UNIVERSITY of CAMBRIDGE
ESOL Examinations

Cambridge English

Teaching Science through English – *a CLIL approach*

CLIL – CONTENT AND LANGUAGE INTEGRATED LEARNING

Contents

What is CLIL?

CLIL is an acronym for Content and Language Integrated Learning. It is an approach to teaching the content of curricular subjects through the medium of a non-native language. In a CLIL course, learners gain knowledge and understanding of the curricular subject while simultaneously learning and using the target language.

Content first

It is important to notice that 'content' is the first word in CLIL. This is because curricular content leads language learning. Learning about science involves developing knowledge and understanding of: the material and physical world; the impact science makes on life and on the environment; scientific concepts; scientific enquiry. In addition, learners need to develop the accurate use of scientific language. For example:

Biology

Describing characteristics:	Plants have three main organs: leaves, stems and roots.
Explaining a process:	Photosynthesis takes place in leaves. The leaves take in and expel gases from the atmosphere. They get rid of excess water in the form of water vapour.
Describing functions:	The stem keeps the plant upright and supports it. It also carries water and minerals to other parts of the plant.
Expressing purpose:	Plant roots have two functions: to fix the plant to the ground; to absorb water and minerals.

Science teachers in CLIL programmes therefore have to know the specific academic language that learners need in order to communicate their knowledge of scientific concepts, processes, functions and purposes. They also need to ask scientific questions, to analyse scientific ideas, to evaluate experimental evidence and to make conclusions and justify them. In order to achieve competence in communicating ideas, teachers should help learners notice key grammatical patterns as well as key content vocabulary.

The 4Cs of CLIL

It is helpful to think of Coyle's 4Cs of CLIL for planning lessons (Coyle, 1999).

① **Content:** What is the science topic? e.g. plants.

② **Communication:** What science language will learners communicate during the lesson? e.g. the language of comparing and contrasting in order to analyse similarities and differences between fungi and plants.

③ **Cognition:** What thinking skills are demanded of learners in the science lesson? e.g. classifying leaves, thinking about advantages and disadvantages of growing plants in polytunnels.

④ **Culture** (sometimes the 4th C is referred to as **Community** or **Citizenship**)**:**
Is there a cultural focus in the lesson? e.g. learners can find out about plants which are indigenous to their home countries and also find out about popular plants which are grown around the world. Fertilizers used to help plants grow can also be compared. Which chemicals are used in different fertilizers? These questions encourage learners to express opinions about the effect of science on the environment. In multilingual contexts, it is important to encourage learners to find out about plants found in their home countries as they can learn the names of a wider range of plants, and discussion can take place about conditions in which different plants grow well.

Content-obligatory or content-compatible language?

Learners need to produce the academic register of science and they need to know both content-obligatory and content-compatible language. 'For every academic topic, certain language is essential for understanding and talking about the material.' (Snow, Met & Genesee, 1992)

Content-obligatory language

Every subject has its own content-obligatory language associated with specific content. This is the subject-specific vocabulary, grammatical structures and functional expressions learners need to:

- learn about a curricular subject
- communicate subject knowledge
- take part in interactive classroom tasks.

Content-compatible language

This is the non-subject specific language which learners may have learned in their English classes and which they can then use in CLIL classes to communicate more fully about the curricular subject.

For example, science teachers could identify the following language for learning about vertebrates:

Content-obligatory language	Content-compatible language
vertebrate ↔ invertebrate endoskeleton ↔ exoskeleton bones, backbone terrestrial aquatic *(explaining differences)* Vertebrates have endoskeletons but/whereas invertebrates have exoskeletons or no skeleton.	short ↔ long group, class head, body, tail They lay eggs. They catch fish. *(defining)* It's an animal that lives in the sea/on the land.

Teachers do not need to use the technical descriptions of these two types of language.
Usually content-obligatory language is described as subject-specific or specialist language.

Considerations when planning a CLIL science lesson

Activating prior knowledge

It is helpful to start a lesson by finding out what learners already know about the science topic. Learners may know many facts about a topic in their L1 (first language) but may have difficulty explaining this knowledge in a second or third language. When brainstorming ideas about a new topic, expect learners to use some L1 and then translate.

Input and output

Teachers need to plan the input, i.e. the information that is being presented in the CLIL class. Will it be delivered orally, in writing, on paper, electronically? Is it for whole class work, group or pair work? Will it include practical demonstrations? Teachers also need to plan for learner output. How are learners going to produce and communicate the content and language of the lesson? Will it be communicated orally, in writing or by using practical skills? What will success for the learners look like?

