i>wavelength</i> .	Activity 2
Stage 3: Investigation	Perform an <i>UV-Visible spectrophotometric investigation</i> by a scaffolding technique: in a virtual lab at the beginning, then in a analytical chemistry lab.	Activity 3
Stage 4: Conclusion	<i>Analytical data</i> processing and making inferences	Activity 4
Stage 5: Discussion/ Evaluation	Presenting a report The teacher evaluates students by crossing different data	Activity 5

Table 2. Lesson plan of “Spectroscopy” learning unit

LESSON PLAN	
Aim	To understand the radiant energy’s nature. This unit focuses on the study of the components of visible light in order to investigate the relationship between dyed substances concentration and absorption of light.
Level	B1 Lower
Content - Subject	Chemistry
Communication - Language	It is necessary to provide a suitable scaffold for the use of language, that could be a glossary (in this case <i>multimedia tool</i>), sentence structures (see <i>Key info</i>) or the use of a dictionary. <ul style="list-style-type: none"> ➤ Language <i>of</i> learning: Key words and specific vocabulary ➤ Language <i>for</i> learning: Adjectives (opposites, comparatives), Questions and Verbs (to be likely to, present passive, zero conditional and first conditional sentences) ➤ Language <i>through</i> learning: Expressing opinions, Sequencing words
Approx. time overall	5 lessons (stages) of 60/90 minutes. They will be developed during three weeks with students who attend the fifth year of compulsory Secondary Education. The group of 18 years-old students has a poor motivation and Lower-B1 linguistic skills.
Teaching objectives	By the end of the unit students will be able to achieve teaching aims that include <u>content</u> (C) and <u>language</u> (L): <ul style="list-style-type: none"> • Classify EMw according to their wavelengths or frequencies (C) • Describe relationships between wavelength, frequency and energy (C) • Estimate complementary colour of a substance (C)

	<ul style="list-style-type: none"> • Correlate the absorption to the concentration (C) • Draw the block diagram of a double-ray UV-Vis spectrophotometer (C) • Discuss the phases of experimental activity (L) • Apply analytical procedure, working with order and security (C) • Write a lab report using specific vocabulary (L) • Explain their lab experiment in front of peers (L)
Basic competences	<ul style="list-style-type: none"> ➤ Linguistic communication (C¹) ➤ Knowledge and interaction with the physical world (C²) ➤ Data processing and use of ICT (C³) ➤ Social skills and citizenship (C⁴) ➤ Learning to learn (C⁵) ➤ Autonomy and personal initiative (C⁶)
Methodological principles	<p>Students undertake active guided experimentation that involves a series of suitable scaffolding, both linguistic, procedural and multimedia aids. It is also necessary to integrate content and thinking skills, using a taxonomy.</p> <p>The right combination of CLIL and ISBE methodologies allows:</p> <ul style="list-style-type: none"> ✓ To activate prior knowledge ✓ Continuity and progression of contents ✓ Interrelation of contents ✓ Activity (student-centred learning) ✓ Personalized learning ✓ Socialization ✓ Functionality of learning ✓ Sequencing of the activities and organization of time ✓ The role of the teacher as a guide
Facilities	<p>Teachers can create their own personal inquire learning spaces using the Web platform Graasp of Go-Lab project (<i>Global Online Science Labs Inquiry Learning at School</i>); it allows teacher to build a learning space based on the Inquire cycle, and students to perform personalized scientific experiments with online labs in pedagogically structured and scaffolded learning spaces that are extended by collaboration facilities</p>
Evaluation	<p>The teacher evaluates students by crossing data obtained from:</p> <ul style="list-style-type: none"> ➤ observing how they work during practical activity (interest and participation) - Progress report A ➤ observing how they learn to write scientific explanations linking their hypotheses to the evidence collected during the investigation phase - Progress report B ➤ the results of final test - Progress report C

To check if students achieve the teaching aims - taking into account the established assessment criteria - we have thought three possible types of report, that flow into a specific rubric. Here teacher can measure both content and language.

Student will learn

1. Classification of electromagnetic waves (EMw): the EM spectrum.
2. Property of EMw: Wavelength, Frequency, Energy.
3. Complementary colors.

4. Core concepts of transmittance and absorption.
5. Lambert-Beer law.
6. Components of double-ray UV-Vis spectrophotometers.
7. Writing a lab report.
8. Oral presentation of the lab experiments.

Student will understand:

1. Relationship between absorption and wavelength
2. How a double-ray UV-Vis spectrophotometer works.
3. Use of visible radiations to measure concentration of a dyed substance by a spectrophotometer

Student will think about:

1. Interaction light-matter;
2. Composition of matter;
3. Colors.

Table 3. Activity 1 of inquiry cycle

Activity 1: Orientation	
Procedure	<p>Warm-up: students watch the "<i>Introduction to Light</i>" video with subtitles to activate prior knowledge. Activity on Worksheet 1 helps students to <i>scavenge</i> different parts of video and summarize some core concepts.</p> <p>Reading exercise (Template) shows the meaning of specific key words; students can discuss in pair to repeat definitions.</p> <p>Worksheet 2 guides students to elaborate a simple report.</p> <p>Worksheet 3: a crossword (<i>Criss cross puzzle</i>) to summarize key words.</p> <p>Homework: students will have to use a <i>Concept mapper</i> tool to create links between studied keywords</p>
Approx. Time	90 minutes
Learning outcomes	<p>Students will:</p> <ul style="list-style-type: none"> • be able to identify light as a form of energy • be able to describe importance and impact of light on human life • understand reflection of light • understand how the light interacts with matter • demonstrate that light travels in all directions away from a source
Indicators	<p>Students will have to:</p> <ul style="list-style-type: none"> • select specific words • select secondary words • schematize • respect timing
Materials	<p>All materials are uploaded to the following Platform http://graasp.eu/spaces/570208cbc831445e00a05003 1. Video + Worksheet 1 https://edpuzzle.com/media/56ffcfbd8ad0ee39419f9ec3 2. Template 3. Worksheet 2 4. Worksheet 3 5. Homework: Use of concept mapper tool</p>

CONCLUSIONS

At the conclusion of the methodological course on CLIL, which was attended at the Language Center of the University of Calabria and funded by the Italian Ministry of Education, the authors, both chemists, have presented a project work in which they offer their students of technical school a learning unit, called "Spectroscopy", combining CLIL methodology with IBSE methodology. By using the IBSE methodology, the authors will involve students in a series of activities of observation, exploration, use of computer equipment, data processing, reflections which will allow them to acquire the content through foreign language communication.

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