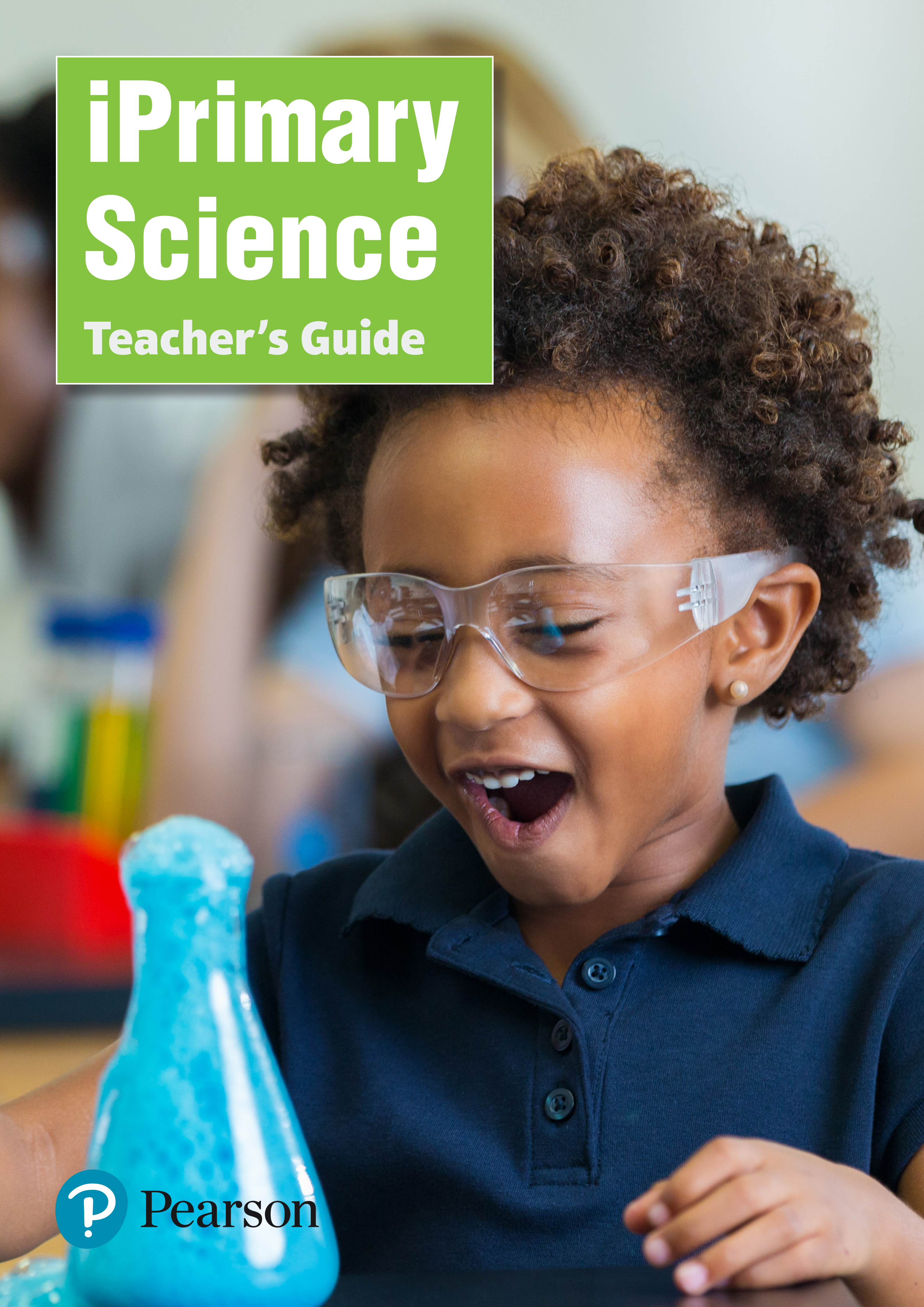
iPrimary Science

Teacher's Guide



Pearson

Published by Pearson Education Limited, 80 Strand, London, WC2R 0RL.

www.pearsonglobalschools.com

Copies of official specifications for all Edexcel qualifications may be found
on the website: https://qualifications.pearson.com

Designed by Pearson Education Limited 2018
Typeset by Pearson CSC
Cover design by Pearson Education Limited
Cover photo/illustration © Getty Images/Steve Debenport

The rights of Clare Buntic, Lesley Butcher, Naomi Norman and Dee Reid to be identified as authors of this work have been asserted by them in accordance with the Copyright, Designs and Patents Act 1988.
First published 2018
21 20 19 18
10 9 8 7 6 5 4 3 2 1

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Early copy for training purposes

Acknowledgements
The publisher would like to thank the authors, Clare Buntic, Lesley Butcher, Naomi Norman and Dee Reid for their invaluable contribution to the creation of these Teacher's Guides.