Wait time

Wait time refers to the time teachers wait between asking questions and learners answering them. When subjects are taught in a non-native language, a longer wait time than usual is needed so that learners can process new subject concepts in a new language. This is especially important at the start of new CLIL courses so that all learners are encouraged to take part in classroom interaction.

Collaborative tasks

Include tasks that involve learners in producing key subject-specific vocabulary and structures in meaningful pair or group work activities. Tasks may be at word level, e.g. a pair work information-gap or labelling activity, or at sentence level, e.g. pairs can ask and answer questions about different body organs, groups can explain how they plan to do an experiment or explain their results after doing an experiment. They can do this either digitally or face-to-face. Activities should support processing of new science content and language.

Cognitive challenge

Learners usually need considerable support to develop their thinking skills in a non-native language. They need to communicate not only the everyday functional language practised in many English classes, but they also need to communicate the cognitive, academic language of school subjects. In CLIL, learners meet cognitively challenging materials from the beginning of their courses.

Providing scaffolding, i.e. content and language support strategies which are appropriate but temporary, is therefore very important. For example, writing a substitution table on the board to support skills of expressing purpose:

Living things need glucose	to	get energy.
Reptiles have hard scales	in order to	keep them warm.

The cells in the seed multiply	so	a new plant can develop.
Some cells are long and thin	so that	they can absorb water and minerals from the soil.

Providing effective scaffolding is a challenge to all CLIL teachers because learners vary in the amount of support they need and in the length of time the support is needed. Learners might need more support and for longer in one subject than in another.

Developing thinking skills

Teachers need to ask questions which encourage lower order thinking skills (LOTS), e.g. the what, when, where and which questions. However, they also need to ask questions which demand higher order thinking skills (HOTS). These involve the why and how questions and therefore require the use of more complex language. In CLIL contexts, and especially in science subjects, learners often have to answer higher order thinking questions at an early stage of learning curricular content.

What kind of challenges are there in CLIL?

Challenges for teachers

Subject teachers need to feel confident about their English language level, especially if they have not used English for some time. For example in science, subject teachers need to:

- be able to present and explain concepts in their subject area clearly and accurately
- check pronunciation of subject-specific vocabulary which may look similar to other words in English but have different pronunciation
- be able to use appropriate classroom language to present new concepts, to question, paraphrase, clarify, encourage and manage their classes in English.

Language teachers may decide to teach subjects in CLIL or may be asked to. They need to feel confident about their knowledge and skills related to the subject they are going to teach. For example in science, language teachers need to:

- know how to explain scientific concepts and applications of science in meaningful and creative ways that will deepen learners' understanding
- be prepared to answer questions about scientific concepts which may be unfamiliar to the learners, for example, 'What is the difference between bacteria and viruses?'
- widen their knowledge of science vocabulary and its pronunciation.

Challenges for learners

Most learners need considerable support in the first two years of CLIL courses. Most teachers do not know how long learners will take to do tasks, complete worksheets or understand instructions and explanations until they have used materials for the first year. Learners are all different; some need more support in order to understand subject concepts, while others need more support to communicate ideas about subject concepts. Learners may need differentiation of:

- input
- task
- support

The table below gives an example of the way a classroom activity can be differentiated for less able learners who are finding out about bones.

Types of differentiation	Examples
outcome	to explain the steps of an experiment (rather than to explain the findings of the experiment)
task	pair less able learners with more able peers
support	provide gap-fill sentences to help communicate the steps of an experiment: First we prepared _____. Then we took straws and _____. Next we measured the _____ and recorded the _____ in the table. We used a forcemeter to _____. After recording _____, we repeated the experiment with _____. It was a fair test because _____.

Differentiation is also necessary for more able learners. Teachers need to plan extension activities to develop learner autonomy and learners' higher order thinking skills for science. This is when Information and Communications Technology (ICT) can be very useful for online learning activities such as web quests and independent fact-finding.

Use of L1

In CLIL, it is recognised that some use of L1 by learners, and sometimes by teachers, is a bilingual strategy that helps learners communicate fluently. Moving between L1 and the target language, either mid-sentence or between sentences, is quite common for learners in CLIL. This is known as code switching. Classroom observations show that use of L1 and the target language happens between learners in the following interactions:

- clarifying teachers' instructions
- developing ideas for curricular content
- group negotiations
- encouraging peers
- off-task social comments

It is important that teachers avoid using L1 unless they are in a situation when it would benefit or reassure learners. Some schools have a policy where no L1 should be used. Teachers should be able to justify when they use L1.

