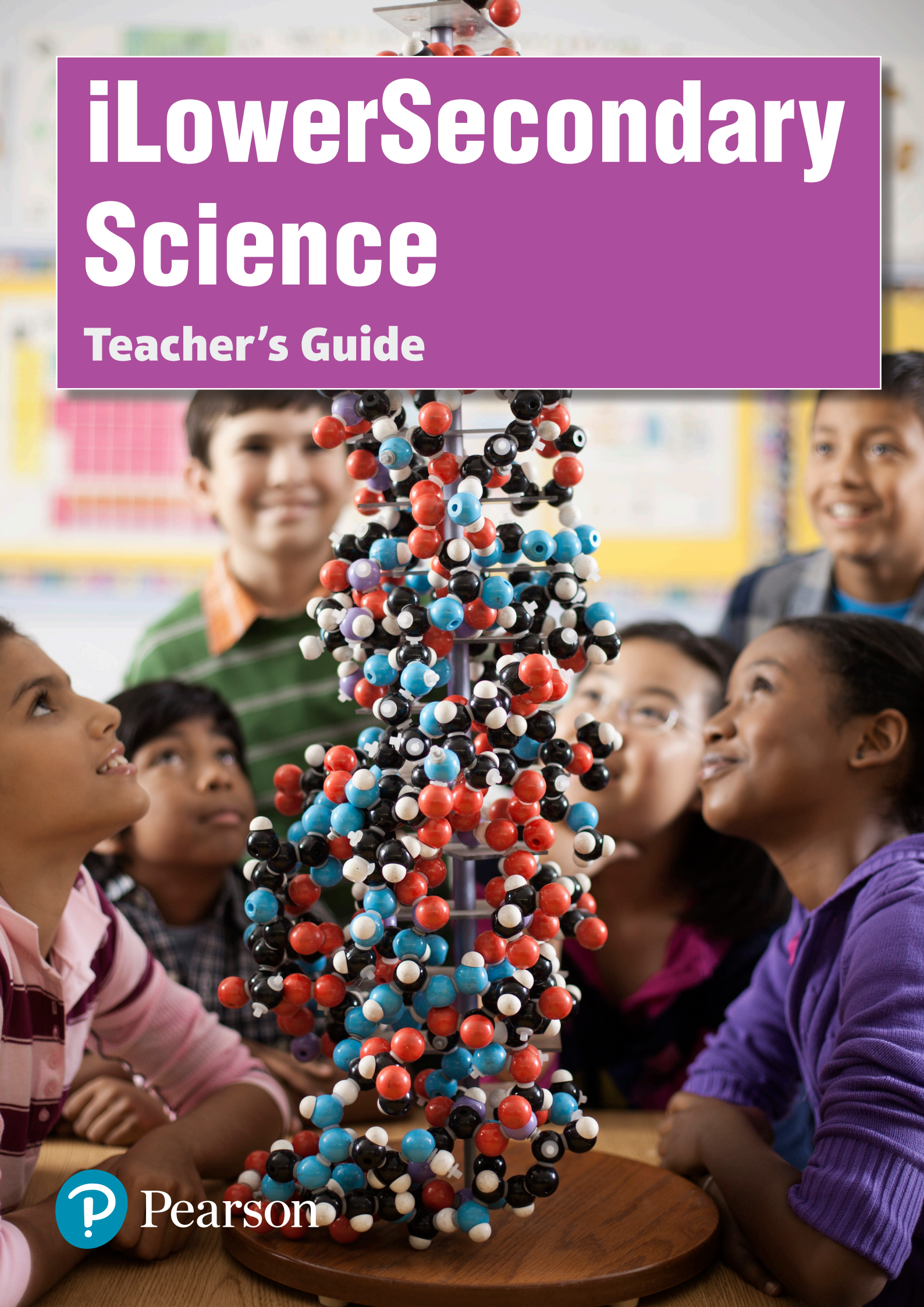
iLowerSecondary Science

Teacher's Guide



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Contents

Welcome to your *iLowerSecondary Teacher's Guide*

Welcome to the Pearson iLowerSecondary teacher community. We hope that you find your *iLowerSecondary Teacher's Guide* a useful resource as you start your iLowerSecondary curriculum journey. We are confident that it will support you in teaching lessons where all students enjoy learning, make good progress and do well in examinations.

The iLowerSecondary curriculum for Science develops important learning skills for students. Broadly based on the English National Curriculum, it is written with the specific needs of the international student at heart and focuses on developing key learning skills. This will give your students the confidence to successfully meet a range of challenges in and out of school and help prepare them for examinations and a successful secondary education.

This guide will give you:

- tips for recognising whether a new technique is working
- ideas for seeing how much impact a new strategy has on your students' learning
- techniques for reflecting on your practice
- ways you can discuss teaching and learning with your colleagues.

As you work with your guide you should see all your students:

- solving more problems
- asking effective questions and actively listening
- thinking deeply, creatively and critically
- making connections between ideas and transferring their learning from one context to another
- taking greater responsibility for their own learning
- working together in different ways to develop their thinking and knowledge
- developing lifelong learning skills to equip them for International GCSE-level and beyond.

Learning is supported throughout. The iLowerSecondary curriculum objectives are written to provide students with the necessary coverage of skills and knowledge to prepare them fully for examinations.

Your guide is easy to use and packed full of practical teaching tips and ideas for you to try out. You may be familiar with some concepts and find that others are new to you. You may choose to work with other colleagues to select the ideas you would like to use. No two classrooms are the same, so you will find what works best for you and your school's priorities.

HOW TO USE YOUR *iLOWERSECONDARY TEACHER'S GUIDE*

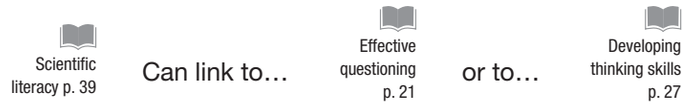
You can use your *iLowerSecondary Teacher's Guide* in a number of ways. It is *your* guide to be used *by you* and *for you*. The following suggestions may be helpful.

- Select the ideas that seem most manageable and give a couple of them a go!
- Decide to try out a new good idea each week.
- Think about your professional development targets and select the good ideas that will help you achieve your targets.

This guide is separated into seven easy-to-navigate sections.

1. **Welcome to your *iLowerSecondary Teacher's Guide*:** an overview of this guide and the curriculum, including guidance to help you to keep track of your progress as an iLowerSecondary teacher and information on where you can go for further support.
2. **Creating an iLowerSecondary classroom environment:** ideas and tips for integrating active learning, positive behaviour management strategies and a variety of classroom arrangements into your classroom. These techniques help to engage students and support them in making progress.
3. **iLowerSecondary planning:** advice and information on how to plan and adapt effective lessons using the iLowerSecondary curriculum.
4. **Principles for progress:** the top ten general principles (identified by our pedagogical experts) that can be applied to your teaching in order to help achievement and progression, such as how to involve all your students in a class discussion and how to plan lessons that provide all students with the right amount of challenge.
5. **Teaching in science:** a variety of techniques and approaches to teaching to help students succeed in this subject, compiled by a subject-matter expert. This includes practical tips and guidance designed to support students' progress and engagement.
6. **iLowerSecondary assessment:** a general overview of formative and summative assessment in the iLowerSecondary curriculum, outlining what summative assessment is provided as part of the curriculum and offering general tips and guidance on how to best prepare students for this.
7. **Assessment in science:** specific advice and guidance on teaching assessment in this subject, including examples of formative assessment, common question types for this subject and things to watch out for.

As you work through this guide you will notice cross references linking various key sections and concepts. These are designed to help you easily navigate to the information you need and to demonstrate how the strategies and principles described in the guide can be used to complement one another in the classroom. For example:



SUPPORTING YOUR iLOWERSECONDARY DEVELOPMENT

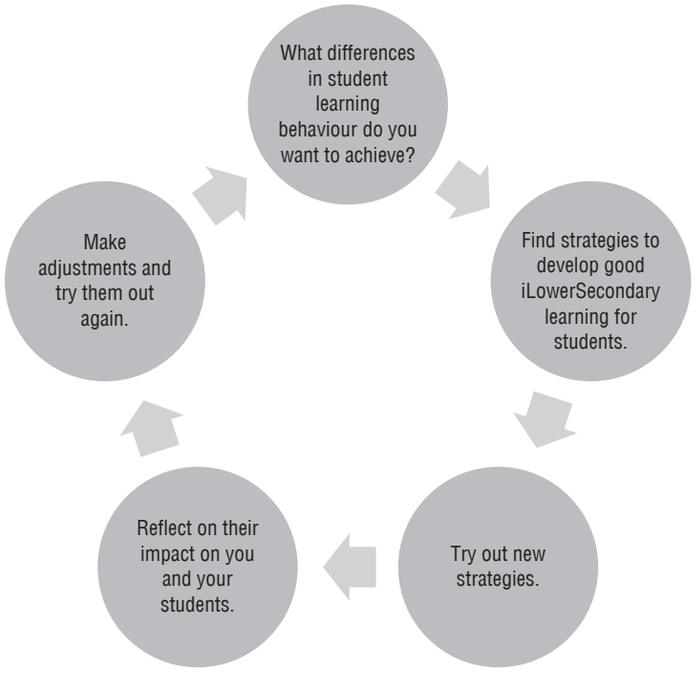
An important part of being an iLowerSecondary teacher is that you demonstrate the habit of developing and assessing your own practice. Focusing on your own development can directly help outcomes in the classroom, which means students learn more effectively and achieve more highly.

When embarking upon your journey as an iLowerSecondary teacher, it is important to remember that:

- you are not working in isolation; there is a network of support available through your iLowerSecondary colleagues and the iLowerSecondary online community
- there are clear practical tools and tips within this guide to help you to deliver the curriculum effectively
- iLowerSecondary colleagues can support each other by discussing challenges and sharing good practice
- you can work with your peers to observe practice and to give each other feedback.

Reflective teaching practices

You are likely to develop the following reflective teaching practices, which work in a circular way.



Tools and templates at your disposal

In **Appendix A** you will find a *Try it out* template and accompanying guidance. Make as many copies of this template as you like. The template supports you through the following five steps:

Choose an idea → Think about what you want to achieve → Make a plan → Try it out → Reflect and adapt practice

In **Appendix B** you will find a 'My iLowerSecondary checklist' template that you can use to record practice and plan next steps. You can make as many copies of this as you need and keep revisiting practices until you are confident.

Where to go for help

- To download support, lesson plans or the details of your local Pearson representative, please visit the iLowerSecondary website.
- Information and support from the iLowerSecondary Schools Community can be found on the iLowerSecondary forum of the Pearson International Schools Community.
- Contact your local Pearson representative for details of our Professional Development offering or with any questions you may have.

Creating an iLowerSecondary classroom environment

The iLowerSecondary curriculum supports a classroom environment that engages all students in learning activities and in which all students can progress.

A classroom environment that is engaging for students usually contains some or all of the following characteristics.

- Learning objectives are shared with students and the teacher checks that all students understand what is being asked of them.
- Class discussions involve all students participating in some way.
- Teacher talk is important but is always accompanied by opportunities for students to consider the new content/problem/ideas being presented by the teacher.
- Students see the connections between what they are learning and their lives.
- Students will have a go even when they are not sure of the answer.
- Students enjoy lessons and take their share of responsibility in making progress.
- Classrooms have attractive resources and student work on display which are used by both teacher and students.
- Seating arrangements will vary to suit the learning objectives, including desks arranged for small-group work.
- Students will often use resources to work on problems and carry out inquiries together where the teacher guides – rather than directs – this process.
- Noise levels can be quite high but the talk is productive and on-task.

This next section will outline some of the key instructional methods you will have at your disposal in the iLowerSecondary classroom to create an effective learning environment and explain why these are an effective way of engaging students.

ACTIVE LEARNING

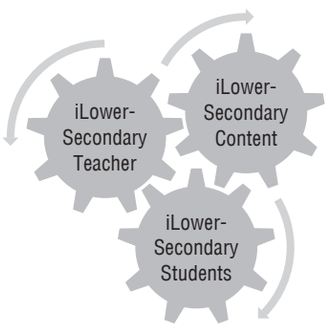
Broadly, a positive classroom environment will involve the teacher leading what can be called 'active learning strategies'. Active learning can sometimes mean that students are literally more physically active, but it *always* means that all students are required to think about what they are doing. As an iLowerSecondary teacher you will ensure students *engage* in learning activity. You will view learning as an interactive process and help students to take some responsibility for their own learning. There are three key areas:

1. students interact – or engage – with you, the teacher

2. students interact – or engage – with resources and new content

3. students interact – or engage – with each other.

These three axes of engagement interact and feed into each other as illustrated in the following diagram:



Strategies for implementing active learning

This guide is full of ideas that will support you in creating an active learning environment in your classroom where *all* students can engage, contribute and make progress. See in particular the sections on **Engaging everyone**, **Collaborative activities** and **Developing thinking skills**.

Engaging everyone p. 15

POSITIVE BEHAVIOUR MANAGEMENT

Collaborative activities p. 24

Positive behaviour management simply refers to the effective management of student behaviour in the classroom in a way that is conducive to a positive classroom environment. This involves establishing a kind of social contract with students that is based on mutual respect.

Developing thinking skills p. 27

The benefits of positive behaviour management

A positive iLowerSecondary classroom environment will bring the following benefits.

- Creating and maintaining positive relationships with students can be of great benefit to the students and to teachers themselves; teachers will find that learning progresses more smoothly as students are positively engaged.
- Students will be more motivated in their learning because they value being respected and involved in the learning process.
- Teachers and students will have a far more enjoyable classroom experience if they are able to maintain mutually positive relationships.

Strategies for implementing positive behaviour management

The following suggestions aim to support positive student–teacher relationships.

1. Create opportunities for one-to-one conversations with students to get to know them as individuals. This can be done outside class (at break times or at the school gate/class door) or achieved during group activities where the teacher aims for one-to-one chats with each student. It doesn't matter if it takes several days to fit in a chat with each student, providing everyone has had the opportunity for some individual time.

   For example: *So, Aisha, let's look at your last homework activity. Tell me a bit more about how you did x? What might make it even better? Next time could you try y?*

2. Try to personalise the written feedback you give to students. It will not necessarily be possible to do this every time you mark a student's work, but try to write something that shows you know the student as often as you can.

   For example: *Rajesh, you have done x, y and z well. I am particularly impressed with the way you… For you next piece of work try a, b and c…*

3. Aim to be curious rather than judgemental when interacting with your students. Ask yourself why a particular response or a behaviour that you are unhappy with might be happening. Think hard about the root causes rather than the surface behaviour.

   For example, if students are easily bored you could ask yourself: *Is the work challenging enough? Or does it need more structure for them to really understand it? Do they have enough input into the task?* And so on.

4. During group work, circulate the room and lean in to praise some good work or constructive learning behaviour where relevant.

   For example: *That was an excellent explanation, Ivan,* or *I like the way you asked such a good question there, Yu Yan,* or *I can see that this group is working very well together by working well within your assigned roles*.

5. When providing feedback to students, aim to make this as specific as possible to help students to act upon it.

   For example: *Next time, Elisabeth, write sentences of no more than ten words. This will help you focus on the main message of your sentence*.

6. Ensure that students are clear on what the goals of a specific piece of work or activity are.

   For example: *YongJae, can you explain what you should be able to do by the end of this task?*

7. Show an interest in students' lives and bring in examples of their interests outside school so that you can add meaning to their learning.

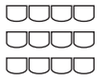
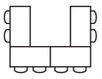
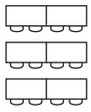
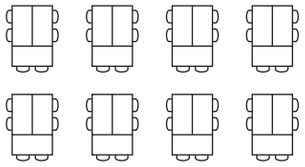
   For example, if you know that Luka is interested in fishing, say: *Luka, how have you learned to be so patient that you can wait hours at a time to catch a fish?* Or make reference to a cultural event that will involve the students and may be occupying their thoughts (such as an end-of-term event, a local pop concert or a sports competition).

SEATING ARRANGEMENTS

Seating arrangements are a very simple yet powerful tool for creating an engaging and effective classroom environment for your students. As an iLowerSecondary teacher, you will find it helpful to vary your seating arrangements to suit the task in hand.

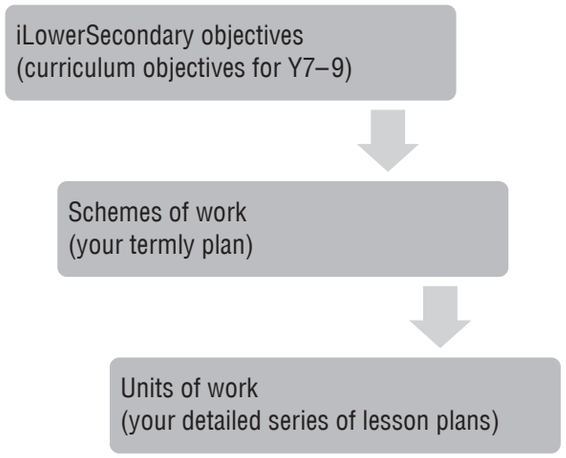
Examples of seating arrangements to use in various classroom situations

Here are some examples of seating arrangements you may try:

Seating arrangement	Learning purpose
 Single desks in rows	Single desks facing the front particularly suit test conditions. Here, students can concentrate and work individually.
 U-shape or horseshoe	A U-shape formation lends itself to whole-class discussion. It can also accommodate a combination of whole-class discussion and pair work.
 Small groups of desks	The small-group desk arrangement suits activities involving students in inquiries or other kinds of small-group work.
 Paired rows	Paired rows can be suitable for a combination of whole-class presentation and pair work. Paired rows can also be turned quickly into small groups of four.
---------- (front of class)  Group desks with all chairs able to see front board	This may be good for a semi-permanent arrangement as it enables groups to work together as well as whole-class work where everyone needs to see the board.

iLowerSecondary planning

The iLowerSecondary curriculum provides you with detailed curriculum objectives to guide the planning for termly schemes of work and more detailed week-by-week lesson planning.