The authors and publisher would like to thank the following schools, which took part in the pilot programme:
Asia Language and Business Academy, Myanmar
Asian International School, Sri Lanka
Eastern International College, Sri Lanka
Excellent Myanmar, Myanmar
Gateway College, Sri Lanka
Horizon College, Sri Lanka
International Language and Business Centre, Myanmar
Kestrel Manor School, Kenya
Kitengela International School, Kenya
Lakehead Grammar School, Bangladesh
May International School, Myanmar
Myanmar International Academy, Myanmar
Nairobi South School, Kenya
Potterhouse School, Kenya
Ray International Academy, China
Victoria Kindergarten Shenzhen Arcadia Court, China
South Breeze School, Bangladesh
Windsor International School, Myanmar

All other images © Pearson Education

Disclaimer
Neither Pearson, Edexcel nor the authors take responsibility for the safety of any activity. Before doing any practical activity you are legally required to carry out your own risk assessment. In particular, any local rules issued by your employer must be obeyed, regardless of what is recommended in this resource.
Where students are required to write their own risk assessments they must always be checked by the teacher and revised, as necessary, to cover any issues the students may have overlooked. The teacher should always have the final control as to how the practical is conducted.

A note from the Publisher
Pearson examiners have not contributed to any sections in this resource relevant to examination papers for which they have responsibility.

Examiners will not use endorsed resources as a source of material for any assessment set by Pearson. Endorsement of a resource does not mean that the resource is required to achieve this Pearson qualification, nor does it mean that it is the only suitable material available to support the qualification, and any resource lists produced by the awarding body shall include this and other appropriate resources.

Author biographies

Clare Buntic

Clare is an education consultant specialising in teacher professional development, leading curriculum change in schools and enhancing student ability, creativity and independence in learning. She has experience at senior level in higher education specialising in teacher education, several years of secondary school teaching experience and an M.Litt from Oxford University. As Assistant Director of a national UK education research company, Clare developed and delivered national level mentoring and coaching training for school leaders and teachers. She has carried out school improvement consultancy, writing and training internationally, most recently in United Arab Emirates, Kingdom of Saudi Arabia, Qatar, Malaysia, Sri Lanka and Brunei. She has recently been awarded a doctorate for research on nation building education policy.

Lesley Butcher

Lesley is a member of the Chartered Institute of Educational Assessors and has over 30 years' experience in question setting and marking of public examinations, most recently as Chair of Examiners for the legacy PLSC qualification. After completing her Bachelor of Science degree, Lesley obtained a PGCE, followed more recently by a Master's degree specialising in Science Education. She has extensive science teaching experience at both Primary and Secondary level, up to and including A-level Biology, and is a Fellow of the Royal Society of Biology. Past management roles have included Head of Department and Head of Learning Extension at a leading UK independent school. Lesley is currently a freelance educational consultant, specialising in international curriculum and assessment projects, including PISA and TIMSS.

Naomi Norman

Naomi is a qualified mathematics teacher. She has a D.Phil (PhD) in mathematics education from Oxford University, and is a member of their Mathematics Education Research Group. She works as an independent educational researcher, consultant and author, and has more than 20 years of experience consulting and writing for mathematics print, TV and digital products. She has been involved in resource design at every level of mathematics education for clients across the world as well as spending some time as a curriculum consultant in the UK Government's Department of Education.

Dee Reid

Dee has a Master's degree in Children's Literature and was a classroom teacher for many years before becoming a Tutor at the Centre for the Teaching of Reading at Reading University. Dee taught on the Initial Teacher Training course at Oxford Brookes University and then became an independent literacy consultant. In addition to running training courses the length and breadth of the United Kingdom, she has trained teachers in Brazil, Australia, the Lebanon, Dubai and Saudi Arabia. Dee is co-creator of 'Catch Up' – an extremely effective literacy intervention programme used in over 4000 primary schools in England and Wales. She is the author of many very successful educational resources for teachers including 'Rapid Reading' and 'Rapid Writing' (Pearson).

Contents

Welcome to your *iPrimary Teacher's Guide* ***5***

How to use your *iPrimary Teacher's Guide* *6*

Supporting your iPrimary development *6*

Creating an iPrimary classroom environment ***8***

Active learning *8*

Positive behaviour management *9*

Seating arrangements *10*

iPrimary planning ***11***

The iPrimary curriculum objectives *11*

Developing schemes of work *11*

Planning units of work *12*

Principles for progress ***14***

Engaging everyone *15*

Differentiation *17*

Enabling independent learning *19*

Effective questioning *21*

Teacher talk *23*

Collaborative activities *24*

Teacher demonstration *26*

Developing thinking skills *27*

Reflection on learning *29*

Feedback (in both directions) *30*

Teaching in science ***31***

The language of science *31*

Using scientific terminology *32*

Science equipment *33*

Health and safety *35*

Demonstrating practical work *36*

Scientific literacy *37*

Class investigations 1: organising *38*

Class investigations 2: variables *39*

Using practical tasks for formative assessment *40*

Recording results *41*

Processing results *42*

Teaching about bar charts *43*

Teaching about line graphs *45*

Interpreting simple line graphs *46*

Concluding and evaluating *48*

Biology *50*
Chemistry *52*
Physics *54*
Monitoring students' progress in science *56*
iPrimary assessment *57*
Formative assessment *57*
Summative assessment *58*
Assessment in science *63*
Ways of assessing in science (formative assessment) *63*
Preparing students for a written science test (summative assessment) *64*
Appendices *68*
Appendix A: The *Try it out* template *68*
Appendix B: My iPrimary checklist *74*

Welcome to your *iPrimary Teacher's Guide*

Welcome to the Pearson iPrimary teacher community. We hope that you find your *iPrimary Teacher's Guide* a useful resource as you start your iPrimary 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 iPrimary 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 secondary school and beyond.