Lack of materials

One of the most common concerns of CLIL teachers is that they can't find appropriate science materials for their classes. Either they cannot find anything to complement the work done in the L1 curriculum or adapting native-speaker materials takes too much time. Increasingly, publishers are producing resources for specific countries. However, as teachers gain more experience of CLIL, they generally start to feel able to adapt native speaker materials from science websites and from subject-specific course books.

Assessment

CLIL assessment leads to much discussion. Teachers are unsure whether to assess content, language or both. Different regions, different schools and different teachers assess in a variety of ways. What is important is that there is formative as well as summative assessment in CLIL subjects and that there is consistency in how learners are assessed across subjects in each school. Learners, parents and other colleagues need to know what learners are being assessed on and how they are being assessed.

One effective type of formative assessment is performance assessment. It involves learners in demonstrating their knowledge of content and language. For example, they could:

- explain how they set up an experiment to test bone strength
- describe how they applied their knowledge of bones to do a survey of broken bones and recovery rates from the breaks, and then recorded the data using ICT.

Teachers observe and assess learners' performance using specific criteria. Performance assessment can involve individuals, pairs or groups of learners. As CLIL promotes task-based learning, it is appropriate that learners have opportunities to be assessed by showing what they can do individually and collaboratively. Performance assessment can also be used to evaluate development of communicative and cognitive skills as well as attitude towards learning. For example, teachers can look for evidence of learners' ability to explain the effects of microorganisms on the human body (communication), reflect on the reliability of their findings (cognitive skills) and share information with other group members (attitude).

How can CLIL teachers overcome the challenges they face?

What can teachers do?

What subject teachers can do

- use an online dictionary with an audio function to hear the pronunciation of science vocabulary, e.g. Cambridge School Dictionary with CD-ROM
- use a grammar reference book in order to practise producing questions which involve: high order thinking skills such as hypothesising. For example for the topic of light and sound:
- What would happen if the speed of light slowed down?
- How could noise (reverberations) in the school hall be reduced?
- Look at the diagram of the light experiment and the data collected. How could the students have made the results more accurate?
- make sure learners know the functional language needed to talk about their subject area, e.g. explaining why a flower stem in a glass vase looks bent; describing what happens when sound waves hit an obstacle.

What language teachers can do

- using online sources or subject-related books in English or the L1, read about science and the concepts learners will need to understand the skills they need to practise
- highlight the subject-specific vocabulary learners need and present new words in topic-related word banks rather than in alphabetical order, e.g. digestion: mouth, oesophagus, stomach, liver, pancreas, small intestine, large intestine, rectum
- practise delivery of science materials, prepare questions which demand low and high order thinking skills and predict questions learners might ask about the topics presented.

What both subject and language teachers can do

- if possible, plan curricular topics together so that both benefit from each other's area of expertise.

How can teachers plan for CLIL?

There are more components in a CLIL lesson plan than in a subject or language lesson plan. The following nine areas need to be planned:

• Learning outcomes and objectives

Teachers first need to consider the learning outcomes of each lesson, each unit of work and each course. What will learners know and understand about science? What will they be able to do at the end of the lesson, unit or course that they couldn't do at the beginning? What skills will they master and what attitudes about collaboration will they develop? Learning outcomes are learner-centred as they focus on what the learners can achieve rather than on what the teacher is teaching.

For example, in the science topic of living things:

Learners should know ...	Learners should be able to ...	Learners should be aware of ...
that living things are organisms made up of cells similarities and differences between plant and animal cells the functions of cells how plant and animal cells divide	explain the features of plant and animal cells draw diagrams of plant and animal cells compare and contrast functions and features of cells using a table explain how plant and animal cells divide	the history of the discovery of cells

• Subject content

What content will learners revisit and what content will be new? Learners need to hear subject-specific language more than once, so revisiting a new concept is necessary. For example, endoskeleton and exoskeleton may be confused because the words are similar, or reflection and refraction may be confused because the concepts are both related to the topic of light. To revisit concepts, teachers should present learners with different tasks that demand different language skills but that are aimed at communication of the same concepts. While planning, teachers should also note any anticipated difficulties learners may have with content and language learning.

• Communication

As CLIL promotes collaborative learning, teachers need to plan pair work or group work activities so that learners can communicate the language of the subject topic. Communicative activities should be integrated during the lesson, rather than left to the end of the class. They can be:

- **short,** e.g. tell pairs of learners they have 3 minutes to brainstorm words related to muscles
- **longer,** e.g. tell learners they have 10 minutes to work with a different partner to draw a diagram of how arm muscles work. Finally, pairs tell their partners how accurate their diagrams are.