THE iLOWERSECONDARY CURRICULUM OBJECTIVES

You will find topics and curriculum objectives in the curriculum specification. The iLowerSecondary curriculum has been developed to give students the breadth and depth of knowledge they will need in order to confidently take external tests and be fully prepared to begin their International GCSE years.

The curriculum objectives cover the knowledge, understanding and application that students are expected to demonstrate in clear detail. Further guidance or examples are provided as appropriate. For example, a curriculum objective might say: *Know the similarities and differences between plant and animal cells.* This will be accompanied by examples of what students should know or be able to do, for example: *Know that plant cells have a cell wall, chloroplasts and permanent vacuole, in addition to the parts an animal cell has.*

DEVELOPING SCHEMES OF WORK

You may work with colleagues or independently to develop a termly scheme of work for your subject area using the curriculum objectives and topics outlined in the curriculum specifications. Here you will decide upon how to divide topics and select the relevant curriculum objectives. The scheme of work is a general plan that outlines what you will cover – and expect students to learn – over the course of a term.

Developing the termly plan or scheme of work will give you and your colleagues the opportunity to match curriculum objectives to topics that:

- go together well
- complement each other
- build upon each other in order to consolidate understanding
- coincide with a local or national event (sporting, musical, cultural).

For example, the following scheme of work, taken from Year 9 of the iLowerSecondary science curriculum, contains objectives that have been grouped together because they all cover the topic of static electricity.

SCIENCE

iLowerSecondary Pearson

The following document provides a suggested order of teaching. Please note that the order topics are taught **within** a year group is open to change depending on the needs of students or of a particular region (for example different regions may want to move topics around plants to their growing season).

Year 9 Science Scheme of Work

Topic	iLowerSecondary Science objectives	Activities
Static Electricity	**P9.2.2A** Know the structure of an atom in terms of the central nucleus containing positively charged protons (and neutral neutrons) with negatively charged electrons moving around it. **P9.2.2B** Understand how different insulating materials can be given different charges when rubbed with a cloth. **P9.2.2C** Know that a charge of static electricity can build up when different materials rub together and that static electricity can cause small electric shocks. **P9.2.2D** Know that when a charged object comes near to another object, they will either attract or repel each other. If the charges are the same they repel; if the charges are opposite they attract.	Recall how objects can be given a charge of static electricity, and describe some of its effects; describe the kinds of materials that can and cannot be given a charge of static electricity; recall the two types of charges and their effects on each other; use ideas about attraction and repulsion to explain electrostatic phenomena involving repulsion between like charges; explain why a conducting object cannot be given a charge of static electricity; state what is meant by electric field, and recall the shape and direction of the electric field around a charged object; describe the effect of an electric field on electrically charged objects; explain how the transfer of electrons results in the two materials gaining equal and opposite charges; recall and explain how a charge can be induced in an uncharged object and use this idea to explain familiar electrostatic phenomena.

PLANNING UNITS OF WORK

Once you have your high-level termly plan, or scheme of work, you will then plan for a series of lessons. Here you will outline the detailed activities you plan to carry out in each lesson. Your individual lesson plans will involve deciding upon key vocabulary and concepts you aim to convey. You will also outline information about individual students or groups of students and, for example, any additional challenge or support that you may need to provide. You should also decide which specific curriculum objectives you are addressing in that lesson. The following lesson plan provides an example structure that you might use.

MATHEMATICS

iLowerSecondary Pearson

Year 7 Autumn Term 1 Lesson 1

Main Focus	Prior Knowledge	Key Vocabulary	Curriculum Objectives
Use two-way tables Interpret and draw dual bar charts and compound bar charts	Students have experience of data handling and drawing and interpreting simple bar charts.	Mode, modal, dual bar chart, compound bar chart, frequency, frequency diagram, two-way table	**S7.1E** Compare sets of data using their ranges and averages **S7.2 A** Represent data in tally charts, frequency tables, bar charts, bar-line charts and pie charts **S7.2B** Interpret simple tables and bar charts for grouped data **S7.2E** Read and interpret information from bar charts, bar-line charts, dual and compound bar charts and line graphs

Teaching Summary

Provide a simple bar chart on a topic of interest. Ask students to read and interpret it, in pairs.

Display this table of Year 7 favourite potato dishes.

Potato dish	Mashed	Baked	Chipped	Boiled
Frequency	6	3	11	5

Explain the term 'frequency' and draw a 'frequency diagram' (bar chart). Describe the features of the chart: title, axis labels, horizontal (values), vertical scale, bars of equal width, same colour and equally spaced.
Add another row to the table for Year 8 and introduce the term 'two-way table'.

Potato dish	Mashed	Baked	Chipped	Boiled	Total
Year 7	6	3	11	5	
Year 8	5	5	10	4	
Total					

Ask for the totals and what they mean, including the grand total.
Draw a dual bar chart for the data. Emphasise the need to add a key to the chart.
Draw a compound bar chart for the data. How would the charts change if you added data for Year 9? (another set of bars, new colour)

As an iLowerSecondary teacher you will ensure that you include activities that engage the students using a variety of techniques. Your planned activities will involve students in interacting with new content, with each other and with you in interesting and energising ways. Your plans will include a range of activities, including: using mini-whiteboards, structured small-group discussions, whole-group discussion where students have thinking time, student presentations, jigsaw grouping, hot seating, gallery walks and other active learning techniques. This guide is full of ideas to help you do this.

As part of the planning process, you will also include opportunities to carry out formative assessment in each lesson. This will help you to know where to support and challenge individuals or groups of students. It will also help you to assess how much the whole class has understood and whether you need to skip over content or repeat ideas. You can plan for formative assessment opportunities at the beginning, part way through and at the end of lessons.

Formative assessment p. 57

Your planned formative assessment opportunities are likely to include some of the following.

- Traffic-light cards to assess students' understanding halfway through an activity. Students may hold up a green, amber or red card indicating their level of understanding.
- A variety of questioning techniques, including open-ended questions that may reveal student misconceptions or assess the level of secure understanding.
- Mini-whiteboards to determine prior knowledge or remaining questions. You can check students' responses at a glance, or concentrate on certain students or groups.
- KWL charts (what students **K**now, what they **W**ant to learn and – at the end of the lesson – what they have **L**earned) or posters to assess and activate prior knowledge, and to assess how much has been learned.
- Asking students to keep an individual 'shared' learning log that allows for the student to capture their learning against certain criteria, to make reflective comments, to ask questions and then to gain individual comments and responses from the teacher. This enables the student to invite and receive some high-quality *individual* dialogue, input and feedback. Shared learning logs work best when they include clear assessment criteria in the form of levelled rubrics in order to be very specific about the feedback given.
- Focused talks with individual students help to determine levels of understanding and progress (you can plan to see individual students while the class is conducting group work, for example).

Your plans will allow for these formative opportunities in order to determine the pace and level of your students' progress. You will therefore also need to plan for some flexibility, such as additional activities for students who grasp ideas very quickly or going over key concepts in different ways to ensure all students have grasped the ideas sufficiently.

Principles for progress

The principles for progress are a collection of the ten principles (identified by our pedagogical experts) that will give your students the best opportunity to make progress in their learning. Each principle is accompanied by guidance relating to specific teaching approaches, tips and issues to watch out for, all written in clear, practical steps that you can use in the classroom. Formative assessment underpins and runs through all of these principles. Knowing each student's starting point, understanding their learning and reflecting on their development helps to ensure progress for all.

	Principle	Summary
1	Engaging everyone	Techniques to ensure that all students are involved in the lesson and participate in discussion, including whole-class question-and-answer sessions.
2	Differentiation	Provides techniques for adapting your teaching to ensure that all students can access the learning according to their level and achieve good outcomes. These techniques also convey the importance of having high expectations of all students.
3	Enabling independent learning	Outlines suggestions to support your students, encouraging them to 'have a go' and not to be put off by challenging ideas or tasks. It also has techniques for helping all students to take more responsibility for their own progress.
4	Effective questioning	Offers practical tips for asking questions that make students think. It outlines question types (for example, closed, open, factual, conceptual, probing, discussion) and provides examples of each.
5	Teacher talk	Teacher talk is important and this section outlines how to make it as effective as possible with ways of engaging your students as you introduce new content and explain activities.
6	Collaborative activities	Outlines lots of practical ideas for grouping students and ensuring that group work is really focused and productive. It also outlines ways of developing student ownership of their learning and the ways in which group work can build confidence too.
7	Teacher demonstration	Focused on how to conduct effective teacher demonstrations and how you can model important learning behaviours too.
8	Developing thinking skills	Provides good ideas for developing your students' abilities to think critically, to problem-solve and to carry out their own mini-inquiries.
9	Reflection on learning	Ideas to encourage students to think constructively about their own learning and to take control over how to make better progress.
10	Feedback (in both directions)	Offers practical ideas for conducting good two-way feedback between you and your students in order to improve learning and achievement.

ENGAGING EVERYONE

As an iLowerSecondary teacher, you will work hard to involve everyone in your lesson activities, including whole-class discussion. The following ideas will support you in conveying your own enthusiasm for the lesson content, finding connections to engage students' interests and using techniques to ensure that all students *have to* participate in discussion and activities.

Teaching approaches for engaging everyone

1. Convey enthusiasm

- Remember that enthusiasm is infectious (in a good way!) so aim to share your own interest in the subject.
- Even if you are not enthusiastic about a particular subject, try to act as if you are. You are likely to find that your enthusiasm and your students' keenness grow as a result.
- Make connections between the subject and examples in your own life or in the wider world and aim to show that learning about the topic matters.

Scientific literacy p. 39

2. Find links to students' interests and existing knowledge

- **Create a KWL chart**

  One simple technique is to ask students to complete a KWL chart. This asks them to say what they already **K**now, what they **W**ant to learn and – at the end of the lesson – what they have **L**earned. This is very useful information as it can help you plan group tasks, to know when to provide supporting resources for some students or to skip over part of a topic quickly because the students are already familiar with it. It also provides students with the opportunity to show what they are interested in.

- **Use a gallery walk to activate existing knowledge**

  This technique involves you creating four to six prompt questions (or images/drawings) that you write on flip chart posters and display around the room. Each of the four to six prompts relates to a new topic. Arrange students into small groups and assign each group their first chart/poster. Invite students to write their ideas and comments relating to the prompt for about three minutes. Then ask each group to move to their next poster where they read the comments from the previous group and add their own. Ask probing question as you circulate. Note any ideas where students have strong previous understanding, gaps in their knowledge or misconceptions.

3. Engage everyone in whole-class discussions

- **Use 'hands down' and 'wait time'**

  One effective way of engaging everyone in a class discussion is to insist that students keep their hands down when you pose a question. This allows you to provide your students with 'thinking time' as you wait before asking a particular individual to provide an answer.

- **Think–pair–share**

  During this 'wait time' after posing a question you can ask your students to engage in a minute of **thinking** on their own. They then turn to their partner to work in **pairs** to develop and exchange their thoughts. You then ask pairs of students to **share** ideas with the whole class.

- **Use mini-whiteboards**

  When posing a question or setting a task, give each student a mini-whiteboard (or plain paper/card) to work on his or her answer. Then – at a set time – ask all students to hold up their answers for you to see. This allows students to work quietly without too much pressure from the 'quick responder' who usually provides the answer. It also enables you to see the different levels and types of response to help you plan your next steps/question.

- **Use name cards for randomly selecting students**

  Create a set of cards displaying each student's name. After asking a class question, give students time to think (wait time) and then pull out a card at random and ask the named student to respond. Alternatively, you could pull out two names at a time and start a discussion between two students. When students get into the habit of expecting to think and understand that they may be asked for the answer publicly they will start to engage with the learning more. You can pull out more cards to encourage other students to respond to the original student's answer in constructive ways. That way, your whole-class discussion feels more like basketball (lots of people bouncing ideas around) than singles tennis (you getting answers from individual students).

4. Work the room to engage with individual students

When you have set a class task you can then work the room to check in with certain individuals and ensure that they are engaged and making progress. Depending on what you find when working the room, you could:

- identify three students that are a bit withdrawn and engage them in a conversation

- suggest that particular students take on the role of reporting ideas back to the whole class in order to encourage them to speak out in front of the other students. You could give them a few starter suggestions about how to do this if you feel they will need that level of support.

Watch out for…

- The same students always answering the class questions. This can discourage other students and lead to them giving up or relying on these students.

- Shyer students who may need some extra support in speaking out in front of the whole class (think–pair–share is a good technique to use here).

DIFFERENTIATION

Effective differentiation means adapting your teaching to enable students to access learning. This involves lesson planning that pitches and scaffolds tasks for all students to make progress. It is *not* about locking down or limiting potential by only providing easy tasks for students with limited (existing) ability. This approach is based on conclusive research that intelligence and ability can grow and is not fixed. Therefore, as an iLowerSecondary teacher you will differentiate activities while keeping high expectations for everybody and keep individual students' progress under review.

Teaching approaches for differentiation in the classroom

1. Differentiation by outcome

This approach consists of setting the same task for all students and providing levelled success criteria outlining what different level answers would look like. This enables you to show what you expect all students to achieve and to provide guidance on how to achieve a high standard. You are not making any advance assumptions about what certain students can or cannot do. For example:

Topic: Rainforests

Outcome: Identify and explain key features of a rainforest

Task: After watching a short video and slide presentation (with opportunities for think–pair–share ideas), students work in groups to plan a presentation explaining the importance of the world's rainforests to the survival of our planet for a fictitious student geography conference. Students are given packs containing key information about rainforests but are also expected to conduct some independent research to find information beyond what is provided. Students are also given success criteria explaining what a good answer looks like. The 'presentation' could take the form of an electronic pamphlet, a video or a group presentation using good media technology. Students then present to the whole class. The students in the 'audience' engage in some peer review of each presentation and are provided with a simple rubric to guide this peer review. After all the presentations are complete there is a whole-class discussion capturing the strengths and areas for development for each presentation.

Success criteria:

- Satisfactory: Two or three well-argued key reasons, use of basic communicative media, two or three illustrations, short explanations (three sentences or fewer), all the provided research information included and one or two other sources of independently sourced information included.
- Good: Four or five well-argued key reasons, good use of communicative media, three or four clear and labelled illustrations, longer explanations including references to the provided information and three or four sources of independent research.
- Outstanding: A strong integrated explanation of the importance of rainforest, excellent use of communicative media, well-referenced arguments using all provided information and several (five or more) sources of independent information gained from independent research.

Some students may find it harder to understand the success criteria or to visualise what a good answer looks like. Here you can share a 'pretend' answer relating to a different topic that exemplifies 'good' or 'below standard' so they all know what to aim for or avoid.

Students will provide answers of varying standards according to several factors, such as their writing ability. Once the task is completed, share anonymised examples from the class of what 'good' looks like to all students and discuss how to improve for the next task. You can follow up with specific feedback for individual students on how to improve.

2. Differentiation by levels of support for a specific task

This involves providing certain students with more support to achieve a (common) task, therefore you can plan how to intervene to support those students who may have grasped the ideas very quickly and to support those who are struggling.

For example, with the rainforest lesson on the previous page, you would identify students with specific needs that may make certain aspects of the task more challenging for them (such as reading or writing levels). You could arrange students into groups and spend more time supporting particular groups in preparing for the task.

Teachers will work with all abilities to encourage them to achieve more highly so that 'teacher support' is viewed as a 'normal' expectation of every task.

3. Differentiation by resources

This involves providing different students, or groups of students, with different resources aimed at supporting them in achieving a common task.

For example, with the rainforest lesson on the previous page, this might mean that you create 'learning packs' with different 'levels of difficulty' for different groups of students. The packs might contain explanations in more complex or simpler language or you may vary the amount of information in each pack. You could also provide some information for higher achievers to enable them to create their own resource to support the presentation.

4. Differentiation by time to master key concepts

This approach helps you to support all students to achieve mastery of a particular concept by not moving on to the next level of difficulty until *all* are ready to do so. Those who have grasped the idea quickly should have the opportunity to go deeper into the concept and those who are struggling should be provided with extra support.

For example, with the rainforest lesson on the previous page, this may mean identifying the essential concept that you want the students to grasp, for example, photosynthesis. You would ensure that all students have grasped this idea before moving on to the next topic. This could involve giving those who grasped the ideas quickly opportunities to analyse photosynthesis in different contexts. Students who are struggling to grasp the idea might be given a number of short videos to watch and be asked to answer specific questions to ensure they understand the process and significance of photosynthesis.

5. Differentiation by task

This involves giving different tasks (relating to the same topic) to different students according to their current level of understanding and achievement.

For example, with the rainforest lesson on the previous page, you could ask lower-achieving students to carry out lower-level tasks like 'describing' features of rainforests, including photosynthesis, and ask the higher-achieving ones to research and explain how botanists measure rates of photosynthetic activity.

The advantage of this approach is that you tailor learning to suit current needs and therefore students are able to succeed and achieve the outcomes more easily. This can boost student confidence. However, when using this approach it is easy to make judgements about student ability that keep them somewhat 'fixed'. To avoid this, aim to only use this approach when there is a specific concept or skill that requires concentrated input. Monitor achievement closely and ensure that you are providing tasks that always contain some stretch for students regardless of their current ability. Alternatively, you could frequently provide open-ended tasks which will allow you to differentiate by outcome too.

ENABLING INDEPENDENT LEARNING

Engaging students so that they know the 'big picture' purpose of the lesson, the main activities and why they have been chosen encourages students to take more responsibility for their part in the learning process. Independent learning is further supported by:

1. arriving at a clear, shared understanding of what success looks like (i.e. the 'success criteria')
2. understanding the steps needed to achieve this success.

Having clear success criteria and steps to success will develop students' confidence to 'have a go'. This understanding also helps students work with each other more effectively and makes them less reliant on the teacher.