Learning is supported throughout. The iPrimary 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 *iPRIMARY TEACHER'S GUIDE*

You can use your *iPrimary 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 best ideas that will help you achieve your targets.

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

1. **Welcome to your *iPrimary Teacher's Guide*:** an overview of this guide and the curriculum, including guidance to help you to keep track of your progress as an iPrimary teacher and information on where you can go for further support.
2. **Creating an iPrimary 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. **iPrimary planning:** advice and information on how to plan and adapt effective lessons using the iPrimary 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. **iPrimary assessment:** a general overview of formative and summative assessment in the iPrimary 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 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:

Scientific literacy p. 37 Can link to… Effective questioning p. 21 or to… Developing thinking skills p. 27

SUPPORTING YOUR iPRIMARY DEVELOPMENT

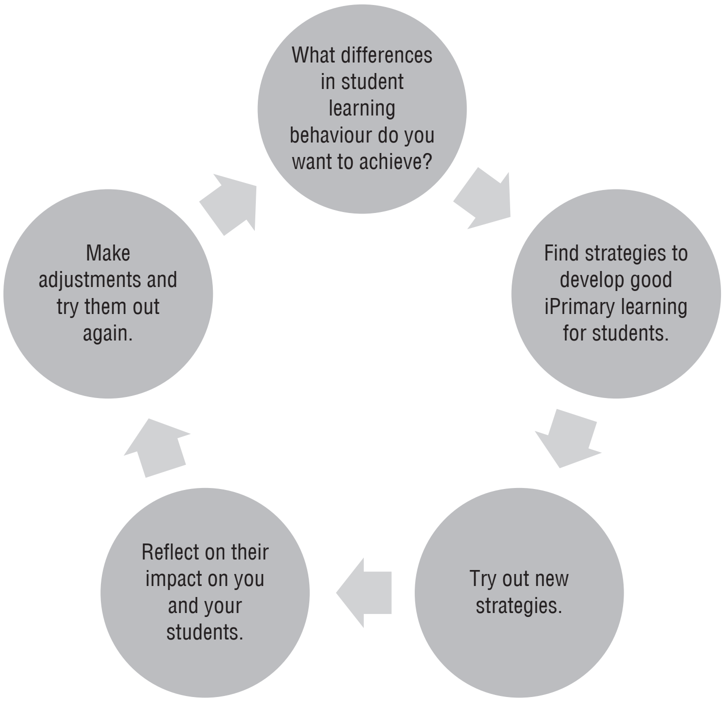
An important part of being an iPrimary teacher is that you demonstrate the habit of developing and assessing your own practice. Focusing on your own development can directly help outcomes in the classroom, which means students learn more effectively and achieve more highly.

When embarking upon your journey as an iPrimary teacher, it is important to remember the following.

- You are not working in isolation; there is a network of support available through your iPrimary colleagues and the iPrimary online community.
- There are clear practical tools and tips within this guide to help you to deliver the curriculum effectively.
- iPrimary 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 iPrimary 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 iPrimary website.
- Information and support from the iPrimary Schools Community can be found on the iPrimary 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 iPrimary classroom environment

The iPrimary 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.

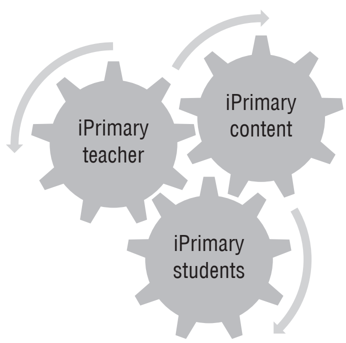
This next section will outline some of the key instructional methods you will have at your disposal in the iPrimary classroom to create an effective learning environment and explain why these are an effective way of engaging learners.

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 iPrimary 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

Collaborative activities p. 24

Developing thinking skills p. 27

POSITIVE BEHAVIOUR MANAGEMENT

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.