• Thinking and learning skills

The development of both thinking and learning skills needs to be planned. Do learners move from lower order to higher order thinking skills during the lesson? Subject teachers need to plan and sometimes practise types of questions they will ask to develop both types of thinking. The table below provides some examples:

Lower order thinking questions	Purpose	Higher order thinking questions	Purpose
Are most chemical reactions reversible or irreversible? Which three things are needed for a fire to burn?	to check understanding of a new concept to review learning	Look at the diagrams. In which test tube will the iron nail rust? How do you know? Why do you think fireworks contain metal salts?	to develop skills of evaluating and reasoning to develop creative thinking

CLIL teachers need to plan how to support learners in developing learning skills, such as planning how to set up an experiment, 'following instructions and working safely, making observations and measurements, recording observations and measurements, handling data, drawing conclusions, evaluating the experiment.' (Hayward, 2003)

• Tasks

Teachers need to think about the kind of tasks learners will do during the lesson and as a follow-up. It is important to plan a range of tasks which require different challenges, such as less demanding tasks which involve transferring numerical data, for example about the times different metals take to react to acid, and comparing results of tests shown on two different graphs. More demanding tasks include evaluating evidence of, for example, changes in rocks as a result of chemical weathering, and applying subject knowledge to everyday or hypothetical situations, e.g. Why does water in some areas of the country damage washing machines and how could the damage be reduced?

• Language support

All teachers need to plan to support for:

① the language of input
② the language of output

Sometimes support for input and output can be the same. It is useful to think of support at word, sentence and text levels. In science, tasks include all three. The table below shows some examples from the topic of food chains:

Word-level support	Sentence-level support (explaining a process)
Word bank: ecosystem habitat community producer primary/secondary/tertiary consumer herbivore carnivore omnivore	**Substitution table:** 1. Plankton | is food for / is eaten by | fish. 2. Fish | are food for / are eaten by | whales. **Sentence starters:** Herbivores are animals which only eat _____. Primary consumers are animals which eat _____.

• Materials and resources

In all teaching, teachers need to find or create materials and then evaluate them to make sure the content and language are suitable for the stage the learners are at. In CLIL, most subject materials need adapting because of the complexity of language used in the instructions, in texts or in the activities themselves. This can also be an issue when teachers recommend science websites for learners to access. Web links need to be checked to ensure the language is comprehensible.

• Cross-curricular links

CLIL promotes links with other subjects in the curriculum so teachers should plan to include references to learning similar content in other subjects. For example, if learners are studying the topic of forces in science, it is useful to find out if they have been studying how the body uses forces in P.E. (physical education). For design and technology, learners can find out which levers are applied in the home and in industry. Teachers can then make links to forces in biology and physics. The example of bones that follows can be linked to learning in P.E.

• Assessment

In CLIL plans, it is important to link the assessment of learning, i.e. formative assessment to the attainment of learning outcomes for the lessons. Many European CLIL programmes use 'Can Do' statements as these are clear for both teachers and learners. Assessment criteria are therefore transparent. For example, in a science topic:

Learning outcomes *Most learners should:*	Assessment *Most learners can:*
know: • the properties of acids and alkalis and the differences between them • that acids and alkalis are found in everyday products • that acids and alkalis can react to make neutral solutions and that these can change the pH of certain substances be able to: • explain the properties of acids and alkalis and the differences between them • describe the use of acids and alkalis in household products and in daily life • explain how neutralisation reactions can change the pH of substances • apply theory to a natural example	• explain the properties of acids and alkalis and the differences between them • give examples of where acids and alkalis are found in daily use • describe how neutralisation takes place • describe applications of neutralised solutions in farming and industry • explain a practical example of neutralisation using plants: nettles (produce acid if hairs on leaf break) and dock leaves (contain alkali)

Teachers should keep ongoing records of continuous, formative assessment done through observation of learning experiences in the classroom, in the science lab or outside. It is not necessary to record information about each learner during each lesson. However, over a period of several weeks, evidence of learners' progress as they work towards achieving the learning outcomes needs to be recorded. Here is part of a record for formative assessment in science. Teachers record the date when they observe learners' achievement of the following:

	Assessment criteria (matter)			
name	can describe the three physical states of matter and how a substance can change from one state to another	can give examples of substances which are mixtures of components	can ask a research question related to separating mixtures, and set up an experiment	can check a hypothesis by separating mixtures and evaluate the experiments

What helps learners learn?