Teaching approaches for enabling independent learning

1. Communicating learning objectives

- Use student-friendly language to describe the learning objectives for the lesson, for example, *Today, we are learning to...*
- Ask students to predict the learning objectives for the lesson based on what they have learned in previous lessons. For example: *What do you think we should be learning today given what we did last lesson?*
- Once you have established the objectives of the lesson, ask students to complete the following sentences (this can be done verbally or in written form, but it has to be short and lively).

  This lesson will be successful if:

  - *the teacher*… (for example: explains clearly, gives us time to think)
  - *all the students*… (for example: listen to each other, can discuss our ideas)
  - *I*… (for example: contribute my ideas, ask good questions).
- Ask students to show red, amber or green cards following a traffic-light system to communicate how well they are meeting the objectives.
- At the end of the lesson, invite students to look back at the objectives to see in what ways and to what extent they have been achieved. You can do this by asking each student to fill out an 'exit slip' (a small piece of paper to capture their view on whether or not they met the objectives) or to add to their shared learning log for a series of lessons.

2. Developing shared understanding of success criteria

- Use student-friendly language to describe the success criteria, for example, *What I am looking for today is…* or *What we should achieve during this unit/term/topic is…*
- Encourage your students to come up with their own ideas for what success should look like once you have described the learning objectives. Ask them: *What do you think all of us should be able to do by the end of today's lesson?*

- Standardise your use of certain verbs in your lesson outcomes so that these become familiar to students, for example:

  You will be able to:

  - ***remember*** *the fact that…*
  - ***explain*** *to someone else how to…*
  - ***create*** *a…*
  - ***evaluate*** *(or judge or assess) how to…*

- Make sure learning outcomes are very specific. For example: *You will be able to write a paragraph on x subject*.

3. Establishing class norms

- Involve students in the process of creating and agreeing behavioural standards.
- Express expected standards in positive language, for example, 'be on time' rather than 'don't be late'.

4. 'Three before me'

- When working in groups, encourage your students to ask three classmates a clarifying question before they turn to you for information.

5. Peer evaluation

Peer review is a powerful learning technique which needs to be supported by clear criteria. In other words, students need to know what 'good', 'excellent' and 'poor' performances look like. You can communicate these criteria in different ways for different ages of students and incorporate the following techniques.

- At early stages of introducing peer evaluation, create peer-assessment pairs so that students can assess each other's work in relative safety.
- Return marked tests and encourage students to work in pairs to check their partner's grades.
- In preparation for a test, give students a mark scheme and a set of anonymous work (of varying quality) and ask them to work in pairs to mark it.

6. Encouraging a 'have a go!' attitude

- Model thinking through a difficult question or problem.
- Explain that very successful people make – and learn from – mistakes.
- Publicly reward effort by students who try hard to solve or tackle a difficult task.

EFFECTIVE QUESTIONING

Asking good questions that *lead to thinking* is one of the most important techniques that iLowerSecondary teachers can use. There are many types of questions and these can either be open (e.g. *What do you think about this idea/story?*) or closed (e.g. *What is a verb?* or *What does the term 'metaphor' mean?*). It is important to have a balance of both and to ask the type of question that suits your purpose.

Examples of questions with different purposes

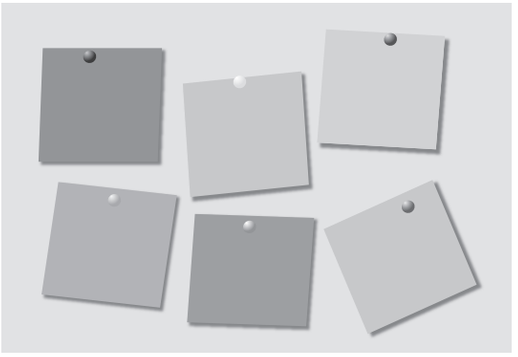
Question purpose	Examples
Make predictions	*What do you think might happen next?* *How many more of x might be needed if y happened…?*
Analyse	*What is the connection between… and…?* *What are the most important facts/issues here?*
Assess understanding	*What are the big ideas for this lesson?* *What have you tried so far?*
Think divergently	*Who can add to that idea?* *What might be another way to tackle this problem?*
Identify problems	*Can someone repeat those instructions in their own words?*
Clarify thinking	*What are your next steps?*
Reflect on learning	*How would you explain this to a friend?*
Make guesses	*What might have happened if…?*
Compare	*How is x similar/different to y?*
Probe for deeper thinking	*What is another way of looking at this or solving this problem?*
Redirect focus	*How does this discussion on x relate to the problem with y?*
Ascertain interest	*How does this relate to your experiences outside the classroom?*
Demonstrate curiosity	*What further questions would you like to answer about this?*
Assess prior knowledge	*How does this relate to what you've done before?*
Assess progress	*Where are you confident and where do you need further support?*

Tips for effective questioning in the classroom

Engaging everyone p. 15

- Discourage 'hands up' and tell the class that you expect everyone to be prepared to answer.
- Use PPP ('pose, pause, pounce'):
    - **P**ose the question to the whole group
    - **P**ause to allow all students to think of (or discuss) the answer
    - **P**ounce by naming a student to provide an answer.
- Ask students to explain the reasons for their answers. Spread the questions around the class so that all can participate. Encourage all to join in – in a regulated manner – for example: *Ivan, can you give an example of what Mohammad means?*

- Encourage student questioning. For example, provide an 'answer' such as the number 12. Then ask students to come up with questions for which only the number 12 could be the answer.



- Create a question wall and invite students to capture their questions throughout the activity or day or week. Address the questions at regular intervals in front of the whole class. Questions can be anonymous if necessary (which can allow for more 'risk-taking').

- Once students are confident with the question wall technique (described above), task a different student (or groups of students) with taking ownership of the question, conducting research and making a presentation to showcase the answers.

- Introduce a topic and invite students to think of as many questions about the topic as they can. Working in small groups, get the students to ask their classmates the questions.

- Ask higher-order questions, which encourage students to go beyond basic information, for example, *Which of these ideas/answers is the strongest? Why do you think that? What if we add this new information? Does that change your view/answer?*

- Have a series of question cards. Plain pieces of card with key question words written on one side, like *what*, *when*, *where*, *which*, *who*, *why* and *how*. Have students shuffle these and choose a card a random, then come up with a question using this prompt word.

Watch out for…

- Do not make the assumption that if hands go up everyone understands the question or knows the answer. Sometimes putting hands up is a habit rather than a real show of understanding.

- If lots of hands go up too quickly this may mean the questions are too easy.

TEACHER TALK

As an iLowerSecondary teacher you will probably find that you spend less time giving long explanations to the whole class and more time engaging with students directly. However, the way you present information, for how long and the language you use remains very important.

Tips for effective teacher talk

- As you plan a lesson involving presenting new content or class discussion, plan several questions that require an elaborated response from students, such as those that begin with 'Why' or 'How'.
- As you engage students in the lesson, pause often to ask questions that require more than a single-word response.
- Value some silence.
- Give students thinking time to absorb what you've said and don't answer your own questions.
- As students share their ideas, ask others to elaborate or respond to their peers' ideas. Continue the discussion by probing student responses to foster more in-depth thought.
- Encourage students to ask any questions when they are halfway through your presentation.
- Ask students to predict what might come next in your presentation.
- Avoid speaking for too long without engaging students in a task for them to process the information.
- Frequently check for understanding by asking questions that assess understanding and progress.

Effective questioning p. 21

Teaching approaches for teacher talk in the classroom

1. Write–pair–share

This is similar to the think–pair–share technique. Here, students write a response to a question or prompt, then share with a partner. During lessons in which delivering new content is most appropriate, pause every five to ten minutes to allow students two minutes to consolidate their notes and/or share their summary with a partner. You may also provide opportunities for students to engage in short, one to two minute writing exercises that then lead to class discussion.

2. Brainstorm before presenting new content

Arrange for students to work in a small group to create a list of ideas on a given topic. This can be used to activate prior knowledge or to summarise concepts and make connections. Students can also engage in some peer evaluation by placing sticky notes with comments next to ideas in other groups' lists relating to ideas they would like to ask more about or challenge. This will mean they are highly engaged when you carry out your presentation.

Watch out for…

- The same students giving you correct answers as you present new content and assuming that this means the whole class has secure understanding.
- The length of your (uninterrupted) presentations of new content and aim to keep these to a maximum of ten minutes (usually less).
- The feeling that you have done more work in processing ideas than your students. They should be (generally) talking more than you in most lessons.

COLLABORATIVE ACTIVITIES

Research shows that *structured* group work can lead to very high-quality learning. The best-quality group work requires each member of the group to take genuine responsibility for the successful outcomes of the task. The iLowerSecondary curriculum gives you plenty of opportunities to incorporate this kind of collaborative work. This will enable students to work together well, learn from each other and work on a problem together to arrive at a solution.

Teaching approaches for collaborative activities

1. Assigning group roles

- Present some new content and then divide the class into small groups to carry out a task that will deepen their understanding of the new content or enable them to apply their understanding. Groups should have no more than four members. Assign each member a role, for example:
    - group chair/leader
    - spokesperson (who reports back to the whole class)
    - scribe (who writes down the main ideas)
    - 'fact checker' or 'quality controller' (who has to make sure that the ideas are accurate or to ensure the best-quality responses).
- Assign group members different responsibilities during a discussion task, where they have to take on the role of the:
    - critical thinker
    - positive thinker
    - person who has to think of all the things that could go/be wrong
    - neutral person who sees all sides of the discussion.

2. Jigsaw grouping

The jigsaw approach is a cooperative learning strategy in which each member of a group is assigned a portion of a task to complete. Students then work within their small group to piece together the individual pieces into one coherent task.

Here are some tips for using this approach.

- Plan an activity, such as reading and reviewing a story, that can be split into smaller chunks.
- Create student groups and assign each group one part of the task.
- Direct students to complete their part, then talk with their peers who had the same task. This allows students to dig deeper into their part of the task.
- Then create new student groups in which each group has a student that completed each part of the task.
- Allow all students to share their ideas or understanding from their part of the original task so that the whole group has a complete picture of the whole task.

3. Using a gallery walk

A gallery walk is an activity in which students rotate to various stations around the classroom, completing tasks at each station. A gallery walk can also be used to showcase work completed by other students, giving an opportunity for students to learn from their peers.

Here are some tips for using this approach.

- As you plan a lesson, create several 'station' ideas. For example: students answer a question, students read and discuss a document, students respond to some quotations, etc.
- Place each station's materials in a designated spot in the classroom and place flip chart paper and marker pens at each station.
- To start, create student groups and assign each group one station.
- Provide an appropriate amount of time for students to complete the task at their station (five to seven minutes is generally acceptable but adjust as needed). Ask students to complete the task and write their ideas onto the flip chart paper.
- When the time is up, ask students to rotate to the next station to complete the next task.
- Continue the process of providing time at each station before having students rotate to the next station until groups are at their original station.
- Provide time for students to review the responses on their original station's flip chart paper to summarise the main ideas.
- Allow each small group to share out the responses on their flip chart paper in a whole-class discussion.

4. Hot seating/ask the expert

- First, you act as the expert and ask students to work in pairs or small groups to come up with as many questions as they can. You might be a famous inventor, scientist, mathematician or historical figure. Students then take it in turns to ask you questions.
- Then encourage a group of students to act as the expert panel (consisting of scientists, inventors, etc.), while other students create and ask questions. Rotate the expert-panel group so that all students get to be experts as well as questioners.

5. Developing positive relationships between students

- Small-group tasks: set each small group a challenge and reward their ways of working together as well as the outcome of the task.
- Assign different group leaders to tasks over time to build up confidence and skills for all students.
- Peer marking of quick quizzes: encourage students to swap their quiz papers and to mark each other's work (with you providing answers from the front).
- Reward collaborative behaviour: give a weekly prize for the group or pair of students that have worked in the most collaborative and constructive way that week.

TEACHER DEMONSTRATION

As an iLowerSecondary teacher you will be modelling learning behaviours for your students. You will also have lots of opportunities to demonstrate ways of thinking, problem solving and structuring tasks that will be especially useful for students.

Teaching approaches for teacher demonstration

1. Modelling behaviour

- Create a positive and supportive emotional environment in your classroom. This will increase student confidence and allow more students to take risks in their thinking and problem solving too. Model respectful behaviour, do not allow belittling and reward or acknowledge thoughtful behaviour.
- Be curious rather than critical when responding to students and model this using appropriate language. For example: *I am curious about why you chose to… Can you tell me a bit more about why you have focused on x rather than y?*
- Use polite and respectful language, even when you are reprimanding a student.

2. Think alouds

A 'think aloud' is when a teacher talks the class through his or her thought process when solving a problem or engaging in an activity. Students rarely get a chance to see a teacher struggle with a problem, but sharing these experiences can be a very powerful technique for students to witness. You should aim to model internal dialogue, self-questioning, decision making, false starts and self-corrections to show students what problem solving looks like.

You might ask aloud questions such as:

- *What are some of the ways I can begin?*
- *What might be the benefits of these different ways to approach this problem?*
- *What do I already know that might help me?*

Students will benefit from this approach in the following ways.

- They will make connections between their own and an expert's experiences with material.
- They will begin to understand that mistakes are a normal part of trying something new and will learn how to self-monitor and make corrections.
- Listening to students thinking aloud can provide you with useful formative assessment data.

Formative assessment p. 57

3. Teacher-led demonstrations

- These allow you to demonstrate model answers to the class and to show your working out as you go. Try to include various ways of approaching the problem or task and demonstrate how to tackle each.
- Use video clips of demonstrations and invite students to comment during intervals by asking focused questions such as: *What do you think he or she will do next? Is this the only way it could be done?*

4. Student-centred demonstrations

- Involve students in demonstrations by asking them to work in pairs at the board to show how to structure an approach to an answer.
- As students develop confidence, encourage them to be an 'instructor' and carry out a demonstration at the front of the class.
- Invite students to demonstrate their planning of an investigation or project report.
- Give students opportunities to demonstrate the ways they have conducted research for a report through a class presentation (and allow the student to decide the format of the presentation).

DEVELOPING THINKING SKILLS

As an iLowerSecondary teacher, you will know that developing thinking skills – especially critical and creative thinking – are very important for students to do well in examinations. Metacognition (i.e. thinking about thinking) is also essential for students and will enable them to make a smooth transition to Upper Secondary school as well as improve their lifelong learning skills.

Enabling students to develop thinking skills

1. Critical thinking skills

The following table outlines some of the main critical thinking skills and the accompanying command verbs and task instructions that you can use to structure tasks and develop these skills.

Critical thinking skills	Command verbs	Example task instructions
Analyse	Compare; Explain Calculate; Estimate Conclude; Outline Plan; Organise Summarise; Classify	• Compare the items in this list and sort them into three categories (most important, important, least important).
Evaluate	Judge; Measure Predict; Select Justify; Persuade Conclude	• Judge the order of this list by giving arguments for and against each point.
Creative thinking	Design; Compose Imagine; Adapt Develop; Propose Invent	• Propose changes to the list and decide how you would improve it.

2. Concept mapping

Concept or mind mapping is a small or large group activity which is separated into two parts.

1. Students generate as many ideas as possible around a question, topic, idea, or problem. At this stage, the focus is on generating ideas, not on judging the ideas.

2. Students organise the ideas into common categories or concepts.

To support students in this process you could model one example before asking students to go through the same process in a small group.

Then ask students to share their concept maps in a 'gallery' by displaying maps on the classroom wall and conduct a gallery walk where all students review each other's work.

3. Metacognition

You can encourage students to think about their own thinking by prompting them to ask themselves questions before, during and after lessons and also in preparation for tests. For example:

Before the lesson

- What do you already know about this topic?

- What do you think I am asking you to do in this assignment/task?

- How are you going to actively monitor your learning in this lesson?
- What questions do you already have about this topic that you want to learn more about?
- What resources do you need to complete this task?
- Have you done something like this before? If so, how can you use what you learned to do better this time?

During the lesson

- What questions are coming up?
- How are you determining which information is important?
- What strategies have you tried, and which are working well/not working well?
- What is challenging to you, and how can you address these challenges?
- How are the learning supports helping you?

After the lesson

- What was the lesson about?
- What did you learn that was new or that challenged what you already knew?
- How did today's lesson relate to prior lessons?
- What are your strengths and weaknesses with respect to this lesson?
- How did you use the resources that were available to you?
- If you were to do this activity/task again, what would you do differently?
- What worked well/did not work well for you?

In preparation for tests

- How will you prepare for the upcoming test or quiz? Why have you chosen that approach?
- What resources are available to you and how will you use them?
- How does your strategy compare to the strategies of three of your peers?
- What are your main areas of weakness/strength? How should you use that information to plan your study time?
- Based on your prior assessments, what advice would you give yourself for preparing for the next test or quiz?
- What are the big ideas from the unit or chapter?
- How do you feel before a test or quiz? What will you do to ensure that you are calm before the test or quiz?

REFLECTION ON LEARNING

As an iLowerSecondary teacher you will regularly reflect on your students' learning and progress and use this information to make adjustments to your lessons. In addition, you will encourage strong learning habits in your students that will stand them in very good stead for examinations and lifelong learning.

Teaching approaches for reflecting on learning

1. Developing a growth mindset among students

- Create a classroom culture where students are encouraged to see their own ability as 'expandable' and not 'fixed'.
- Praise effort as well as outcomes and be specific, explaining what was good about the way students went about the task.
- Give examples of brilliant people who have persisted before coming to a new theory or invention which will inspire students to achieve more. For example: Nikola Tesla (who invented an earlier version of the electric motor used in electric cars today) and Thomas Edison (who patented the first commercially viable light bulbs).
- Praise the success of the task rather than directly praising the student. For example, say: *The way you planned that project was very impressive because*…. NOT *You are very clever*.
- Use questions to encourage your students to think about their own thinking.