The benefits of positive behaviour management

A positive iPrimary 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 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 does not 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 your 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.*

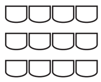
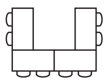
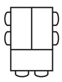
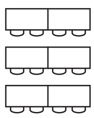
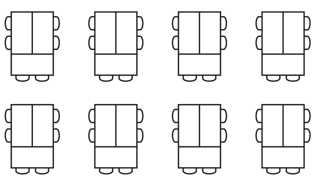
6. Ensure that students are clear on what the goals of a specific piece of work or activity are.
   For example: *YongJae, can you explain what you should be able to do by the end of this task?*
7. Show an interest in students' lives and bring in examples of their interests outside school so that you 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 iPrimary 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 enquiries 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 enable groups to work together as well as whole-class work where everyone needs to see the board.

iPrimary planning

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

iPrimary objectives
(curriculum objectives for Y1–6)

↓

Schemes of work
(your termly plan)

↓

Units of work
(your detailed series of lesson plans)

THE iPRIMARY CURRICULUM OBJECTIVES

You will find topics and curriculum objectives in the curriculum specification. The iPrimary curriculum has been developed together to give your students the breadth and depth of knowledge they will need in order to confidently take external tests and be fully prepared to move on to their Edexcel International GCSE.

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: *Recognise and name plant parts on familiar local examples.* This will be accompanied by examples of what pupils should know or be able to do, for example, *'Names (if applicable): petals, stem, roots, leaves, trunk, branches, twigs, seeds, bulbs, fruit'.*

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 2, Term 1, 'Health and growth' topic of the iPrimary science curriculum contains objectives that have been grouped together because they all relate to that particular topic.

SCIENCE iPrimary Pearson

Year 2 Science Scheme of Work

Teaching week	iPrimary Science objectives	Activities
Year 2 Term 1 Health and growth	**B2.1A** Understand that humans need the correct amounts of water and food to stay alive. **B2.1B** Understand that there are many types of food and humans may have different diets. **B2.1C** Understand what is meant by a balanced diet. **B2.1D** Know the main food groups and be able to categorise food by type. **B2.1E** Understand the need for exercise to stay healthy. **B2.1F** Understand that human and animal offspring need differing types and amounts of parental care while they are growing. **B2.1G** Understand that personal and food hygiene is important to maintain health. **B2.1H** Understand why humans take medicines and recognise hazards associated with taking and storing medicines.	Discuss and understand what humans need to survive and be healthy. Identify and name the main food groups and some foods in them. Explore how exercise keeps us healthy. Be able to show what kinds of care young humans and animals need. Understand how to use food and medicines safely.

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.

SCIENCE iPrimary Pearson

Year 2 Unit: Health and growth Lesson 2

Main Focus	Prior Knowledge	Key Vocabulary	Curriculum Objectives
Name the main food groups and some foods in them	Understand that different animals eat different diets; Understand that some foods are healthy, and some unhealthy	diet, food groups, healthy, unhealthy, treat, energy, categories	**B2.1C** Understand what is meant by a balanced diet **B2.1D** Know the main food groups and be able to categorise food by type

Teaching Summary

Ask the students to discuss what they learned in their last science lesson. Recap and address any misconceptions. Explain that today we will focus on food, which is a basic need for humans and animals. Ask the students to name some **healthy** and some **unhealthy** foods. Tell them that we can sort foods into different **categories**, called '**food groups**'. These are:

- Fruits and vegetables
- Starchy foods
- Meat, fish and eggs
- Sugary and fatty foods
- Milk and dairy foods

Use Which Food group? or write the following words on the board; apple, cheese, chicken, pasta, cabbage, potato, butter, chickpeas. Ask the students to sort each food into the correct food group.

Ask the students if they think that a human's diet should have the same amounts of each food group to stay healthy. Reinforce that our diet should have mostly fruit and vegetables, with good amounts of starchy foods, some meat, fish and eggs and milk and dairy, and small amounts of sugary and fatty foods as a **treat**. We call this a **balanced diet**. Ask what happens if we eat a balanced diet (we are fit, healthy and well; we have lots of energy; we stay a healthy weight). What about an unbalanced diet? (We can become ill; we have low energy; we can become overweight).

Main Activity

Core

Show or draw an image with the above food groups (if you are using an existing image, make sure the terms used are the same as above). Give the students a sheet with a large circle divided into five 'wedges'. Ask them to label each of the wedges around the outside of the circle with each of the food groups. Inside the circle, draw two or three examples of a food in that group and label them.

Support

Give the students words and/or pictures of two or three foods for each group and ask them to sort them into the correct groups.

Extend

Ask the students to add one or two healthy choices, and one less healthy choice in each section.

Plenary

Bring the students back together. What have they put in each food group? Ask the students to 'vote' by putting hands up/showing a thumbs up if they agree with what everyone has said and discuss if necessary.

As an iPrimary teacher you will ensure that you include activities that engage your 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.
- 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 complete an 'exit slip' where they summarise understanding at the end of the lesson on a piece of paper or large sticky note.
- Focused talks with individual students 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	Reflecting 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 iPrimary teacher you will work hard to involve everyone in your lesson activities, including whole-class discussions. 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. 37

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 to plan group tasks, to know when to provide supporting resources to 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 lolly sticks for randomly selecting students**

  Create a set of wooden sticks (or cards) displaying each student's name. After asking a class question, give students time to think (wait time) and then pull out a stick/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 that they may be asked for the answer publicly they will start to engage with the learning more. You can pull out more sticks 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 do either of the following.