Two different surveys carried out with secondary CLIL learners produced interesting findings (Bentley and Phillips, 2007). The first set of questionnaires was completed by 14–15 year old Spanish learners who were studying science in English. It was their second year of learning science and fifth year of learning English. Here are a few responses to the question 'What helps you learn science in English?':

- '*More vocabulary and more diagrams on the worksheets*'
- '*Give us more explanations*'
- '*Use easy words for the explanations and vocabulary*'
- '*Work with games*'
- '*The complicated words in English with the Spanish words next to the English*'
- '*Put the hard vocabulary in a side of the page in Spanish. Put more pictures.*'
- '*Add a list of vocabulary and illustrations*'
- '*Maybe put the most difficult science words with translation*'

It is clear that the quantity and complexity of new science vocabulary was causing problems. Highlighting key content vocabulary with explanations can be helpful.

The second set of questionnaires asked learners to tick a list of factors that help them learn school subjects in English. The learners were aged between 13 and 16 and were from different Spanish schools implementing CLIL programmes.

- pictures: 38%
- diagrams: 19%
- word lists: 18%
- translations: 49%
- use of computers: 19%
- teacher explanations: 56%
- friends: 36%

The results of the surveys show, firstly, how important it is that teachers explain their subject content effectively and, secondly, if friends support each other in the classroom, it is important to include experiential learning, especially in science subjects.

CLIL teachers also report that at the start of courses, learners need considerable scaffolding and encouragement to help them learn. This can be in the form of clearly presented step-by-step instructions or explanations, constructive feedback and use of language frames. Learners respond positively to meaningful contexts that personalise learning. They also need regular consolidation of new content and language.

Appropriate task types

There is a range of task types that teachers can use in CLIL. Learners need a variety of tasks to stimulate output of content and language. Some tasks are more time-consuming to set up and create, and also take more time to complete.

It is useful to keep a list of task types and to tick off the ones that have been used over a school term or a year. Here are some examples of task types for science:

circle, underline, tick the word, sentence or diagram which is true	describe and guess, e.g. the bone, muscle	information transfer from text to graph or table	sequence stages in a scientific process
classify types of materials, plants etc.	domino games	jigsaw map	word searches and web searches
collect and organise information	find the mistake or find the link, e.g. between different organisms	label or match diagrams or images	true/false; yes/no, e.g. an elimination game Is the material solid? (yes) Is it organic? (no) Is it a mineral? (yes) Can it be several colours? (yes) Is it a type of rock? (yes)
compare and contrast results of experiments	gap-fill	multiple choice/odd one out	
complete the diagram/table/graph	identification keys, e.g. a binary key with questions to help learners identify minerals	PowerPoint presentations	

Questions teachers should ask about the tasks they use are:

- Which tasks motivate the learners?
- Which tasks involve interaction?
- Which tasks develop thinking skills for the subject I teach?
- Which tasks need language support?

Applying CLIL to a science lesson

The example of a science lesson is taken from Stage 7 of the Cambridge Secondary Science 1 curriculum framework. Although many of the ideas described here are topic-specific, they can be modified to fit any science topic, and for students at other stages.

The lesson described concentrates on the development of scientific enquiry skills.

The human skeleton

Learning outcomes

- to review the names of the main bones in the human skeleton
- to understand the functions of the human skeleton
- to investigate a question about the strength of bones
- to be able to use a forcemeter to measure forces in newtons
- to be able to record numerical data in a results table
- to be able to consider the variables to be kept the same when carrying out an investigation
- to be able to use results to make conclusions

Learning outcomes

The above learning outcomes can be divided into those which focus on science content, i.e. bullet points 2, 3, 4 and 6, and those which focus on content and language, i.e. bullet points 1, 5 and 7. It is important that teachers notice learning outcomes which may need language support. Many teachers like to write the learning outcomes on the board so that learners are clear about what they should understand and achieve by the end of the science lesson. Learners also need to understand that the aim of the experiment is to help them develop scientific enquiry skills in addition to learning about bones.

Activating prior knowledge

Begin the lesson by using questions to establish what learners already know. For example, they may already have used a forcemeter in a physics lesson. You could ask:

What is a forcemeter?
How do we use one?
Which unit is used to measure forces?

Questions

When asking questions, remember to use direct questions such as the examples listed. Indirect questions can cause some difficulty with word order and are more difficult for some learners to comprehend. Avoid using, 'Does anyone know …?' or 'Do you know …?' because with teenagers in CLIL contexts, these can sometimes lead to silence.

Remember to wait for an answer to each question because learners need additional time to process language, to think of an answer and to work out how to express it in English.

If learners have already covered the concepts, check understanding using a quick oral or written quiz. For example, hand out to pairs of learners a five-question multiple-choice quiz with questions such as:

What is the unit we use for measuring forces?

A gram B joule C metre D newton

Set a time limit of four or five minutes to answer and check that learners agree with each other before taking feedback.