Developing thinking skills p. 27

2. Providing reflection points during learning

- Traffic lights: ask students to rate their level of understanding or rate of progress by showing red, green or amber cards. Students can place the cards on their tables as they work so that you can monitor and intervene with groups or individuals as needed.
- Mini-whiteboards: at key points during an activity, invite students to share an answer or make a statement about their progress on whiteboards and to hold them up for you to see. Note which students to follow up with, based on their answers, as some may need stretching further and others may need support.
- TTYP (Turn To Your Partner): ask students to turn to their partner and discuss a 'progress' question. After five minutes, ask for feedback on what went well so far (WWW – **W**hat **W**ent **W**ell) and what could be even better (EBI – **E**ven **B**etter **I**f). Summarise points and provide support to the whole class or individuals/groups as necessary.

3. Providing reflection points at the end of a task

- Give students the opportunity to mark their own work before they hand it to you.
- Ask students to reflect on why they think they achieved the score they did and ask them to create their own improvement points.
- Conduct plenaries that allow students to share reflections on their own learning, for example, one thing they are proud of and one skill they would like to strengthen. There are fun ways of conducting plenaries, including using a ball of string to pass between students as they make statements about their learning that connect to each other.

FEEDBACK (IN BOTH DIRECTIONS)

Specific, actionable feedback improves learning. Feedback can be written or oral. Giving students immediate spoken feedback is a powerful technique, leading to improved achievement. You should plan lessons carefully to provide opportunities for you to engage with individual students.

Teaching approaches for incorporating feedback into the classroom

1. Teacher-to-student feedback

- Implement a 'beacons and targets' system in your classroom.
    - 'Beacons' tell the student they have done well. It is important to set out why the student work is deserving of a beacon in specific terms, for example: *This is very good in terms of the way you addressed x…* (NOT *Well done – this is a good answer*).
    - 'Targets' are individual goals that help the student focus on what they need to do to improve their work.
    - Each new target is an opportunity for you to adjust your students' learning.
    - Checklists, prompts and marking frameworks will be a useful aid for tracking targets and beacons feedback.
    - Encourage students to think of their own beacons and targets.
    - Have dialogue with students to agree on beacons and targets together.
- WWW and EBI: speak with students one to one to give five minutes of verbal feedback containing What Went Well (WWW) about a task and one thing that they could be Even Better If (EBI) for next time. Speak with everyone over the course of a few lessons.
- Personalise written feedback when possible. For example: *You have done x well*; *I am impressed with the way you did x because*…; *For your next piece of work try y*…'
- Show how to invite and welcome feedback – even if it is not all positive. Share examples of constructive feedback you have received and how this has helped you develop. Demonstrate a feedback conversation with some students showing growth points and targeted praise. You could also show an ineffective conversation (too critical or vague and no actionable points) and good feedback with growth points as well as praise.

2. Student-to-student feedback

- Conduct gallery walks where students write constructive comments on and ask questions of displayed work by other students.
- Provide assessment criteria and invite students to mark their own and their partner's homework, then to compare their assessment with yours.
- Return marked tests and encourage students to check their partner's grades.
- Provide opportunities for students to take notes during group tasks in order to gain insight into improving their own learning.

3. Student-to-teacher feedback

- Provide exit cards (pieces of paper or card) which students complete with thoughts about the lesson, their current level of understanding and what they need more help with. This provides you with feedback to help plan subsequent lessons.

- Ask students to keep an individual 'shared' learning log that allows for the student to capture their learning against certain criteria, to make reflective comments and ask questions and to gain feedback from the teacher. This enables the student to invite and receive some high-quality *individual* dialogue and input from the teacher. Shared learning logs work best when they include clear assessment criteria in the form of levelled rubrics in order to be very specific about the feedback given.

- Students complete an evaluation of a unit of lessons, including the learning activities. This is not intended for students to rate you as the teacher but it can provide useful information about activities that students enjoyed and helped them make good progress.

Watch out for…

- Avoid feedback that makes students defensive as this shuts down their learning. Ensure feedback is outcome-based (focused on an aspect of behaviour in completing the task) rather than ego-based (focused on the student themselves).

- Avoid over-praising students with vague positive feedback. This can lead to them seeking personal approval rather than constructive strategies to improve their work.

Teaching in science

THE LANGUAGE OF SCIENCE

As they embark on iLowerSecondary science, many students will already have formulated their own long-term goals. In addition to the formal milestones of school and international assessment success, school students are learning to be scientists. For many, the skills of 'being a scientist' may form part of everyday life in their chosen career.

What takes place in the science classroom or laboratory is intended to be a smaller-scale version of what takes place in the scientific community around the world. Science worldwide is a very discursive subject; ideas and evidence are discussed and subsequent analyses and conclusions are peer reviewed, therefore spending some time on the language of science would be a good investment for students.

The benefits of reinforcing scientific language with Lower Secondary students

- Reinforcing basic terms such as 'investigation', 'conclusion', 'explanation' and 'evaluation' as they arise enables students to share a common language of science with their peers and with reference sources, as well as the teacher.
- Building on these terms, as students mature further, enables them to read and write about science with confidence.
- Alongside the above, students become increasingly familiar with a repertoire of language that will be used later in external assessments.

Examples of scientific language

Differentiation p. 17

Although students' English-language skills will have developed since Primary level, the pace at which new terminology is introduced will still vary with the age and fluency of individual students or groups. It is better for students to confidently use fewer terms than to use many terms hesitantly or inaccurately. The former will encourage students to try harder to use new terms as they arise. Often, they may wish to practise these with their peers in small-group discussion first.

Class investigations 1 and 2 pp. 40–42

- **scientific question(s)** from which a prediction can be made
- **investigate/investigation** – rather than switching between this and 'experiment'
- **variables** – gradually introducing 'independent' and 'dependent' with more fluent/older students
- **controlled variables** should be encouraged rather than 'fair test' so that older students consider *why* the test is not fair rather than just stating that it is not
- **results** – talk about 'drawing a table' and, with more fluent/older students, 'tabulate'
- **pattern** – talk about 'looking for patterns' and 'anomalies' or 'anomalous result(s)' as those not fitting the anticipated pattern
- **conclusion(s)** – refer to 'drawing conclusions' as this is often misunderstood when translated literally
- **evaluation** – this can refer to improvements in the investigation itself or to the degree of trust students have in their results.

USING SCIENTIFIC TERMINOLOGY

Teacher talk
p. 23

Students will already have a basic scientific vocabulary and will be increasingly confident in using scientific terms precisely. It is important to keep reinforcing the use of precise terms (for example, 'breathing' distinguished from 'respiration') as the use of correct terminology can be crucial to scoring marks in written assessments in science.

Teaching approaches for introducing and reinforcing new terminology

- Students could keep a vocabulary list in their exercise books or in a notebook so that they can actively learn/practise saying and writing these key terms. This could be organised by topic and will be particularly useful in topics where a lot of new vocabulary will be introduced. Students may wish to keep the word and its definition spaced sufficiently far apart on the page so that they can cover the words when revising.
- Introduce groups or pairs of words together so that students can see which are nouns, verbs or adjectives, etc. as in a language class. This gives more fluency to their longer answers.
- The preparation of vocabulary groupings in the form of lists could be done in groups as a revision activity in preparation for an end-of-year test. Each group prepares a vocabulary list for a particular topic then groups exchange lists to see if anything has been missed before these are shared with the whole class.
- Students who are less fluent in English may find that making annotated drawings for some of the vocabulary may assist in contextualising it, for example, vocabulary associated with dissolving or with filtration.

Example of a vocabulary list for Year 7 chemistry

The following table gives exemplar vocabulary groupings for Year 7 chemistry. It is not exhaustive as students may wish to add adjectives associated with describing properties of metals, for example. Guide students in making similar lists, revision cards or mind maps, but bear in mind that to learn them effectively, the student needs to have some ownership of how they are presented; some may wish to colour code it, for example. They may even find it useful at iLowerSecondary level to use black pen for words they already know (as a reminder to include them in revision) and a colour for words that they are less familiar with.

Year 7 chemistry key vocabulary groups	
particle diffusion element atom molecule compound mixture	dissolve, dissolves, dissolving, solution solvent solute saturated solution suspension colloid
solid, liquid, gas (change of) state	melts, melting freezes, freezing evaporates, evaporating, evaporates, evaporating basin condenses, condensation
filtration, filtrate filter funnel, filter paper distillation (paper) chromatography, chromatogram	reactants, reaction products combustion thermal decomposition
acid, acidic base alkali, alkaline neutralise, neutralisation salt indicator	Periodic Table group period

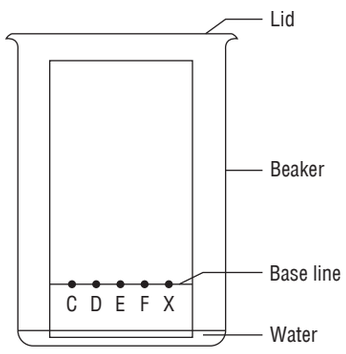
APPARATUS DIAGRAMS

Teacher demonstration p. 26

At Lower Secondary level, the term 'apparatus' is usually used for glassware and associated items such as bungs, and 'equipment' is used for bulkier items such as electric water baths and oscilloscopes. However, students will often meet these terms interchangeably. The availability of these items for science will inevitably vary from centre to centre. Computer simulations and video clips could be used to show items not readily to hand and to demonstrate the reading of liquid levels (detailed later in this section).

Enabling students to draw accurate apparatus diagrams

By Lower Secondary stage, students should be familiar with the basic conventions of drawing scientific apparatus diagrams. However, it will be beneficial for students if you revisit the basic conventions before introducing more.



- Draw and label in pencil, using a ruler for label lines. Each label line should just touch the structure it is labelling but an arrow is not needed.
- Avoid crossing label lines and write the words at the end of the line, not on it.
- Shading or colouring is not needed.

Examples of science apparatus drawings

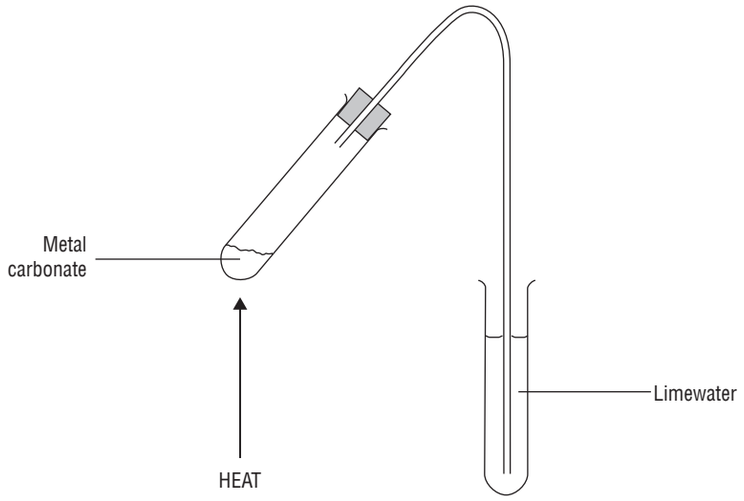
Here are some examples of how students could be shown 2D versions of more complex apparatus.

1. Bungs, delivery tubes and Bunsen burners

This is an examination paper drawing; it is not necessary to shade the bung, but watch for gaps between the sides of the bung and the boiling tube.

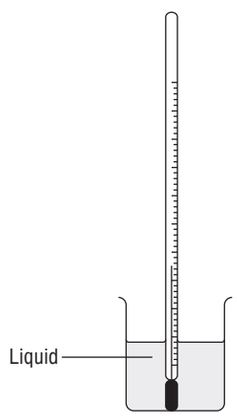
Also look out for drawings that show the delivery tube blocked at either end, rather than open, as shown here.

Explain to students that it is not necessary to draw a Bunsen burner; an arrow labelled 'heat' will suffice.



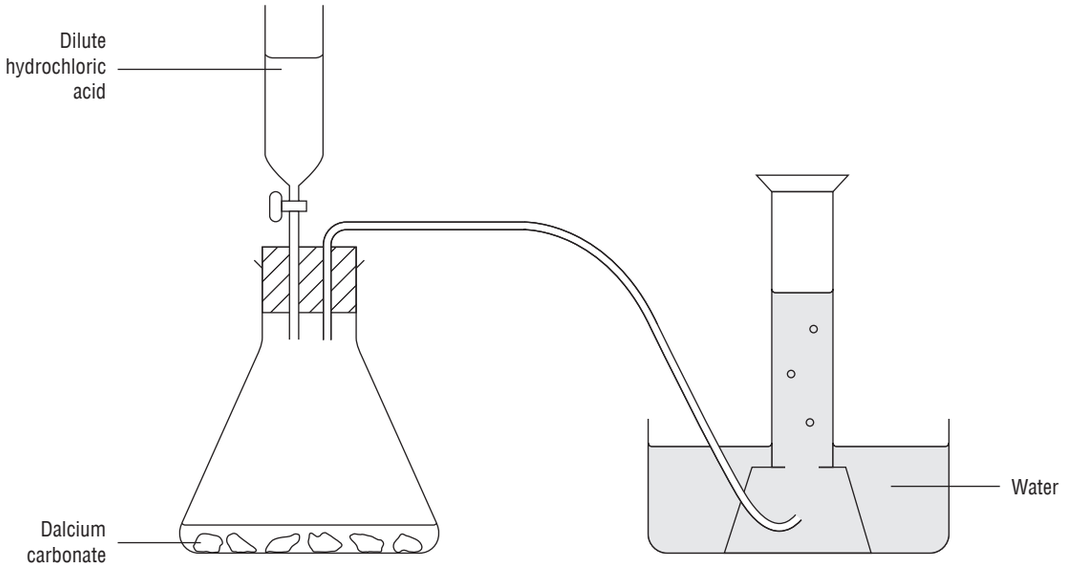
2. Accurate liquid levels

The concept of a meniscus is unlikely to have been introduced until Lower Secondary level. Students will now start to see this type of diagram in tests and examinations. If you explain to them in simple terms why a meniscus is formed they are more likely to be able to draw liquid levels accurately.



Explain that the meniscus is the curve in the upper surface of a liquid and ideally show students an enlarged on-screen photo of what you mean. Explain that it is shown in a diagram where the upper surface of the liquid is in contact with the container (in this case, the sides of the beaker), or another object (in this case, the thermometer).

You could use a more complex examination diagram as a teaching resource (hence shading for clarity only), such as the following diagram, to demonstrate good drawing techniques. It combines all the principles detailed in this section.



HEALTH AND SAFETY

Individual institutions worldwide will have their own health and safety policies that must be adhered to. Research has shown that students engage more when they participate in thinking about and discussing safety in real contexts, rather than just being told what to do. Students tend to respond well to positive rules, especially if they understand the reasons why the rule is in place.

Clearly overall responsibility for safety still remains with the teacher, but discussing it with students will help them to develop as scientists and set in place good habits for later work.

Teaching approaches for helping students understand how to work safely

It is essential to revisit safe working practices regularly, both as they arise and as a start-of-term refresher. If the safety briefing is delivered in exactly the same way each term, then students, like some airline passengers before take-off, may think they have 'heard it all before'.

Try a variety of ways, such as:

- a quick quiz recognising hazard symbols
- a short group activity in which each group writes some safety rules on a large sheet of paper then exchanges with other groups
- a similar activity to the group task above but each group just writes a list of hazards and then exchanges with another group to write risks for their hazard list; a third exchange is used to add control measures
- a teacher-led activity in which the teacher shows a series of objects or images, for example, a bottle of acid, an electric fan, a scalpel, hot water, bacterial culture, etc., and students identify the hazard(s), risks and control measures
- if appropriate, set a homework task to design a safety poster, computer presentation or video clip (many students at this age are keen to show their developing design and ICT skills and this provides an opportunity for those who are less fluent in English to showcase other talents).

Tips to encourage safe working

In the classroom or laboratory, students are likely to adhere to rules as a result of the teacher's authority. The same may apply at home. However, teaching students the basic principles of assessing risk allows them to transfer this awareness to everyday life as they grow up.

Students could be taught how to assess risk in the science classroom by explaining to them that there are four key factors to consider.

1. What are the hazards?

Enabling independent learning p. 19

For example: using acids, using electrical equipment, liquids spilt on the floor.

2. What is the potential consequence of each hazard?

For example: blistered skin, burns, electrocution, broken limb, death.

3. What is the risk of this injury happening *today in this room*?

For example: Very likely or not very likely?

The emphasis on 'today in this room' is to convey the idea that in another room on a hotter/colder/wetter day, or when the room is more/less crowded, the risk needs to be re-evaluated accordingly. Ask students to consider why. For example, the floor may be more slippery on a wet day or fans may be in use on a hot day. The risks for a teacher alone differ from the risks for a class of 30 students, such as spillages and trip hazards.

4. What control measures could be put in place to reduce the risk of injury?

For example: wear gloves, wear safety glasses, clear up spills.

Ask students to consider the implications of an unsafe working practice, for example, not wearing safety glasses. Encourage students to build up their own set of safety rules in pairs or small groups and share their ideas with the rest of the class. This is more likely to engender a feeling of collective responsibility for the safety of themselves and their peers.

Engaging everyone p. 15

As stated earlier, the teacher has overall responsibility for student safety so group-generated rules should always be checked for errors or omissions.

Watch out for…

- Students stating ‘wear glasses’; they should refer to them as ‘safety glasses’ or ‘goggles’.
- Students making a very common mis-spelling of the latter as ‘googles’.

Something for you to try – hazard symbols

Ensure that students are familiar with the more common hazard symbols/warning signs. Shown here are some common hazard symbols, although these are just examples as Lower Secondary students would not necessarily encounter all of these. From the top row, left to right: flammable/oxidising/toxic; corrosive/explosive/moderate hazard or irritant; hazardous to the environment/serious or longer term health hazard/gas under pressure.

Using ICT (or pre-printed symbols if writing), ask students to construct their own table of:

- hazard symbols
- examples of where they might be seen
- control measures.

As it is essential that you check every student has recorded the examples and control measures correctly, it may be necessary to present this as a matching task using information you have constructed for each symbol. Students with more limited English-language skills can then match the examples and control measures to a symbol.