- 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 are not fixed. Therefore, as an iPrimary 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: Volcanoes

Outcome: Identify and explain key features of volcanic activity

Task: After watching a short video and slide presentation (with opportunities for think–pair–share ideas), students work in groups to plan a pamphlet for visitors to Vesuvius (or other more relevant volcano to your location) describing and explaining key features of volcanic activity. Each student then creates their own pamphlet in class and in 'home learning' time. Students are given packs of key information about volcanoes and clear success criteria explaining what a good answer looks like.

Success criteria:

- Satisfactory: two or three illustrations, short explanations (three sentences or fewer), some of the research information included.
- Good: three or four clear, labelled illustrations, longer explanations including references to research, all required features are covered.
- Outstanding: clear, labelled illustrations as required, clear explanations directly linked to each research point, pamphlets are attractive and clearly written and cover all required features.

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 also 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 volcano lesson above, you would identify students with specific needs that may make certain aspects of the task more challenging for them (such as reading or writing level). 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 volcano 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.

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 volcano lesson on the previous page, identify the essential concept that you want students to grasp and ensure that all students have understood the idea before moving on to the next topic. If the essential concept you have identified is 'volcanic eruption', you might ask students to analyse volcanic eruptions across the world and to work out how volcanologists predict volcanic eruption. 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 volcanic eruption.

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 volcano lesson on the previous page, you could ask lower-achieving students to carry out tasks like 'describing' features of volcanic eruption and ask the higher-achieving students to research and explain how volcanologists predict eruption.

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 that 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 (that is, 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...* Younger students should be familiarised with the idea of a WALT (**W**e **A**re **L**earning **T**o), which you can refer to throughout the lesson to remind students of its purpose.
- Ask students to predict the learning objectives for this 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 they met the objectives).

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…* Younger students should be familiarised with the idea of a WILF (**W**hat **I** am **L**ooking **F**or).
- 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 do a drawing of a butterfly*, etc.

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 that 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 a comfortable environment.
- 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 regardless of whether or not they reach the correct answer.

EFFECTIVE QUESTIONING

Asking good questions that *lead to thinking* is one of the most important techniques that iPrimary teachers can use. There are many types of questions and these can either be open (e.g. *What do you think about this picture/idea/story?*) or closed (e.g. *What is 2 + 2?* or *What does the word '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

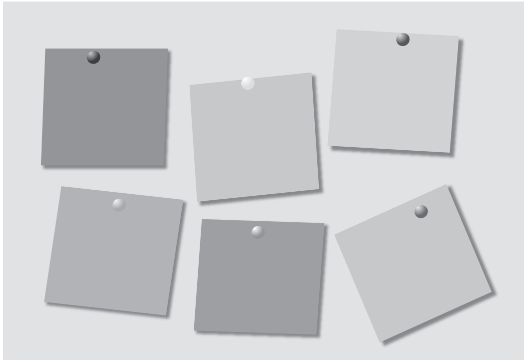
Question purpose	Examples
Make predictions	*What do you think might happen next?* *How many more of x might be needed if y happened…?*
Analyse	*What is the connection between… and…?* *What are the most important facts/issues here?*
Assess understanding	*What are the big ideas for this lesson?* *What 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.

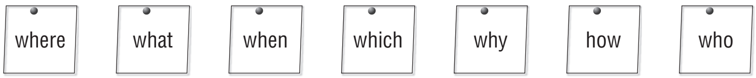


- Create a question wall and invite students to capture their questions throughout the activity or day or week. Address the questions at regular intervals in front of the whole class. Questions can be anonymous if necessary (which can encourage 'having a go' attitudes).

- 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 iPrimary 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 have said and do not 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 students' 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 different coloured stickers next to ideas in other groups' lists that they either find interesting or that they'd like to 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.
- Overlong (uninterrupted) presentations of new content: aim to keep these to a maximum of ten minutes (usually shorter).
- You doing 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 iPrimary 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 to 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 their 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.
- 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 iPrimary 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 to show how to structure an approach to an answer.
- As students develop confidence, encourage them to 'act like the teacher' and carry out a demonstration at the front of the class.

DEVELOPING THINKING SKILLS

As an iPrimary teacher, you will know that developing thinking skills – especially critical and creative thinking – are very important for students to do well in examinations. Metacognition (that is, thinking about thinking) is also essential for students and will enable them to make a smooth transition to 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 that 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 answer?
- 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 then 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 iPrimary 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 in which 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 succeeding, 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 ‘medals and missions’ system in your classroom.
  - ‘Medals’ tell the learner they have done well. These can be anything considered a reward, for example, stickers, praise, extra playtime, etc.
  - ‘Missions’ are individual targets that help the student focus on what they need to do to improve their work. Each new mission is an opportunity for you to adjust your students’ learning.
  - Checklists, prompts and marking frameworks will be useful aids for tracking medals and mission feedback.
- Three stars and a wish: speak with students one on one to give five minutes of verbal feedback containing three positive things to say about a task and one thing that they could improve on 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 about 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.