As well as ensuring that all students have a firm basis from which to begin the lesson, oral or written questions also help to consolidate some of the vocabulary that will be used in the lesson: forcemeter, force, unit and newton. You can help students to learn and understand these words by showing them a forcemeter and using the words as you demonstrate how to use it. Ensure that they are all able to read the scale on the meter.

Building a scientific glossary

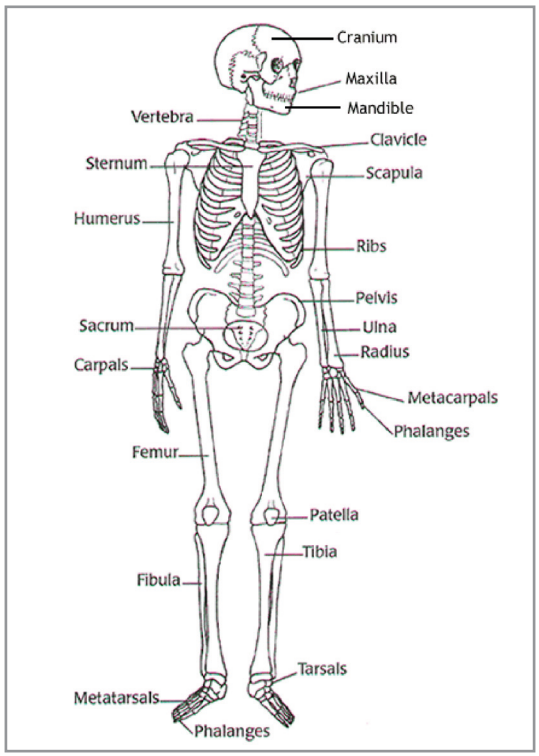
It is a good idea for students to build up a glossary of scientific terms as they learn about new science topics. Examples of key words can be highlighted in bold on their worksheets. You can help the class to build up definitions of the four terms listed above, and allow time for learners to add each term to their glossary. Doing this electronically, e.g. in Word, makes it easy to insert new terms in alphabetical order at any stage. As well as this, make two sets of 10–12 cards using two different colours of card: put the words on one colour and the definitions on cards of the other colour. Periodically, hand out sets of cards to small groups and ask them to match each word with its definition.

Scientific vocabulary

Science is full of technical terms that need to be used correctly. Some of the science terms have different meanings when used in everyday speech. For example, the word 'force' and 'unit' have several different meanings in English. This could lead to confusion or, in some cases, learners may not know the meanings in everyday use so are less likely to be confused by them.

Structure and function of the skeleton

This part of the lesson introduces learners to the main bones in the skeleton and their functions.



If possible, show students a model of a skeleton. If that is not available, a good diagram can be used instead. Ask the class to suggest what their skeleton does. Use this to introduce the term **function**. The idea that structure relates to function is an important one in science and will recur in many different topics. Elicit or pre-teach that the skeleton supports the body, protects parts of it (e.g. the brain and heart) and helps with movement.

Talk about the names of the bones with the class, ensuring that they know how to pronounce each name. They will generally enjoy learning the correct technical terms (e.g. 'scapula' rather than 'shoulder blade').

Checking understanding

The following two techniques are effective ways of checking understanding of science vocabulary:

1) Asking learners to 'point to' their ribs provides a quick and easy way to concept check some vocabulary as you can easily see who is unsure of what ribs are.

2) Asking about similarities and differences is an effective way to encourage higher order thinking skills. It also provides practice in naming the bones in the arms and legs and helps learners develop skills of observation as they look at diagrams.

Use discussion and questioning to consolidate both language and understanding of concepts. For example, you could say and ask:

- Point to your ribs. How many ribs do you have?
- Which bones are similar and where are they?

As a class exercise, ask learners to write the names of the bones on an unlabelled diagram of a skeleton, or to attach labels to the appropriate parts of a model. Labelling an unlabelled diagram (preferably one that is not identical to the one in their textbook) is a good homework exercise and helps learners to remember new vocabulary.

Investigating whether long bones break more easily than short bones

This part of the lesson will help learners to develop scientific enquiry skills. Write the question, 'Do long bones break more easily than short bones?' on the board and make sure learners understand that developing scientific enquiry skills is the reason they are doing the experiment. An outline of the steps of an enquiry can help. For example:

Scientific enquiry	
Ideas and evidence	Learners make predictions and if possible give evidence for their ideas.
Planning	Learners decide on appropriate approaches to questions. They identify variables and consider if the test is fair. They use information from a range of sources and identify limitations of secondary data.
Carrying out the investigation	Learners make systematic observations and take accurate measurements using appropriate apparatus. They identify when they need to repeat observations and measurements in order to obtain reliable data.
Recording and presenting data	Learners communicate what they have done using scientific language and diagrams or graphs.
Making conclusions	Learners consider: • How fair was the test? • How accurate were the measurements? • How reliable were the results? • What improvements would you make? They then write their conclusions.