DEMONSTRATING PRACTICAL WORK

Engaging everyone p. 15

Practical activities are an important part of any science curriculum. Practical activities enhance students' understanding of scientific enquiry as well as delivering parts of the curriculum in an engaging hands-on way that helps to reinforce theory work.

Sometimes it is necessary for the teacher to demonstrate a particular practical task. This might be for reasons of:

- health and safety
- limited availability of essential apparatus or space
- difficulty of the task, for example, the degree of manual dexterity required is beyond that of the students.

Teaching approaches for involving students in a teacher demonstration

- In some instances, the above limitations may be insurmountable. However, it is often possible to modify the practical task to reduce risk and/or to use less-sophisticated apparatus or procedures, which would then allow the students to carry out all or part of the practical task themselves. Where this is possible, teachers are encouraged to do so.
- Alternatively, to add variety, there are many videos showing investigations that could be shown to students and then discussed. Software package are also available allowing students or the teacher to run a simulation with values decided by the students.
- If teacher demonstration is the only route on a particular occasion, it is often possible to actively involve students in making and recording observations, taking measurements or suggesting improvements. This would be an opportunity for students to practise:

Class investigations 1 and 2 pp. 40–42

  - refining the scientific question that has led to the practical task
  - identifying independent, dependent and controlled variables
  - making a prediction about what may happen based on scientific theory
  - drawing a results table, including deciding on column headings and units
  - taking turns to assist the teacher with making a reading or measurement
  - recording data as it is collected and looking for a pattern
  - identifying anomalous results
  - making suggestions about how the procedure or apparatus could be improved.

The benefits of students actively participating in teacher demonstrations

By watching teacher demonstrations of safe solution handling and use of apparatus, students' own performance in practical work will benefit. It will also enhance performance in written tests as students will pick up the language of experimental procedures. World ranking tests in science already have interactive components where students are required to select values to input and/or collect data from simulations. Watching the systematic approach demonstrated by the teacher should assist in performance here too.

SCIENTIFIC LITERACY

Effective questioning p. 21
Developing thinking skills p. 27

International discussion of science education has increasingly become focused on 'scientific literacy'. This can be defined in many ways, but fundamentally, a scientifically literate student is one who can understand and help make decisions about the natural world and human activity within it by:

- using scientific knowledge to identify questions that can be answered by scientific investigation
- drawing conclusions based on valid *evidence.*

The benefits of students becoming scientifically literate

Scientific literacy is a set of transferrable skills. By becoming scientifically literate, students can take skills, such as the ability to put an argument together that is supported by evidence, into new situations in the classroom and outside. Scientifically literate students can speak and write with confidence *about* science, rather than recite learned facts.

It is because of this benefit to the students' whole education that most science courses contain a section where scientific literacy skills are developed. In the case of iLowerSecondary this is the 'Enquiry' section of the course content.

Although documented separately for clarity, such sections of a science course are not intended to be taught separately from the biology, chemistry and physics content. Most of the factual content can be taught effectively using many of the approaches documented in the **Principles for progress** section, for example, by effective questioning and by developing thinking skills.

Principles for progress p. 14

Something for you to try

Consider how you might incorporate an aspect of the science enquiry section into every lesson. You may wish to discuss this with colleagues. Developing science enquiry skills, and thus scientific literacy, does not always need to be done with practical work. It could be:

- in a short teacher-led question-and-answer session with the class at the start or end of the lesson, using some open questioning
- as part of a teacher demonstration with student input
- as part of structured pair-talk or group work where students have a problem for which they must think of scientific questions that could be tested (by themselves or by professional scientists) and, in particular, what evidence they would look for
- as part of a class discussion centred on a claim made in an advertisement or news headline.

  For example: Give students time to think about whether there is sufficient evidence to support the claim. If insufficient information is provided, then ask them to consider what else they would need to know to decide if it is a valid claim. How many people were studied? Was the sample size large enough? Were the individuals chosen representative of the whole population? What was measured or counted and how? Were there any repeats by other scientists in other countries? Was there a control experiment or a control group? Is it a reputable source? etc.

CLASS INVESTIGATIONS 1: ORGANISING

Engaging everyone p. 15
Collaborative activities p. 24

Class practical work is much more than the teacher giving instructions, the students following those instructions and then the teacher telling them what they should have learned from it.

The benefits of class investigations

In addition to improving scientific literacy and reinforcing theory work, investigative work provides several benefits to students:

- developing their language skills: students may be more willing to try out scientific terms when talking to their peers in pairs or small groups than in front of the whole class
- improving manual dexterity and organisation: at iLowerSecondary level, students will use apparatus that could topple over or become very hot. They will carry out investigations where they need to coordinate timing and observing, perhaps with one or more other students
- increasing their self-confidence and independence: moving round the classroom to collect apparatus or to compare results with others will enable less-confident students to participate more fully in the lesson.

Tips to facilitate class investigations

- Set out as much of the essential apparatus as possible before the class enters the room – put it in different places around the room to avoid crowding at the start.
- Ensure liquids that have been decanted from a stock solution are in labelled flasks – do not try to do all this when the students are in the room.
- Set up items that need extra time, such as thermostatically controlled water baths that need time to heat up, as early as possible. Ensure data-logging equipment, for example, is working so you do not need to be distracted by this during the lesson.
- Establish a routine for the placement of bags, jackets or other items the students bring to class, so that when they rise from their seats to start the practical work they do not have to clear these items away before starting the task.
- Plan pairing/groups beforehand and tell students who they will be working with, rather than letting them choose – this avoids less able or less fluent students always being paired together and reduces demand for teacher assistance.
- Aim to have an active task (for example, questions, planning, discussing, constructing a results table) for students to carry out as an introduction to the practical; they then have to actively engage with thinking about what they are going to do rather than passively following a set of instructions.
- With larger classes, consider having only half the class doing the investigation and the other half doing a task requiring little teacher input.
- If the investigation requires several stages, for example, collecting apparatus, measuring out liquids, timing, recording, etc., then assign tasks to each student in a pairing/group so that everyone has an active involvement – this can be done quickly by assigning students letters such as A, B and C. Next designate tasks, for example, A collects the apparatus and records the results, B measures out the liquids and takes the readings and C makes a results table and monitors the stopwatch. Everyone has something to do at the start and something to do during the investigation; roles can be changed next time.
- Include in your planning any time that may be needed to show or remind students how to use apparatus or other equipment; this helps to avoid the practical overrunning. Check with colleagues whether you will be the first to use a particular item with this class and plan accordingly.

- Give students a clear warning when they only have a certain time left; this will encourage slower students to speed up.

- Establish a routine for clearing up – again, the A, B, C format could be used to assign tasks. Ensure that it is clear where the students should return apparatus, especially if they are to separate used and clean beakers, for example. Using labelled signs will help to reinforce how to spell the name of each piece of apparatus.

Enabling students to select apparatus

- While it is impractical to have a wide variety of types of glassware available, it is beneficial for students to have to give some thought to the most appropriate piece of apparatus for a given task, particularly for measuring volumes of liquids.

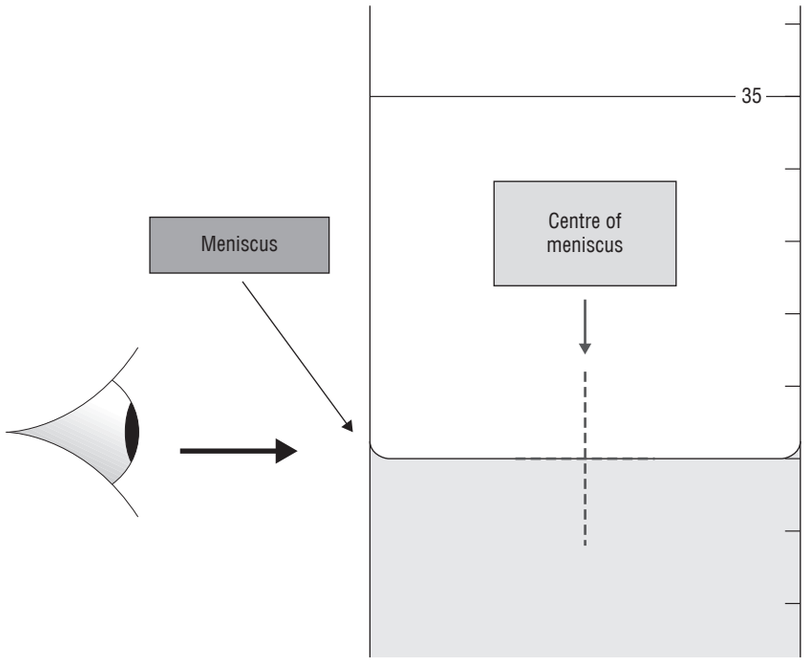
- By iLowerSecondary stage students should be aware that the marks on the sides of beakers are for rough guidance only rather than accurate measuring. Their starting point for measuring out a volume of liquid should be a measuring cylinder, which has 'graduations' (introduce this term), that are appropriate for the task and will be observed at eye level. However, for many tasks, particularly in chemistry, a pipette or a burette will be used instead. Syringes may also be used.

- Create opportunities for students to have to make decisions, even if it is just between two sizes of measuring cylinder.

Watch out for…

- Students using the term 'measuring beaker' as a hybrid between the correct terms 'measuring cylinder' and 'beaker'.

- Students who are not familiar with how to read the measuring cylinder/pipette that they have selected. Some may need help with understanding the graduations. They will all need to be taught how to read the centre of the meniscus, at eye level. The following diagram shows a concave meniscus being read at eye level.



CLASS INVESTIGATIONS 2: VARIABLES

Teacher talk p. 23

Although many students will be able to identify the independent variable and the dependent variable in an investigation, a surprising number of students will not. Many continue to GCSE level without being able to do this consistently well. It is therefore very important to continue to reinforce this and to develop students' understanding.

Teaching approaches for distinguishing between independent and dependent variables

- When using both terms, always use them in the order given in the heading above. This continually signals to the student that the independent variable is the one that should be considered *first*.
- Define the independent variable as 'the factor we are *changing or deciding'.* This could be the different masses of fertiliser we give to groups of plants or it could be the different times we have decided to take a measurement of something, for example, after 1 minute, 2 minutes, 3 minutes, etc.
- Describe the dependent variable in two ways: it is 'the factor that *depends on* what we changed or decided' and 'it is what we observe or count or measure'. Following from the examples in the previous bullet, this could be how tall the plants have grown *as a result of the different masses of fertiliser we chose* or the temperature of a cooling liquid *at each of the time intervals we decided upon*.
- Ask students to identify the independent and dependent variable each time they do an investigation. This will also help them to understand the current task more fully and also to become more adept at identifying independent and dependent variables in unfamiliar investigations on test and examination papers.

Enabling students to understand the idea of controlled variables

- Try to ensure that students are secure in their understanding that *one* factor is changed and another *one* is measured. The idea of keeping everything else constant then follows much more logically, that is, all other variables should be controlled as far as possible.
- More able students could also be questioned to test their understanding that there are some variables that cannot be easily controlled, such as the oxygen or carbon dioxide concentration of the room in which they are working. They might suggest ideas such as conducting all their tests simultaneously in the *same* room, which would reduce the impact of this on their results.

Concluding and evaluating p. 47

- Controlling room temperature fluctuations will be particularly difficult in some centres, but this can be a good teaching point to introduce the idea that a variable such as this, which cannot be *controlled*, should be *monitored*. Monitoring and recording room temperature during an investigation, particularly one involving biological systems, enables students to have additional information when trying to account for any anomalous results.

Watch out for…

- Many students will still refer to a 'fair test', thus writing 'it wasn't a fair test' as a default examination answer. By this level such an answer is seldom, if ever, sufficient to gain credit. Therefore, challenge students who use this phrase to give a more specific description of *which variables* may not have been controlled.

RECORDING, PROCESSING AND ANALYSING RESULTS

To prevent students recording results in a haphazard fashion, encourage them to make a proper results table even if they are recording in rough notes first.

Class investigations 2 – variables p. 42

Tips to help students construct successful results tables

The distinction between the independent and the dependent variable, discussed earlier in the guide, is a fundamental concept that enables students to display and interpret data from investigations with much greater ease.

At Lower Secondary level, students should be able to draw a results table unaided once they have been introduced to the following rules for success.

- When writing column headings, the *independent* variable is always written in the first column of a results table; the column heading for the second column is the *dependent variable*.
- Units are written in the column heading only; they are never repeated down the column.
- If measurements or observations are being taken at timed intervals then the times chosen are written in ascending order down the column.

Something for you to try

The following table shows part of a results table used for an investigation where the temperature of a beaker of liquid is being measured every minute. The investigation is carried out three times.

Independent variable with unit

Dependent variable with unit

Units not repeated in any other rows

Time in minutes	Temperature in °C			
	Trial 1	Trial 2	Trial 3	Mean average
0	60	60	60	60
1	56	55	57	56
2	52	51	51	51.3
3	49	47	50	48.7
4	**51**	46	48	??
5	47	45	47	46.3
6	etc.			

By completing the table as they obtain the results, students would be able to see, even before they write it down, that in this example the result for the time interval of 4 minutes (shown in bold) seems to be unusual; it is *anomalous*, that is, it does not fit the pattern of decrease.

When students look at a set of three results, they should decide if the three values are similar, that is, are they *concordant*? If the three results are concordant, then the mean average they calculate will be more *reliable* than if the values had differed a lot or if they had only done one trial. In other words, they can trust their results more, and trust the calculated mean average more, when their results are *repeatable*, that is, they give similar values each time.

Using this or similar data, ask the students the following.

- **What *evidence* do they have that the first result at 4 minutes is an anomaly?**

  Possible answers:

  - it is higher than the result for this beaker at 3 minutes, and
  - it is not *concordant* (i.e. does not match) with the other two trial results.

- **What should they do about this anomalous result?**

  Possible answers:

  - here it would be difficult to repeat an individual result, but we could do a 4th trial, or
  - we could exclude the anomalous result from their mean average – what effect would this have on the mean average if the result is or is not included?

- **What could have caused this anomalous result?**

  Possible answers:

  - the liquid was not stirred before recording this temperature, or
  - room temperature fluctuated at this point – this is unlikely, unless it is an extremely hot room, but exemplifies the need to monitor uncontrolled variables, or
  - we misread the thermometer.[1]

Examples of how students might process results

Students can often be content to leave their results as raw data. However, the results are likely to be more meaningful if they are processed in some way.

This could be done by calculating:

- a mean average (as in the example above)
- a rate of reaction or rate of change
- a percentage change.

[1] If this was the case then should we assume that this is an isolated random error or a *systematic* error, that is, an error that affects all the results?

TEACHING ABOUT GRAPHS

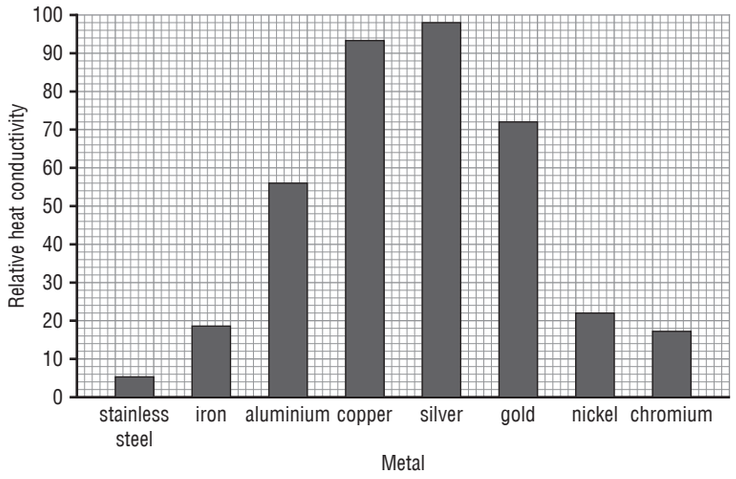
While the terms 'bar chart' and 'bar graph' are used somewhat interchangeably, they are quite distinct from line graphs in terms of the type of data that is being displayed. It is important that students understand this clearly. In the physics and chemistry sections of the course, most graphs that students encounter will be line graphs, but in biology, both bar charts and line graphs are used regularly and students need to know which type to plot.

Enabling students to decide between plotting a bar chart or a line graph

- Tell students that bar charts are used to represent data that is in *categories* (that is, discontinuous data). The height of each bar represents a quantity within each category. This may have been counted or measured.

- In the following example, the x-axis shows the categories, which in this case are metals. The height of each bar represents the relative heat conductivity of each metal in turn. There are no values that are between, for example, silver and gold, or between gold and nickel.

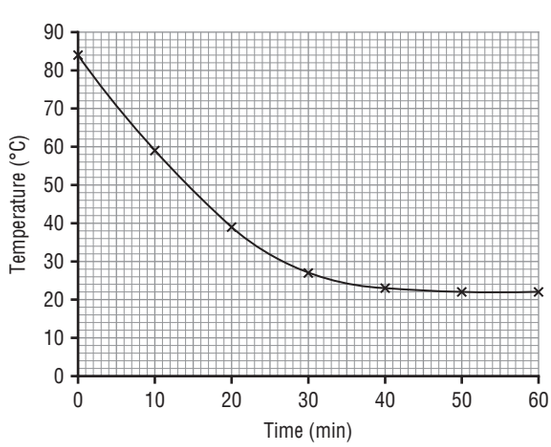
  A graph to show the relative heat conductivity of eight metals:



- Explain to students that line graphs are used to represent *continuous* data (that is, data that is not in categories).

- In the following example, the x-axis represents time. The temperature of a hot drink has been recorded at the start and then every 10 minutes. Each measurement is plotted with a clear, thin-lined cross.

  A graph to show change in temperature of a hot drink in one hour:



Examples of conventions for plotting line graphs in science

Here are some examples of conventions for drawing line graphs that can be shared with students to enhance their progress in this area.