3. Student-to-teacher feedback

- Provide exit cards (pieces of paper or card) that 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.
- 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

In addition to the shorter term, more tangible goals of school and international assessment success, students are learning to be scientists. 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 developing the language of science with younger students

- Introducing terms such as 'investigation', 'conclusion', 'explanation', '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.
- Students do not have to 'un-learn' less accurate phrases, such as 'what we are going to do' or 'what happened' as they become older.
- Students start to become familiar with a repertoire of language that will be used later in external assessments.

Examples of scientific language

Differentiation p. 17

Rather than overload younger students with language that is difficult to describe and spell in the singular and plural, for example, 'hypothesis', try introducing a set of key carrier language to use consistently and regularly. The pace at which this is introduced will vary with the age and English fluency of individual students or groups.

Class investigations 1 and 2 pp. 38–39

- **Scientific question(s)**
- **Investigate/investigation –** rather than switching between this and 'experiment'
- **Variables –** gradually introducing 'independent' and 'dependent' with more able/older students
- **Fair test –** gradually introducing 'controlled variables' with more able/older students
- **Results –** talk about 'drawing a table' and, with more fluent/older students, 'tabulate'
- **Pattern –** talk about 'looking for patterns' and 'not fitting the pattern'
- **Conclusion(s) –** introduce 'drawing conclusions' as this is often misunderstood when translated literally
- **Improvement –** this can refer to aspects of the investigation itself or to the results

Pearson

USING SCIENTIFIC TERMINOLOGY

Teacher talk p. 23

It is important for students to start to build up a scientific vocabulary and to become confident using scientific terms precisely. Often the use of correct terminology can be crucial to scoring marks in written assessments in science.

Teaching approaches for introducing new terminology

- Try starting a Word Wall in the classroom to which new key words are added as they are introduced. It may be helpful to separate terms related to investigations from those relating to biology, chemistry and physics.

- Students could keep a vocabulary list in their exercise books or in a dedicated notebook so that they can actively learn/practise saying and writing these key terms. This could be organised by topic.

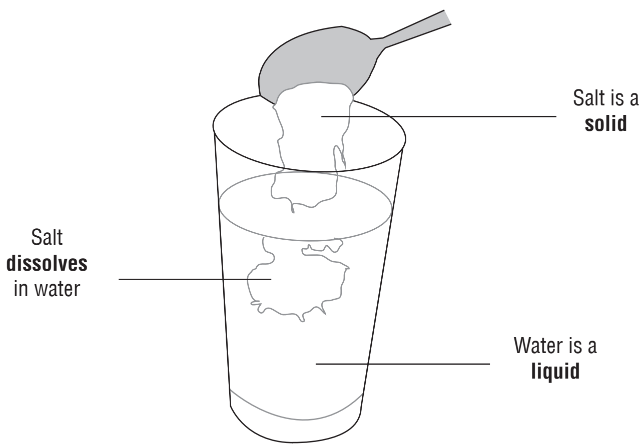
- Introduce groups or pairs of words together so that students can see which are nouns, verbs or adjectives as in a language class. The following table gives some examples of vocabulary groups for chemistry.

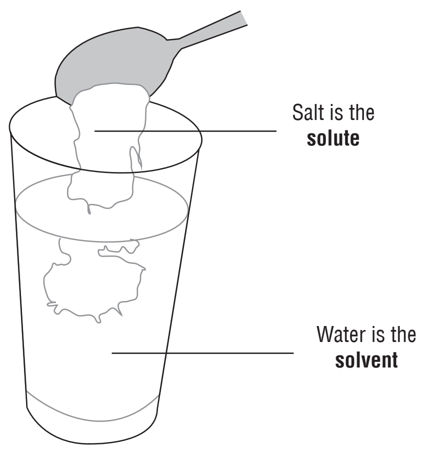
Chemistry p. 52

Topic	Examples of key vocabulary groups
Chemistry: Reversible and irreversible change	dissolve, dissolves, dissolving solution solvent solute
	solid, liquid, gas
	burns, burning melts, melting freezes, freezing evaporates, evaporating, evaporating basin condenses, condensation reversible, irreversible

- Younger students in particular could make annotated drawings to assist in contextualising vocabulary.

  For example:





A salt **solution** is made by **dissolving** salt in water

SCIENCE EQUIPMENT

The availability of equipment will inevitably vary from centre to centre. While it is important for students to have experience of timing, weighing and measuring lengths/volumes as part of their practical work, there is little genuine need for sophisticated equipment at iPrimary level. If a full range of sizes of equipment is not available, video clips or even online science catalogues could be used to show the range of sizes available for equipment such as measuring cylinders.