If possible, take enough materials so that groups of learners can do the experiment in class. A practical approach to learning science is memorable, collaborative and meaningful. Present the instructions as a worksheet and use diagrams to help learners to understand what they should do. If this is impractical, ask learners to watch you demonstrate the experiment at the front of the class. If learners can only read about an experiment on a worksheet, real understanding may not take place.

Using group work to develop language skills and understanding of science

It is good for learners to collaborate in groups while doing practical science work. They should be allowed to talk freely to one another. Encourage learners to talk in English as much as possible because this will give them practice in using the vocabulary of scientific enquiry, and also topic-specific vocabulary. Discussion also helps with the understanding of what they are doing and why. More able learners develop their communication skills by clarifying their ideas as they explain them to others. Less able students are usually supported by other group members, and feel more confident to contribute ideas. Try to move around groups and ask questions that use scientific language associated with enquiry skills, and that require learners to use it in response.

Language support

Collaborative work is an important part of developing enquiry skills. However, learners often do not know enough language to discuss, challenge statements and present alternative ideas. It is helpful to tell learners that 'on-task' talk should be in English, i.e. talking about the experiment and what they are doing. 'Off-task' talk, e.g. negotiating, turn-taking or asking for clarification may be done in the L1 if they don't know the English words. The aim is not to slow down the process of doing experiments but to encourage communication of ideas. It is also helpful to write language on the board or on laminated cards so learners can refer to it and use it when necessary. For example:

1. Define the task	*What have we got to do?*
2. Outline any difficulties	*We/I don't understand the bit where/when …*
3. Arrive at a common understanding	*What do you think this means?* *What do you think he/she/they mean(s)?*
4. Introduce an alternative point of view	*I understand you but I think …* *Another way of doing it is …*
5. Support a point of view	*Yes, of course.* *That's right.*
6. Bring ideas together	*We think the main point is …* *We all agree about …* *We agree about … but not about …* *We don't agree about …*

Experiment: Do long bones break more easily than short bones?

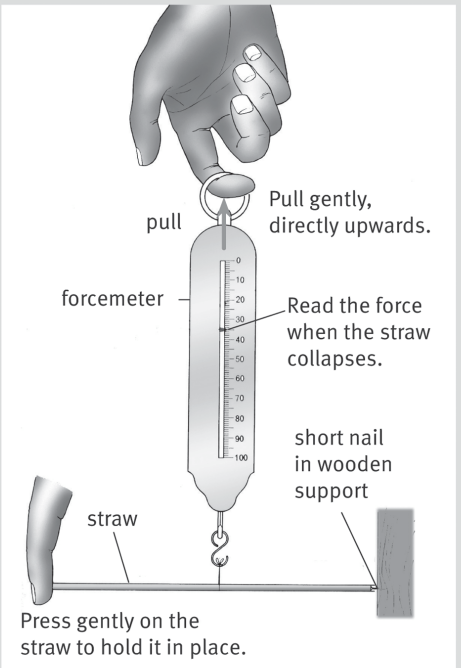
In this experiment, you will use drinking straws instead of real bones.

You will measure the force needed to make the straw bend, rather than break.

The diagram shows how you will find the force needed to bend the straw. You will use a forcemeter.

It's easiest to do this in pairs. One of you pulls the forcemeter. The other one notes the reading on the forcemeter when the straw collapses.

1 Copy the results table, ready to fill in as you do your experiment.
2 Collect two identical straws. Keep one full length. Cut one in half. Cut one of the halves into half again.
3 Measure the length of a full length straw, in cm. Fill in your measurement in the first row of your results table.
4 Find the force needed to make a full length straw bend. Write your result in your results table.
5 Now repeat steps 3 and 4 with the half length straw and the one quarter length straw.



Length of straw / cm	Force needed to bend the straw / N

Questions

A1 To make this experiment a fair test, you kept everything the same except the length of the straws. Write down three things that you kept the same.
A2 What conclusion can you make from your results?

Summary
- The skeleton supports the body.
- The cranium protects the brain. The ribs and sternum protect the lungs and heart.

The experiment is taken from Jones et al. (forthcoming)

Adapting a worksheet

With any materials, teachers need to ask: Is the content suitable? Is the language suitable?