- The values for the independent variable, that is, the one that has been changed by the student during the investigation, are put on the x-axis (horizontal axis).
- The values for the dependent variable, that is, the one that has been measured, are put on the y-axis (vertical axis).
- The numbering on both axes must be in equal steps.
- The units are written in the axis labels either below (x-axis) or to the left-hand side (y-axis) of the graph, not after each number.
- Sometimes a zigzag line is used at the start of an axis between 0 and the first number required, if all the values being plotted are very large.
- The title for the graph follows this type of convention: 'A graph to show the change in [name of dependent variable] with increasing [name of independent variable].'

  For example:
  - 'A graph to show the change in pulse rate with increasing activity.'
  - 'A graph to show the change in pulse rate as activity increases.'
- Points are plotted with a clear, thin-lined cross; in physics and chemistry they are usually joined with a curve or a line of best fit.

Biology p. 49

- Separate guidance is given for joining points in biology in a later section of this guide.

Watch out for…

- Students who, when drawing line graphs, incorrectly extrapolate their line back to (0,0) regardless of what the data shows them.

  Discussing the following example with students should help to clarify their thoughts on this (you may need to draw the axes on a whiteboard):

  - Li Na investigates the effect of temperature on her heart rate.
  - Li Na records her heart rate in a room at 30°C. Then a friend uses the air conditioning to lower the temperature of the room to 28°C, then 26°C, then 24°C and so on, down to 16°C. Li Na records her heart rate at each temperature.
  - Li Na plots the results on a line graph with temperature (numbered 0 to 30°C) on the x-axis and heart rate on the y-axis (numbered 0 to 90 bpm). She joins the points.

Ask students the following question: *If Li Na extrapolates her line back to (0,0) what would the graph now be showing?* Allow students some thinking time.

Answer: It would show that at 0°C (a common winter temperature in many parts of the world), Li Na's heart rate is zero!

CONCLUDING AND EVALUATING

Effective questioning p. 21
Reflection on learning p. 29

While many practical skills, such as dexterity, observation and accurate recording, will develop with practice as students grow older, the ability to reflect on important aspects of their procedure or results is a skill that requires active teaching and guidance in order to develop scientific literacy. In other words, students need to be taught how to reflect, rather than being expected to 'pick it up with experience'.

Enabling students to reflect systematically

1. Writing a conclusion

Students should already be competent in drawing a simple conclusion from their own results, or from data they have been given, by looking for a pattern. At first this pattern statement may take the format:

'when the [x-axis variable name] does [x], the [y-axis variable name] does [y]'.

For example: *As the temperature increases, the number of bubbles produced decreases.*

The basic pattern statement above is unlikely to be adequate for much of the data that students start to work with at Lower Secondary level. Their descriptions will need to become more detailed, but showing them the above format will remind them:

- to refer to **both** variables in their description
- to describe *what happens to the dependent variable* as the independent variable is changed.

An example of a full examination answer is given in the **Assessment in science** section of this guide.

Assessment in science p. 63

2. Evaluating results

Now ask students to reflect on the *quality* of the *evidence* they have to support their conclusion. They should consider this alongside any science content knowledge they already have about what they were expecting to happen.

The following table shows some ways in which effective questioning could be used to guide students' thoughts.

This task is very likely to show differentiation by outcome. Some students will be able to identify more sources of error than others and explain them in greater depth. Collaborative work with mixed-ability groups would help to generate more sophisticated discussion, which could be shared with the whole class afterwards. The challenge of the task increases as you work down the table; it may be better to introduce one or two sections at a time or give each group just one section at a time to discuss.

Differentiation p. 17

Aspect to consider	Questions to ask
Are the results reliable?	• *Were there repeats?* • *How many repeats? Was this enough?* • *Were the results for each repeat 'concordant'?*
Are the results accurate?	• *Was the same measuring technique used each time?* • *Did the same person take all the readings? Why is this important to consider?* • *Were the readings taken at eye level each time?* • *Could there have been an error reading the scale on a measuring instrument? Was it systematic or random? Is there evidence of this in the results?*

(Continued from previous page)

Aspect to consider	Questions to ask
Are there any anomalous results?	• *Does the anomalous result appear to be too high or too low?* • *Why does it not fit the pattern? Is it a problem with the investigation or is it something unusual occurring at that temperature/in that place, etc.?* • *How would you find out the reason for this result not fitting the pattern? Could you repeat that single result?* • *Could you try the investigation again at different temperatures or in different places to see if this anomalous result happens again?*
Could the measuring apparatus have been improved?	• *Would it have been better to use a graduated pipette instead of a measuring cylinder?* • *Would a measuring cylinder, thermometer, ruler, etc., with smaller graduations have been better?*
Did you identify all the variables that needed to be controlled?	• *Was it possible to control variables, for example, temperature of the room? If not, did you monitor this variable?* • *Did the room become warmer or colder? By how much?* • *How could this change have affected the results – would they become higher or lower in value?*

Were enough values of the independent variable chosen?	• *Was the range of values of the independent variable too narrow?*
	• *Should extra values have been obtained:*
	  ❍ *outside the range tested?*
	  ❍ *at smaller intervals within the range used?*

Summary	• *Based on all your thoughts above, how much trust do you have in your results?* • *Do you think the pattern is correct, but the actual values may be a bit inaccurate? Or could the pattern, and therefore your conclusion, actually be somewhat different?*

BIOLOGY

Teacher talk p. 23

Biology poses a great deal of challenge in terms of vocabulary when working in English, both as a first language and as an additional language. It is particularly important not to over-teach beyond the specification without making it very clear to students which is the key vocabulary required and which is additional vocabulary aimed at stretching the most able scientists/linguists.

Biology topics in iLowerSecondary

These lay the foundations for understanding living things. There are four main themes (shown in bold below), the subsections of which are developed across the three years of the course.

- **Structure and function of living things**

  Life processes; Cells and organisation; Movement of molecules; Pathogens.

- **Plants**

  External structure of plants; Transport of water and minerals; Fertilisers; Photosynthesis and crop yield.

- **Humans and animals**

  The musculo-skeletal system; The digestive system; Breathing and respiration; The circulatory system.

- **Organisms and their environment**

  Interactions between living organisms; Interactions with the environment.

One advantage of using this spiral approach, where new material is introduced which builds on earlier work, is that it will help to reinforce vocabulary. Students' linguistic competence will accelerate during this time period and they will more readily assimilate the larger amount of vocabulary needed in Year 9 for the final assessment if it is built on secure foundations.

Watch out for…

1. Terminology with very specific meanings

There are a few terms where a very specific usage should be encouraged from the start. This is far easier for the student in the longer term as they do not have to 'unlearn' incorrect usage later on.

- **'Egestion'/'defaecation' vs. 'excretion':** when studying the digestive system, students will encounter the removal of undigested matter from the large intestine, known as 'egestion'/'defaecation'. Make it very clear to them that this is **not** an example of excretion (which they will have met as a life process). Give them a simple difference: materials that are *excreted* originate *inside* the body's cells, but when faeces leave the digestive system they have not been inside the body tissues, just into the mouth and out of the anus. Clarifying this at an early stage will prevent misuse, and hence no credit, in tests and assessments.

- **'Starvation' vs. 'malnutrition':** distinguish between these terms as *not enough food* (starvation) and *an unbalanced diet, missing one or more essential nutrients such as lack of protein* (malnutrition).

- **'Breathing' vs. 'respiration':** distinguish between these terms as *ventilating the lungs*, that is, air in and out (breathing) and *a chemical reaction inside cells* (respiration).

2. Certain terminology to be avoided

By Lower Secondary level, students may have picked up some generic words that are now inappropriate as more specific terms are needed.

Germs: stop students using this term as it will never score a mark in assessments. Instead, use 'microorganisms' as the general term, or where relevant, be more specific, for example, 'bacteria', 'fungi', etc.

Nutrients: this term is insufficient. Advise students that it should always be qualified with an example, or avoided altogether. 'Plants take up nutrients from the soil' should be replaced by 'Plants take up water and mineral ions, for example, nitrates, from the soil'. Note here that any attempt to use the word 'nitrogen' rather than 'nitrates' should also be corrected; plants do not take up gaseous nitrogen.

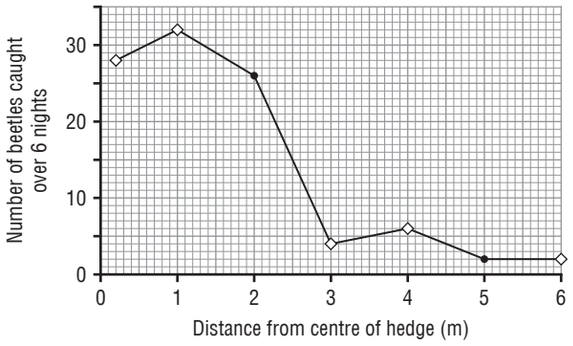
Teaching about graphs p. 45

Enabling students to use line graphs in biology

In addition to the guidance given on plotting line graphs in an earlier section, there is specific additional guidance for students that applies mainly to biology only.

- If you do not know how the values between the plotted points will vary, you should not draw a curve. If intermediate values are uncertain then the points are joined using straight lines, as shown below:

  A graph to show how the number of beetles varies with distance from centre of a hedge.



When discussing this type of graph with students, try to touch upon the following points.

- In this example, we have no idea how many beetles would have been present at 1.5 m from the centre of the hedge – would it have been more than at 1 m, or fewer?

- Based on these data, if we drew a smooth curve, should we exclude the result for 3 m as 'an anomaly'? (It isn't an anomaly as some beetles were there and the number is sufficiently small for us to be almost certain that they were counted accurately.)

- Graphs showing numbers of predators and their prey (predator–prey graphs) are often drawn like this as the populations may only be recorded once each year.

Students should understand that joining points with straight lines is almost exclusively used in biology. One of the reasons is that many more variables remain uncontrolled in biological investigations than those in chemistry and physics. Another reason is that living things do not behave in the more uniform and predictable way that students may have seen in investigations with springs in physics or reactants in chemistry.

CHEMISTRY

iLowerSecondary chemistry topics provide many opportunities for hands-on investigations. Try to use this as an opportunity for students to pose scientific questions relating to everyday life and then to design appropriate investigations wherever possible, particularly in Year 7, where practical work is less specific. Suggestions follow later in this section.

Chemistry topics in iLowerSecondary

These are intended to give students a breadth of experience in chemistry to lay a very secure foundation for GCSEs and beyond.

- **Matter**

  Particle model; Hazards and safety; Pure substances and mixtures; Separating mixtures; Elements, atoms and compounds; Identification of pure substances; Model of an atom.

- **Chemical reactions**

  Chemical reactions introduction; Acids, bases and alkalis; Reactions involving oxygen; More on combustion; Reactions of metals; Formulae and equations; More reactions of acids; Energy changes in reactions; Reactivity series; Rate of reaction.

- **The Periodic Table**

  Periodic Table introduction; Brief history of the Periodic Table; Trends in the Periodic Table; Arrangement of elements; Group 1.

- **Earth and atmosphere**

  Composition of air; Earth's structure; Types of rocks; Oxygen in air; Materials made from substances in the Earth.

Watch out for…

1. Teaching beyond the listed content

Differentiation p. 17

- Some of the iLowerSecondary chemistry topics are already challenging for many Lower Secondary students. They introduce a range of key concepts *in preparation for* GCSE, but it is not the intention that teaching extends beyond what is listed in the learning objectives. Students need to have a clear understanding of this if they undertake extension work, so that their assessment answers remain focused on the printed course content for iLowerSecondary.

2. …and how to overcome this

- Many international centres have very high-calibre students who will have been enthused by the practical work on chemical reactions, as well as their newfound understanding of symbols, formulae and equations. To ensure that the needs of such students are balanced with the needs of less able students, the iLowerSecondary course provides many opportunities for the former to widen the *breadth* of their knowledge of a topic, for example, by conducting independent research on the extraction of different metals in Year 9.

- Setting more able students such extension tasks and giving them an opportunity to present their findings to the class, for example, enables the students concerned not only to broaden their chemistry knowledge, but also to start to develop vital 'soft skills' essential for interview success, for example, speaking concisely and with clarity or answering unseen questions from their peers.

Something for you to try

As indicated at the beginning of this section, chemistry topics give many opportunities for students to explore phenomena in the world around them. They also give opportunities for students to develop practical skills. To focus on this, you could try some or all of the following with Year 7 students.

- **Health and safety:** The science classroom can pose dangers, but so can the home or places outdoors. Rather than starting with the science classroom and the dangers of boiling liquids, Bunsen burners, etc., which some students may be meeting for the first time in Year 7, begin with students' own experiences and the hazards and risks they are already familiar with. They will have done or seen cooking done at home, so ask them how they have seen others handle a very hot baking dish, or a kettle of boiling water, or whether they have seen adults dry their hands before plugging in an appliance.

  Discussing the above first, however briefly, brings the concept of dangers in science into context. It helps the over-confident student see that these risks are real and are taken seriously everywhere else and it enables the concerned students to see the risks in perspective rather than be anxious every time a Bunsen burner is used.

- **Separating mixtures:** When introducing separating techniques, use examples of everyday materials to separate, for example, salty water or muddy water with gravel in it. For paper chromatography, try using the coloured dye coating the surface of sweets and chocolates[2] of various colours. Students can find out what mixture of dyes is used to produce each colour and try to link this to information on the packet.

- **Indicators:** Students can be given the opportunity to test everyday household items with indicators, for example, vinegar, lemon juice or toothpaste. This is best done in the classroom rather than at home, where students may test unsuitable products unsupervised.

  As a follow-on from the above, again to keep practical work investigative, but starting in the students' framework of everyday experience, let them use fruit and vegetables to make their own indicators, for example, berries, red cabbage or beetroot. They can use these to retest the household items or they could name/'brand' their own blend indicator and produce a colour chart for it using solutions you provide.

Enabling students to make short, effective comparisons

Teacher talk p. 23

Even at this level, continue to insist on students giving clear comparisons when they write about their findings.

- *Rock 1 is harder than rock 2.*
- *Element Z is the most reactive. Element Y is more reactive than element X.*
- *Element W is the least reactive.*

Watch out for…

- Once they reach Lower Secondary level, students are very keen to start recording familiar compounds using symbols, often before you have started to teach this.

  Aim to correct any errors arising from students' early use of compounds immediately as they very quickly become a habit. For example: 'CO2' or 'CO^2' should both be corrected to 'CO_2' before the student starts incorrectly writing 'H2O' or 'H^2O', etc.

[2] In addition to other health and safety measures, ensure pupils do not eat/lick the sweets and check student allergies in advance.

PHYSICS

The iLowerSecondary physics section of the curriculum also provides many opportunities for students to gain an understanding of scientific phenomena in the world around them. They may have observed the *effects* of static electricity from quite an early age but now you, the teacher, have an opportunity to take those observations into the discussion and to build the theory work upon them.

Physics topics in iLowerSecondary

These set the foundation for GCSE physics and beyond. There are five main themes (shown in bold below), the subsections of which are developed across the three years of the course.

- **Energy**

  Energy from food and fuels; Energy transfer; Conservation of energy; States of matter; Changes in state; More on energy stores and transfers.

- **Electricity**

  Electric current; Circuits; Voltage (potential difference); Resistance; Electricity in the home; More on resistance, current and voltage; Static electricity; Electromagnets.

- **Earth and Space**

  Models of the Solar System; Beyond our Solar System.

- **Forces**

  Different types of force; Pressure; More on pressure; More on types of force; More on gravity; Magnetism; Forces and motion; Turning forces; Stretching forces.

- **Waves**

  Types of waves; Introduction to sound; Sound waves; Sound detection; Light; Reflection of light; Refraction of light.

In some centres the three sciences may be taught separately; in others they may be part of an integrated science scheme. There are several sections of the physics content of the iLowerSecondary course that are strongly linked to either biology (for example, energy from food or light) or chemistry (for example, states of matter or changes in state).

These links can be used to enhance students' understanding of concepts introduced in one subject area and then reinforced in another. It can also provide an opportunity for more able students to be set tasks that explore these links further.

Something for you to try

1. Energy transfers

Students will have met food chains and food webs at an early age in biology. Younger and/or less able students often forget which way round to put the arrows in a food chain, yet seem able to draw them the correct way when writing energy transfers in physics, which they meet when they are older. Therefore, when energy transfers are first introduced in physics, try making the link back to the food chains topic in biology.

2. Energy from food

In Year 7 physics, students may use burning food items, such as crisps, to heat water and record the temperature change. This could be linked to the role of carbohydrate as an energy source in a balanced diet, which is first introduced in Year 2 biology.

Differentiation p. 17

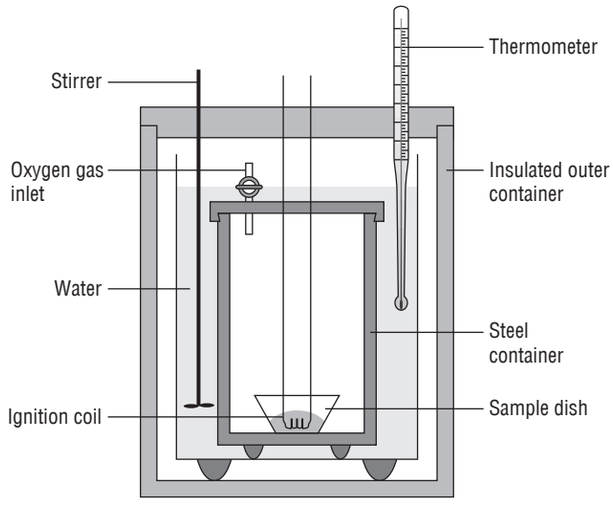
Teacher talk p. 23

3. Extension task for more able students

The following diagram shows a simplified calorimeter. This is a piece of apparatus used to calculate the energy content of a food sample that is placed in the sample dish and burned in pure oxygen.

Use structured questioning to ask students to compare it with the apparatus used for their food burning investigation. For example:

- *What is the advantage of burning in pure oxygen?* (There is a strong link to chemistry here.)
- *Why is the container made of metal? Why is there insulation? Why is the water stirred?*
- *Why will this enclosed system give a more accurate value than burning the food under a test tube of water?*



Enabling students to broaden and extend their knowledge of forces

Some students could be set more open-ended research tasks relating to Winter Olympic sports such as bobsleigh, skiing or curling. Video clips for these sports, for teacher demonstration in class or individual research, can be found at:

https://www.olympic.org/videos

Students could consider how streamlining is achieved in some of the downhill sports. They could also consider why players vigorously sweep the ice during a curling match.