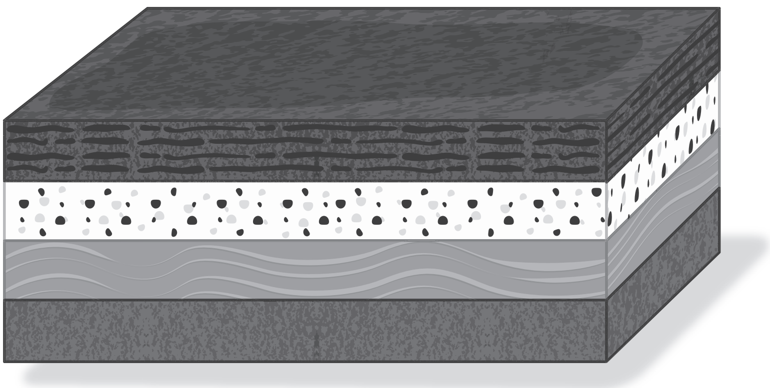
Enabling students to draw science equipment

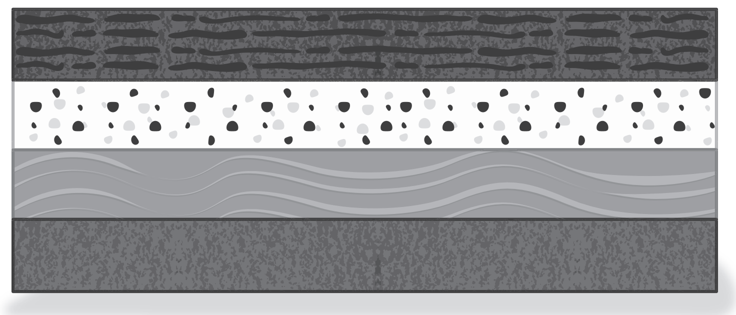
Younger students often find it hard to represent equipment accurately; this is a skill that can be developed over time. Textbooks and test/examination papers often use 3D diagrams to engage and assist students. However, as this is not the conventional style, it is worth investing time in helping students improve their 2D drawings with some simple guidance.

- Draw and label in pencil, drawing label lines with a ruler. Each label line should just touch the structure it is labelling but an arrow is not needed.
- Encourage students to think through where they will put label lines so that they do not cross one another. They should write the words at the end of the line, not on it.
- Shading or colouring is not needed.

To demonstrate, ask student to imagine that they are taking a slice down through each piece of equipment. You could illustrate this in a more familiar way first by showing them your own drawing of a simple layered cake drawn in 3D and then the end face drawn in 2D with the layers labelled.

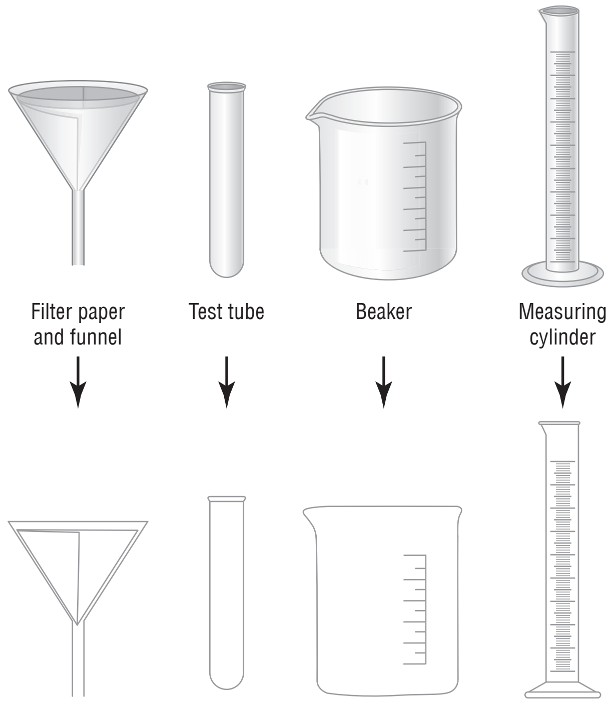
Teacher demonstration p. 26





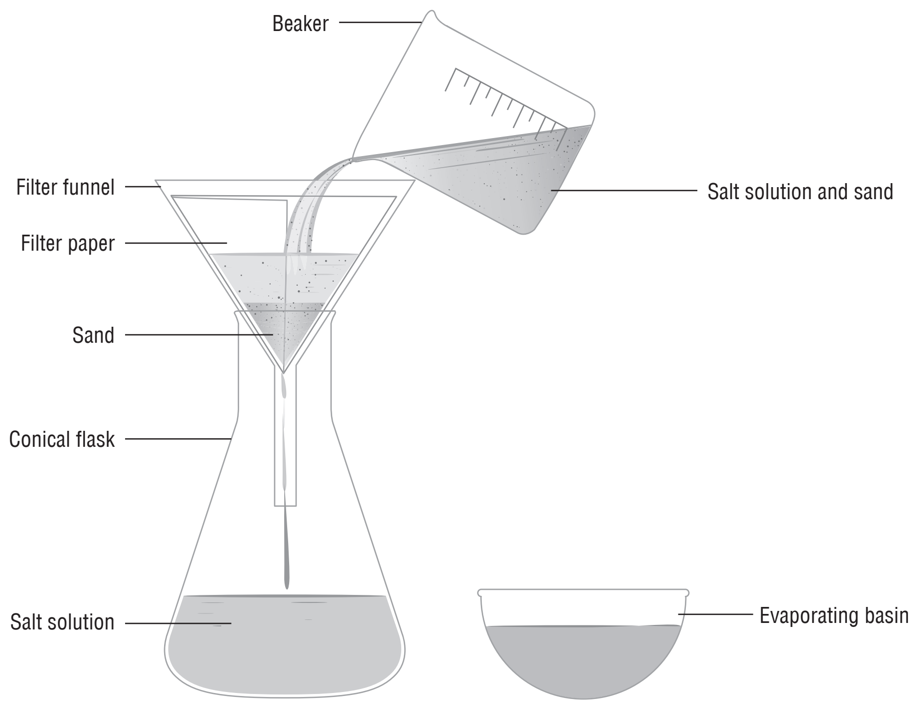
Examples of science equipment drawings

Some examples of how students could be shown 2D versions of simple equipment are given below.