Sometimes, and if possible, changes need to be made. For example, in the worksheet above, it may help learners to:

- *simplify some language: instead of real bones → not real bones*
  rather than break → but not break
- *reduce the amount of language: It's easiest to do this in pairs → Do this in pairs.*
- *delete the 'summary' as this is not important for the experiment.*

Write additional language support on the board to make everything very clear. For example:

- *a list of materials needed:*

  a drinking straw
  half a drinking straw
  a quarter of a drinking straw
  a ruler and marker pen
  a forcemeter, a wooden block with a nail in it at one end

- *add two further headings above the results table:*

  variable ***reading***

- *provide sentence level support for communication of results:*

  The _____er the straw, the _____ easily it breaks.

Variables

It is important to introduce or consolidate the term *variable* before learners start the experiment or to check understanding of it after they have done the experiment. A variable is something that can change in an experiment. In this experiment, the effect of changing one variable (the length of the 'bone') on another (the force needed to make it break) is investigated. Consolidate the meaning of this term by asking learners questions such as:

- What variable will you change/did you change in your experiment? How will you change/did you change this variable?

  (Answer: We will change/We changed the length of the 'bone' by using different lengths of straw.)

- What variable will you/did you measure in your experiment? How will you/did you measure it?

  (Answer: We will measure/measured the force needed to make the straw bend, by pulling with a forcemeter and reading the force when the straw just starts/just started to bend.)

An important feature of a well-planned scientific experiment is that all other variables should be kept the same. This is so that only the variable investigated (the length of the 'bone') affects the results. Learners often instinctively understand that the experiment must be 'fair', and the term 'a fair test' is important. You can ask:

- What variables will you keep the same in your experiment to make it a fair test?

  (Answer: the material of the straw; the diameter of the straw; always pulling halfway along the straw.)

Recording data

Recording data in a well-constructed results table is an important skill. Here, learners have a results table on the worksheet, complete with headings. Later in the course, you can give them partly completed tables, and later still you can expect them to construct their own.

The purpose of a results table is to communicate data clearly. The headings of rows and columns therefore need to be very clear. Learners should always include the units in these headings, rather than writing them with the numbers in the other cells of the table. Check understanding of the word 'unit' by asking students:

- What is the unit we used to measure the length of the straw?
- What is the unit we used to measure the force?

Conclusions

Making a conclusion from a set of results is another important skill. It is often a good idea to look back at the title or aim of the experiment before writing a conclusion. Here, the aim of the experiment was to find out if long bones break more easily than short ones, so the conclusion should use the results to answer this question. A conclusion should be short; a good conclusion is generally a single sentence, which directly answers the question that was being investigated. For example: *From the results of our experiment we have proved that long bones break more easily than short ones.*

Anticipated problems

Content: *some learners may not find the task challenging. You could encourage these learners to address scientific enquiry skills by increasing the level of demand. For example:*

1) Ask them to make three measurements of the force needed to bend each length of straw, then calculate the mean (average) value. They need to modify the results chart if they do this.

2) Ask them to take measurements for at least five different lengths of straw, then plot a line graph of their results with the length of straw on the x-axis and the mean force needed to bend it on the y-axis.

Self-evaluation

Learners should be encouraged to evaluate their experiment. In particular, they should think about how much they trust their results, and how confident they are in their conclusion. This is a high-level skill and many learners will need language support to evaluate what they did. Provide a language frame so they can do this effectively. For example:

The experiment was … (how fair was it and why?) _____

_____

Our measurements are … (how accurate are they?) _____

_____

We are able to answer the question because our results show …. (how reliable are the results?) _____

_____

With time and practice, learners will be able to include a discussion or evaluation each time they write up an experiment. To begin with, it is a good idea to discuss the evaluation orally with the whole class, rather than expecting learners to write their own discussion.

It is important to note that the experiment did not use real bones, and that the forces applied to them are not the same as the kind of forces that break real bones. Most students will be aware of this so they should be encouraged to write one or two sentences about the differences after they write their conclusion, explaining that their experiment cannot really answer this question with any certainty.

Plenary

It is a good idea to conclude the lesson by bringing learners together to round everything off in a plenary. You could discuss:

- any problems that they had when doing their experiment, and how they solved them
- the results that they found – were they what they expected?
- the conclusions they made
- any suggestions for how they could make their experiment better if they did it again.

This provides further opportunity to use and consolidate new vocabulary associated with this topic. At this stage some learners may code-switch, using some L1 and some English. Accept this and encourage them to try again or translate or write sentence starters on the board to help them communicate in English only. Leave time to revisit the learning outcomes and to ask learners:

- Do you think you made a good start at achieving the outcomes?
- What will help you understand them more clearly?

You can then use their answers when giving homework or when planning the next lesson.

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