Depending on the locality of individual centres, snow and ice may be less familiar, but Summer Olympic sports, cycling or motor sports have between them a worldwide presence. Together, these sports also offer opportunities to observe and discuss car tyre treads and bicycle wheels, as well as clothing and helmet design.

The benefits of using a range of sports to exemplify forces in action

Engaging everyone p. 15

- For some students, problems arise when trying to learn abstract scientific ideas in a context-free setting, as this often does not engage them nor provide a wide enough range of experiences from which they can construct meaning.
- The advantage of using examples of forces in sport for mainstream and extension activities is that students can develop, or extend, their understanding of mainstream content without learning new additional content.

MONITORING STUDENTS' PROGRESS IN SCIENCE

Explicit teaching about the nature of science in order to develop scientific literacy is integral to any science course. The content of the science syllabus is the method of delivering this. With this in mind, it is vital to monitor students' progression towards scientific literacy in addition to monitoring how much science content they can recall.

Most science curricula are assessed in three distinct ways:

- knowledge and understanding of science content
- application of knowledge and understanding, including analysis and evaluation
- experimental skills, analysis and evaluation of data and methods.

In iLowerSecondary, written assessment tasks may be limited by language, but this will vary considerably between and within centres. Practice assessment tasks should nevertheless have sufficient breadth to touch on all three bulleted points above. This is because, by the time these students reach GCSE science, no more than 50% of marks on the external written assessment papers will test knowledge and understanding of science content.

Checking progress in science

Feedback (in both directions) p. 30

- Formative assessment of practical skills and content knowledge, understanding and application can be incorporated into science lessons. This type of hands-on demonstration of what students have achieved will provide feedback to the teacher on the progress of both the class and individuals.
- For students with limited English-language ability, simple cloze activities such as short sentences with names of apparatus or key vocabulary missing could be used to check on progress, in addition to verbal tasks such as pointing out patterns in data on tables and graphs.
- Practical assessment tasks give particular encouragement to students with more limited English vocabulary; try to give positive feedback wherever possible in these circumstances.

Examples of assessment styles in tests and examinations

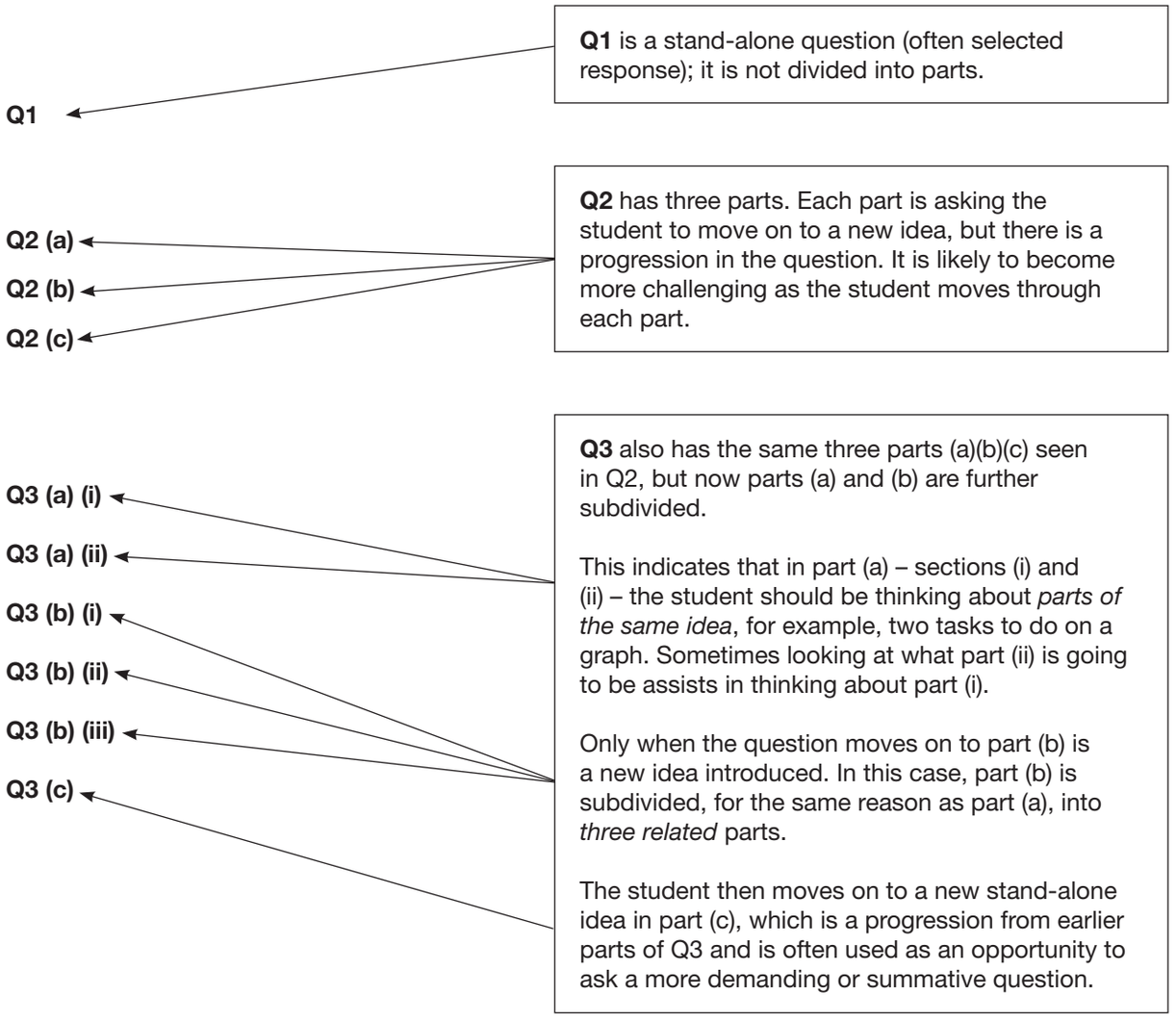
Assessments in iLowerSecondary science regularly use the following question formats.

- **Simple selected response** (often called **multiple-choice**) – one correct answer is selected from statements labelled A, B, C and D.
- **Matching** – students draw a line to match boxes linking, for example, an object and its name or a word and its definition.
- **Sequencing** – students put a series of events or observations in order (for example, parts of the digestive system, a reactivity series) or into a hierarchy (for example, cell/tissue/organ/organism hierarchy).
- **Drawing or annotating** – students might be asked to add an arrow or lines to a diagram or label some structures shown in a diagram.
- **Sentence completion** – students recall words, or select words from those provided, to complete one or more sentences.
- **Short open response** – students provide a single word or short phrase as their answer.

- **Calculation** – students perform a calculation, usually with space to show their working.
- **Writing or completing an equation** – students write or complete a word or symbol equation.
- **Open response** – students typically write two or more sentences as their answer.

Example of question numbering in a hypothetical examination paper

Explain to students in advance of their assessment how looking at the question numbering can help with thinking about their answers using the following example. The first three questions of a hypothetical examination paper are numbered as follows.



iLowerSecondary assessment

Through the iLowerSecondary curriculum, and your teaching strategies and learning activities, your students will further develop the ability to do well in tests. They will be able to:

- make connections between ideas
- transfer their learning from one context to another
- use the same skill in different contexts.

The iLowerSecondary curriculum is designed to develop learning skills and requires your students to become adaptable students. It encourages students to acquire a 'growth mindset', which helps students to see ability as something they can develop themselves. Students are also encouraged to grow in resilience and perseverance, which helps them in test and examination conditions as they are much less likely to be daunted or give up when a question looks difficult on first reading. They will be well prepared to break down questions into logical parts and to 'have a go' at producing an answer.

FORMATIVE ASSESSMENT

As teachers, we make assessments every day about what students know, understand and can do in every class we teach. When we use this information to identify the next steps in learning for students' and to modify teaching and learning activities, this is formative assessment or 'assessment *for* learning'.

This involves a new kind of dialogue between teachers and students. We know from our own experience that learning is driven by what both teachers *and* students do in the classroom.

Formative assessment (or assessment for learning) asks three key questions:

1. Where is the student going?

Formative assessment involves creating, clarifying and clearly communicating learning targets and the success criteria which indicate these targets have been achieved. Through this process, teachers and students develop a common understanding about the end goal of the learning. Using clear success criteria means that the teacher, the student and even a peer can assess the student work.

2. Where is the student now?

The formative assessment process seeks evidence about what students currently know and can do in relation to the learning target. Teachers gather this evidence through a variety of strategies, including questioning, observations of class discussion and review of ongoing work. The teacher reviews how students are engaging with and participating in the lesson and can adjust their teaching to effectively develop student understanding.

3. How will the student get to where they are going?

Using the information gathered about the student's current achievements and the learning target, teachers and students can make adjustments that support student achievement. Teachers adjust their ongoing teaching and learning activities and students adjust their learning behaviours and actions. The formative assessment process closes the gap between students' current learning and desired outcomes.

The benefits of formative assessment

The benefits of implementing formative assessment approaches in the classroom include:

- clear, 'actionable' feedback helps students to improve future work and achievement
- in 'formative assessment' classrooms, students become better all-round students and may do better in examinations
- where formative assessment is used consistently, students take more responsibility for their own learning and have good learning conversations with teachers.

Examples of formative assessment strategies

Assessment in science p. 63

This *iLowerSecondary Teacher's Guide* is full of ideas that will support you in creating a classroom rich with opportunities for formative assessment. For specific examples, see the pages on **Assessment in science**.

SUMMATIVE ASSESSMENT

Summative assessment identifies what has been learned at a particular point in time for comparison against a standard. This type of assessment can also be described as 'assessment *of* learning'. This is important at Lower Secondary stage to prepare students for external qualifications. It also supports students in their understanding about external standards for real-life situations (for example, tasks in later life that resemble examinations, such as job interviews and selection tasks).

Summative assessment can include:

- tests or tasks that measure what a student can do in relation to a particular task at a particular time, for example, iLowerSecondary progress tests
- formal recognition of a student's progress by the teacher
- the recording of current achievement for the student, the parents and the next teacher(s), for example, through end-of-year iLowerSecondary tests
- national exams or international exams which are externally marked.

The benefits of summative assessment

- It measures what is known at a given point, enabling the teacher to 'take stock' of students' current achievement.
- It provides students with a clear measure against expectations/standards so that they can identify their improvement priorities.
- It can give students the motivation to improve performance against a standard.

The iLowerSecondary summative assessment programme

The iLowerSecondary programme consists of progress tests and end-of-year tests which are linked to the iLowerSecondary curriculum objectives. The iLowerSecondary curriculum has been written to ensure students are prepared for external tests at the end of Lower Secondary, and have a solid foundation to begin their International GCSE learning from Year 10.

This means you can feel confident as you cover the curriculum objectives that you are preparing students for these tests.

1. iLowerSecondary progress tests

iLowerSecondary progress tests are useful ongoing tests that allow both students and teachers to measure progress against the assessment criteria.

This helps the teacher to:

- see where individual students might need extra support
- assess what aspects of the curriculum might need further or deeper coverage for the whole class.

This helps students to:

- gain confidence in areas where they do well
- identify areas where they need to do more work to secure their understanding
- tackle questions in a different way to achieve success.

Each year of mathematics and English contains five half-termly tests. Science progress tests are structured around the topics. All tests directly address the relevant curriculum objectives for that year group. The order of the tests is based around the iLowerSecondary example schemes of work, however, you may choose instead to take any test at a different point in the school year for which it is designed, depending on what order you have taught the curriculum objectives in.

The tests themselves contain a range of questions designed to give students the chance to demonstrate their learning in different ways. Timings for these tests will vary between year groups and advice can be found in the marking guidance that is provided with that year's tests.

Question types may include:

- multiple-choice questions
- short, one-word answers
- short-sentence answers
- finding the right answer from the text
- longer answers involving providing reasons for answers.

2. iLowerSecondary end-of-year tests

The iLowerSecondary end-of-year tests are longer than the progress tests and will take longer to complete. They cover a range of objectives from across that year's teaching. Guidance on timings and advice can be found in that year's marking guidance.

Like in the progress tests, there will be a range of question types. This is to prepare students for the broad range of question types they may experience in externally marked examinations.

Preparing students for summative assessment

1. General tips to prepare students

- Go through an example test so that students know what the actual test papers will look like. You might choose to look at a past year's papers, or a combination of progress tests.
- Practise test conditions in the classroom (silence, rules for asking questions if needed, etc.).
- Teach students techniques for time management when carrying out tests, for example, moving on if an answer is difficult and coming back to it at the end.
- Explain the importance of attempting all questions in the test; there are no penalties for incorrect answers, so they have nothing to lose.
- Model answers for the class and encourage students to share in this process by getting them to model answers to the whole class too.
- Students should be writing in **black** ink for externally marked assessments, not blue ink or pencil. It is advisable to encourage them to plot graphs or join boxes lightly in pencil first. Then check it and go over their final answer in black ink.
- Explain the importance of reading questions carefully.
- Reassure students not to worry when they don't know an answer but to 'have a go'.
- Explain to students that if they change their mind they can cross out their first answer and write the answer they want to be marked clearly.
- Discourage students from writing alternative answers. These cannot gain a mark because the student has had *two* attempts at the answer.
- Explain to students that the space provided for an answer on the test paper gives a clue as to what type of answer is needed. For example, if the space provided is a short line or a box, only a few words are needed. For a space consisting of two or three lines, students should write a longer answer.
- Remind students to read over their answers.

2. Revision techniques

While your regular iLowerSecondary teaching and learning activities will give students the breadth and depth necessary to do well in exams, it is also important for students to understand the purpose and value of revision. Good revision techniques include:

- asking students to prepare revision quizzes for each other
- asking students to 'design a game' for their classmates based on a revision topic and then playing them together
- students giving presentations to the class on revision topics that work for them
- modelling good summary note-taking practice. For example, asking students to explain an idea within a word limit of 100 words or to explain an idea in the time it takes for a lift to go up ten floors (an 'elevator pitch')
- providing students with summary notes.

3. Setting practice tests

The iLowerSecondary progress tests can be used as practice for students throughout the year. These are linked to the iLowerSecondary curriculum objectives and can provide a diagnostic tool for the areas your students will need extra revision in.

When setting practice tests, remember that these should be as close as possible to the 'real' test.

- If possible, use the same room, desk arrangement and seating plan as for the real test.
- Give students all the equipment they can expect to have for the real test. For example, for mathematics this might consist of a ruler graduated in centimetres and millimetres, pen, HB pencil, eraser and tracing paper.
- Do not allow students to have anything other than the specified equipment for the real test, and the face-down question paper, on their desk.
- Set up a clock on the wall that all students can see.
- Give students the same instructions as you will give at the beginning of the real test. For example, tell them:
    - how long they have to do the test, and the end time on the clock
    - to keep the test paper face down until they are told that they may turn it over
    - to put their name and any other required details in the spaces for these on the test paper
    - that they must keep their eyes forward and on their work
    - there is to be no talking or trying to communicate with other students
    - if they have a question, raise their hand, and a teacher will come to them
    - to read each question carefully before they start to answer it
    - to try to answer every question
    - to check answers if they have time at the end.

Begin with practice tests that are shorter than the real test. This will allow students to build up to the length of time they will be required to sit and concentrate for in the real test. For example, if in the real test, students will have one hour and 20 minutes to answer approximately 48 questions, then make the first practice test 20 minutes to answer 12 questions; then 40 minutes to answer 24 questions, and so on.

Encourage students to circle the question numbers for any questions they answered, but were not certain they got correct. This will give you, as their teacher, an insight into where they may be lacking confidence in their understanding, and require some additional support.

4. Reviewing test results

It is important to use summative test results in a formative way. In other words, it is useful to review test results with students to improve their learning and to identify next steps. There are various things to keep in mind.

- When you mark students' practice tests, do not only comment on the correctness of an answer, but also take the opportunity to discuss their reasoning with them.
- Having completed the marking of a student's paper, write a comment at the end that provides feedback on any written working (if applicable), as well as total marks. List any concepts where you feel the student would benefit from extra practice.
- Sometimes, allow students to mark each other's practice test papers. Give students an easy-to-use mark sheet to complete. As well as the question numbers, the concept(s) covered, and the total marks available for each question, it should give students who are marking the opportunity to provide feedback on working, and indicate if further practice on particular concepts is required. For example:

Question number	This tests understanding of	Total marks available	Marks received	Written working shown (if applicable)		Extra practice required?	
				Yes	No	Yes	No

- Having completed the marking, work through each answer to test questions with the whole class, offering explanations and discussing reasoning as you go. Advise students to make a note of any question numbers where they still feel unsure (even if they got it correct). Encourage students to discuss the question with other students, or you, as their teacher.
- Give students time at the end for going through a test to decide on the concepts they need additional practice with. Use this decision to inform the work students do as part of their revision programme.
- Make testing a positive experience! When reviewing test results, try to offer two pieces of praise for every criticism. A returned test paper full of red marks will not encourage students to continue practising.

5. Useful assessment vocabulary

It will help students if you share common assessment vocabulary and outline what responses are most suitable for each. For example:

- **describe** – capture something in as much detail as you can in your own words
- **explain** – show that you can give reasons for something and set out in clear steps how it works
- **analyse** – explain **why** something might be the way it is
- **compare** – set out the similarities and differences of two ideas or objects
- **solve** – find the answer to a problem (often in mathematics)
- **know** – use your existing knowledge about something to explain what it is.

Ensure students read all questions carefully so they are confident they understand *what* a question is actually asking them to do.

Assessment in science

WAYS OF ASSESSING IN SCIENCE (FORMATIVE ASSESSMENT)

Students come to science lessons with a world view in which they may have some significant misconceptions and misunderstandings, for example, about the movement of the Earth or what defines a living thing. Waiting for summative assessment to inform you of such misconceptions may leave no time to intervene; the class may have moved on to a new topic or even a new year group.

Formative assessment in science allows you to monitor the following.

1. Concept development

Formative assessment can diagnose where on the journey to full understanding each student is as teaching progresses and, as a consequence, it can be used to target the focus of subsequent teaching.

For example: Instead of starting a lesson by telling students a definition of a balanced diet, or a list of foods that contain protein, give them a variety of food packages and examples/images of other food items (for example, milk, cheese, fish, etc.) in an appropriate form. Ask students to group them according to what they contribute to a balanced diet. Students can draw on both their own experience and on the nutritional information on food packages to assist with food groups. Use think–pair–share so that individuals first decide on their own answers and then discuss. This could be extended to include the energy value of food. Students could go on to design a balanced diet for a defined person, such as an office worker, a manual labourer, a pregnant woman or an active 15-year-old.

2. Constructing arguments

The more that students are engaged in constructing arguments to explain evidence from an investigation, or to explain why they have categorised materials in a particular way, the more progress they will make in their understanding of science.

For example: In Year 9 biology, students study the structure of viruses and why they are not classified as living things. Instead of telling students about this, give them a simple generalised diagram of a virus and a list of labels. Ask them to conduct research into the following:

- how to label the diagram correctly using the words you have provided (low demand)
- write the function of each part labelled (medium demand)
- describe how a virus reproduces (high demand)
- explain the term ‘obligate parasite’ (higher demand).

In addition to generating differentiation by outcome on the above task, harnessing the differing demands of the components, students could then be challenged individually or in pairs, to justify why viruses should be grouped as living things and reasons why they should not.

Differentiation p. 17

3. Scientific vocabulary

The pace at which students become confident in their use of terminology will vary according to their linguistic, as well as their scientific, skills. To enhance individual learning, task students with making their own vocabulary flashcards with definitions on the back. These could also be used to test one another in preparation for examinations.

4. Progress in practical work

Set up some simple practical tasks through which students can demonstrate their ability to weigh a particular mass of powder or measure out a particular volume of liquid accurately. You could do this with individuals during class practical work using a simple tick sheet or a colour-coded symbol indicating their degree of proficiency.

5. Progress in data-handling skills

Give frequent data-interpretation opportunities, such as interpreting line graphs or tables of data. Start with simple examples and then, with the most able students, progress to examples where they are required to interpret less straightforward scales such as a predator–prey graph with a different y-axis on the left and the right.

PREPARING STUDENTS FOR A WRITTEN SCIENCE TEST (SUMMATIVE ASSESSMENT)

Throughout this section, the term 'test' applies to formal end-of-topic tests, end-of-year tests and the iLowerSecondary examination at the end of Year 9, unless stated otherwise.

The benefits of students understanding how the summative assessment works

At each stage of their school career, students meet new assessment tasks for the first time. Conversely, teachers are seeing similar tasks year on year with different cohorts. From a student viewpoint, *what to expect* can be the most daunting aspect of assessment. Diligent students can set aside time to learn the subject content, but the actual content of an assessment is beyond their control. To alleviate some of their concern, teachers can guide students to learn the ways in which the questions will be asked and the ways in which they should construct their responses, as this understanding is within their control.

Examples of science question styles with guidance for students

- **Simple selected response**

  These questions are likely to be presented as a question followed by four answer choices, labelled A, B, C and D. Usually the choice of answers is listed in alphabetical order. For example:

> Which word best describes what happens to salt when it is added to water?
>
> The salt…
>
> **A** dissolves
>
> **B** evaporates
>
> **C** freezes
>
> **D** melts.

  There is ONE correct answer, which happens to be the first one listed because of the alphabetical layout.

Even if they identify the correct answer A straight away, students should still read through all the other options to check that there is not a better answer further down and also to reassure themselves that they are definitely correct.

If they are confident about an answer, students should not be concerned that they have chosen a particular lettered answer more frequently than others. Examiners do not aim for a pattern of letters so it is by chance that, when listed alphabetically, several answers in a row happen to be letter A, for instance.

- **Matching and sequencing**

  For matching questions, students should work out what all the answers are before joining boxes. This can quickly and easily be done using tiny dots. Put a single dot next to the first pair that go together, then two dots next to each item in the second pairing and so on until everything is matched. This reduces the risk of lots of crossing out causing confusion later. Once everything is matched, students can join the pairs using straight lines.

  Similar advice about crossing out should be given for sequencing tasks or ticking and crossing on a table. If a tick is to be replaced by a cross then the original tick should be **crossed out and replaced**. In the example on the right, one mark per correct row was available.

Feature	Plants	Animals
can move from place to place	✗	✓
can carry out photosynthesis	✓	✓✗
are multicellular	✓	✓
have cells with cell walls	✓	✓✗

An attempt has been made to turn this tick into a cross. This row will not score a mark because the student's answer is ambiguous.

This tick is clearly erased and replaced with a cross. This row will score a mark as it is as clear as those on the rows above and below it.

- **Drawing or annotating**

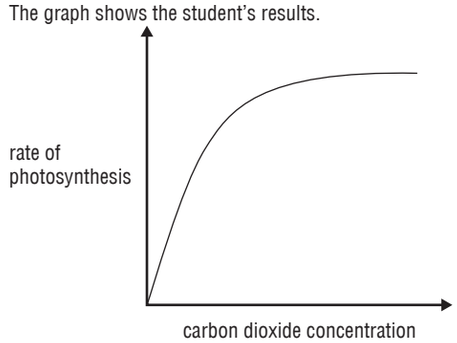
  The frequency with which this type of question is missed is very high; much greater than one would expect from students of this age.

  This example shows a typical situation where some students will not notice that they have to do something for part (a).

  Instead they see the answer space for part (b) and go directly to it to write the equation they have learned and are keen to write down. They have read little or none of the text immediately above it.

A student investigates the effect of carbon dioxide concentration on the rate of photosynthesis in a water plant.

The graph shows the student's results.



(a) Put an X on the graph to show where carbon dioxide limits the rate of photosynthesis. (1)

(b) Write the word equation for photosynthesis. (2)

To avoid this mistake, students should be guided to look at the question number sequence, i.e. a(i), a(ii), b(i), etc., since every one of these will have a question associated with it. Students frequently miss questions that follow straight after introductory information or a table or graph (as in the example above).

As a further check, when they have finished the entire paper, students should be encouraged go back and look at the mark subtotals to check that they have an answer associated with every subtotal.

- **Sentence completion**

  Sometimes words are provided, but this is less usual at Lower Secondary level. If words are provided, students should look carefully to see if there is an instruction saying that words may be used more than once. If they can only be used once, it is a good idea to work out which word goes in which space first. Otherwise the student may reach the final space and not have an appropriate word left. Whether or not words are provided, encourage students to glean additional guidance from the grammatical structure of the sentence.

- **Short open response**

  Short open response questions usually have one to three answer lines and are worth one or two marks.

  The intention is for students to write a brief answer (see bottom image); they should not copy sections of the question stem to pad out their response (see top image). The latter wastes time that could be spent on other questions as well as making their key points less obvious.

  More importantly, in externally marked examinations, a needlessly lengthy answer may exceed the answer space and risk not being seen by the examiner in an electronic clip of the answer marked on screen.

  Students should judge how much to write by the number of marks available. Here the two-mark answer requires two clear statements, one for each mark.

  Note the use of *comparatives* throughout.

The pictures show a drawing pin being pushed into a block of wood and a tractor in a field.

(a) Use your knowledge of pressure to explain the following statements.

(i) The drawing pin **will** go into the wood and **will not** go into the finger. (1)

The drawing pin will go into the wood and not into the finger because there is more pressure. 0

(ii) The tractor has larger rear tyres. (2)

Big tyres on a tractor are better than small tyres because the driver doesn't want to get stuck in some mud and not be able to get the tractor out. 0

Total 0 marks

The pictures show a drawing pin being pushed into a block of wood and a tractor in a field.

(a) Use your knowledge of pressure to explain the following statements.

(i) The drawing pin **will** go into the wood and **will not** go into the finger. (1)

The pressure on the point of the pin is higher ✓ than on the flat top. 1

(ii) The tractor has large rear tyres. (2)

With larger tyres there is less pressure on the ground than with smaller tyres. ✓ With large tyres the tractor does not sink. ✓ 2

Total 3 marks

- **Calculation**

  Usually calculators are allowed in science. However, if the question states 'show your working' then, even if the student uses a calculator, they should write down the calculation they carried out. If the final answer is incorrect, there may be a mark available for the working. Working should not be crossed out as this makes it harder for an examiner to see what was done.

  The final answer that students want marked should be written on the answer line, not just left in the working space. Students should also check whether units are part of the answer line or if they need to write them.

  Questions relating to graphs and tables of data can be included under this subheading as students are seldom asked just to take a reading from a graph or table. They are more likely to be asked to read off two values to compare or to calculate a change. In either case, students should still give *evidence of which values they have used* as part of their working.

- **Open response**

  Extended open response questions are among the most demanding on a question paper. The student requires reasonable competence in English, but also has to judge what to write and what not to write.

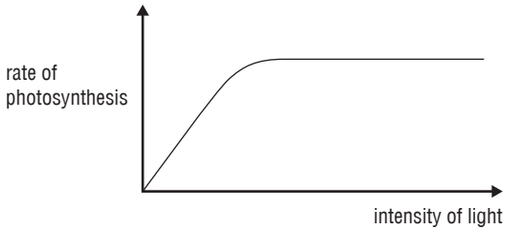
  However fluent their English, all students should be taught to write in *short* statements with no attempt to use subclauses. Those with very limited written English should focus on giving the **scientific terms relevant to the answer**, even if they cannot construct fluent sentences around them.

  The top image shows a fluent answer which gains both marks. The student makes a clear statement about the incline, making reference to both variables. The students then makes a *separate statement* about the plateau.

  The bottom image is also a fluent answer but gains no marks. The answer does not give any clear link between the variables and has not distinguished clearly enough between the two sections of the graph. This students should be encouraged to write more concisely, in shorter *statements*.

  Had axis numbers been shown, the first student should have included a reading from the x-axis to show the light intensity at which the change occurred and the corresponding rate of photosynthesis. If the question was modified in that way, there would be more answer space and probably a third mark.

The graph shows how the rate of photosynthesisis affected by changes in the intensity of light.

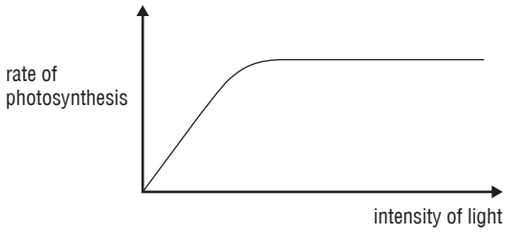


Use the graph to describe the effect of increasing the intensity of light on the rate of photosynthesis.

As light intensity increases, rate of photosynthesis increases ✓ At higher light intensities, rate of photosynthesis stays constant. ✓ (2)

2 marks

The graph shows how the rate of photosynthesisis affected by changes in the intensity of light.



Use the graph to describe the effect of increasing the intensity of light on the rate of photosynthesis.

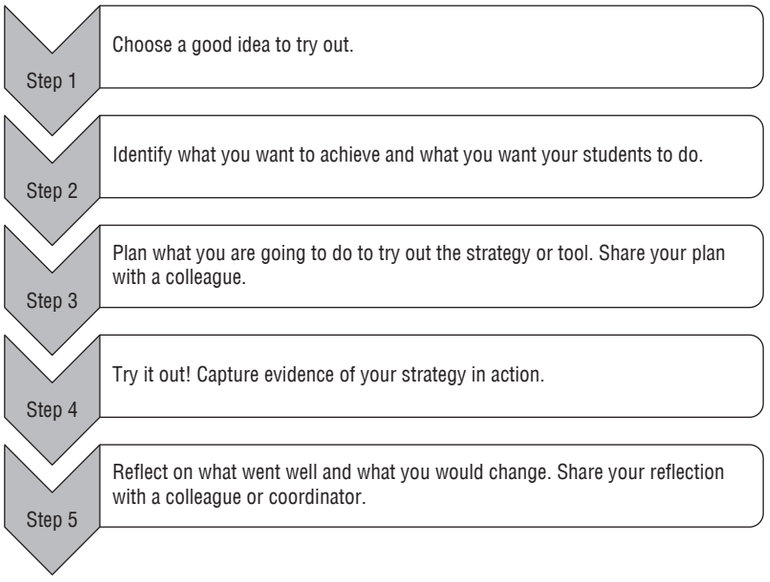
Photosynthesis starts very low and then it gets more and more until it can't go any faster and then it doesn't change very much for a long time. (2)

0 marks

Appendices

APPENDIX A: THE *TRY IT OUT* TEMPLATE

As you try out a strategy or tool of your choice, follow these five steps.



Guidance

Step 1. Choose a good idea to try out

Choose a strategy or tool that you can try out in a lesson or part of a lesson. For example:

> The good idea I shall try is:
>
> *Asking differentiated questions in a class discussion.*

Be as specific as possible. For example, 'use group work' is too broad. Aim for one specific approach, such as:

- supporting students to use various types of manipulatives and tools to solve problems based on their needs
- asking differentiated questions in a class discussion
- working with a small group of students to build needed skills for a new topic
- supporting students to complete differentiated homework assignments
- ensuring students select their own product to create when finishing a unit of study (writing an essay, creating a video, designing a poster, creating a presentation, etc.).

Step 2: Identify what you want to achieve and what you want your students to do

For example:

I have chosen this strategy or tool because:

I have chosen the strategy of using a KWL chart (a chart that asks students to think about what they already Know about a topic; what they Want to learn about the topic and then to reflect on what they have Learned). I have chosen this so that I will get some guidance on what I will need to review or cover in more depth on the topic of plants.

I am hoping to achieve:

I am hoping that my students will come up with some interesting ideas that I did not predict.

I am hoping to gain insight into some things that students want to learn about plants so that I can structure my lessons based on their interests.

I expect my students to:

I expect that my students will reflect on all that they know about plants and bring up ideas and concepts that will make them feel ownership over their learning.

Step 3: Plan what you are going to do to try out the strategy or tool. Share your plan with a colleague

What are you going to do? Be as specific as possible.

Share your plan with a colleague or advisor for their feedback and ideas before you try the plan in your classroom.

For example:

As I try out this strategy or tool, I plan to take the following steps:

I will review the purpose of a KWL chart.

I will then divide students into groups and provide each with a marker and flip chart paper for their KWL chart.

I will give students five minutes to write down everything they know about plants and some things they want to know about plants.

Then I will teach my first lesson on plants. I will then ask students to reflect on the activities and write down some things they learned about plants. I will have students post their charts throughout the room so that they can add to them throughout this unit on plants.

Step 4: Try it out! Capture evidence of your plan in action

Now implement your plan. You may want to get some help from a colleague to capture evidence of your plan in action. Evidence can include:

- a short video
- a storyboard: photos capturing key moments with some text explaining the moments
- an annotated lesson plan
- samples of student work showing impact of the strategy or tool.

For example:

My evidence:

I will annotate my lesson plan to show the impact of the KWL chart and where it enhanced learning.

Step 5: Reflect on what went well and what you would change. Share your reflection with a colleague

Reflect on your practice and add a short commentary relating to your evidence.

For example:

What went well?

I took pictures of each group's KWL flip chart paper. I did not realise just how much my students already knew about plants. Lots of my students were able to share information about what they've learned from having a garden or growing plants at home. It was really interesting to see what my students were interested in.

How might it have been even better?

Since I have these snapshots of data, I am going to change a few of my lessons. Some of them aren't really needed since students already know the information and the others can be adjusted a bit to pull in students' interests. I also like that the students were able to reflect on the lesson and explicitly state what they had learned.

What are my next steps?

As we continue through the unit, I'm going to allow students to add to their charts every day and I might have them add in any ideas for what they want to know that come up during the lessons. This can be an ongoing journal of some sort.

The *Try it out* template

Step 1

The good idea I shall try is:

Step 2

I have chosen this strategy or tool because:

I am hoping to achieve:

I expect my students to:

Step 3

As I try out this strategy or tool, I plan to take the following steps:

Step 4

My evidence:

Step 5

What went well?

How might it have been even better?

What are my next steps?

APPENDIX B: MY iLOWERSECONDARY CHECKLIST

RAG[3]	Statement	Evidence/My next steps	Date
	The learning objectives for the lesson are clear and will be clearly communicated to students.		
	Students are given opportunities to identify success criteria in relation to the lesson's learning objectives.		
	The lesson introduction grabs students' attention and sparks curiosity.		
	Students are given opportunities to connect lesson concepts to their prior learning.		
	Students have several opportunities to reflect on the lesson concepts.		
	Students work with partners or small groups during the lesson.		
	Students are given opportunities to conduct independent, open-ended research.		
	Students will do a considerable amount of the talking during the lesson.		
	Students have opportunities to lead group activities.		
	I have planned several open-ended probing questions that begin with 'Why,' 'How,' and 'When'.		
	I plan to provide enough time after asking a question for students to process and consider their answers using various methods (for example, think–pair–share).		
	I have built in opportunities to provide feedback to students on progress through, for example: whole-class and individual questioning, comments on work, one-to-one conversations, whole-class feedback, through the shared learning log.		
	I have planned how I will transition students from whole-class work to individual or group work.		
	I have planned several opportunities for 'checks for understanding'.		
	Students are given opportunities to self-assess their understanding.		
	Students are allowed to use different methods and materials to reach the learning objectives (as appropriate).		
	I have created opportunities for students to present new knowledge in creative and engaging ways to me and each other.		
	Students are given opportunities to ask questions (including asking questions to other students) about the concepts.		
	Students can freely generate ideas and create examples during the lesson.		

[3] RAG: You can colour code your progress, for example: Red (I need to do much more work on this); Amber (my practice is developing); Green (I am confident and secure in this practice).