Differentiation p. 17

More able students could be challenged to draw more sophisticated diagrams, as shown below. This will provide a further opportunity to reinforce other vocabulary associated with solutions.



At iPrimary level, it is not necessary for students to understand or use the concept of a meniscus (the concave shape at the top of water), when drawing liquid levels. This could be an extension for more able students.

HEALTH AND SAFETY

Individual institutions worldwide have their own health and safety policies that must be adhered to. In addition, students following the iPrimary and, to a greater extent, the iLowerSecondary science curricula are encouraged to assess risk for themselves. 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.

Tips to help students understand how to work safely

- At the start of each school year, task students with making a science safety poster, either individually or in small groups. These could be displayed on the wall of the teaching room or fixed into the front of their exercise book. Revisit the posters termly as a short refresher.

- Word safety rules positively, such as 'Clear up any spills immediately.' rather than negatively, such as 'Don't run in the classroom!' Students tend to respond well to positive rules, especially if they understand the reasons why the rule is in place.

Enabling students to work safely

While in the primary classroom, students are likely to adhere to rules as a result of the teacher's authority. The same may apply at home. However, allowing the students to have ownership of the science classroom rules allows them to transfer their perceptions of risk to everyday life as they grow up.

Teach students how to assess risk in the science classroom by explaining to them that there are four key factors to consider.

Enabling independent learning p. 19

1. What are the hazards?

For example: using a knife, handling hot water, water spilt on the floor.

2. What is the potential consequence of each hazard?

For example: burns, electrocution, broken limb.

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

Very likely or not very likely?

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 misspelling of 'goggles' as 'googles'.

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 and deliver parts of the curriculum in an engaging hands-on way, which 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 equipment or space
- difficulty of the task, for example, degree of manual dexterity required is beyond the students' age.

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 equipment or procedures which 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 packages are also available where either the students or the teacher can run the simulation with values decided upon 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. 38–39

  - refining the scientific question that has led to the practical task
  - making a prediction about what may happen
  - drawing a results table and deciding on column headings
  - taking turns to assist the teacher with making a reading or measurement
  - recording data for themselves as it is collected and looking for a pattern
  - making suggestions about how the procedure or equipment could be improved.
- If appropriate to the task, before the demonstration starts, students could be asked to identify variables and how to make the investigation a fair test.

The benefits of students actively participating in teacher demonstrations

- By watching actions such as careful handling of equipment, pouring and measuring, 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 performances 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 iPrimary, 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 the approaches documented in the **Principles for progress**, for example, by effective questioning or 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 what evidence they would look for
- as part of a class discussion centred around a claim made in an advertisement or news headline. Give students time to think about whether there is sufficient evidence to support the claim – for example, how many people were studied, what was measured or counted, were there any repeats, was it tested fairly, is it a reputable source, etc.

Demonstrating practical work p. 36
Concluding and Evaluating p. 48

To begin with, young students will need a lot of scaffolding to understand what you are asking them to look for. It may be useful to put a set of key 'things to consider' on display, such as those in the final bullet point above.

CLASS INVESTIGATIONS 1: ORGANISING

Engaging everyone p. 15
Collaborative activities p. 24

Research evidence tells us that primary students learn science by constructing ideas and developing competencies. However, especially at this early age, students need a framework on which to build and organise their knowledge and skills. It is therefore essential that class practical work goes beyond 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

- Investigative work allows students to develop their language skills. Some 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.
- Moving round the classroom to collect equipment or to compare results with others will also enable less confident students to participate more fully.

Tips to facilitate class investigations

- Set out as much equipment as possible *before* the class enters the room.
- Position sets of equipment, or different types of equipment, in different places in the room to avoid crowding when everyone starts.
- Establish a routine for 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 one-half of 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 equipment, 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 calling the students by letters, such as A, B and C. Next designate tasks, for example, A collects the equipment and records the results, B measures out the liquids and takes the readings, 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.
- 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 equipment, especially if they are to segregate used and clean beakers, for example. Using labelled signs will help to reinforce how to spell the name of each piece of equipment.

CLASS INVESTIGATIONS 2: VARIABLES

Teacher talk p. 23

Many students well above iPrimary age find it difficult to identify the independent and dependent variables in an investigation correctly. This may in part be down to the two words being quite similar but the confusion also arises when the student does not understand the investigation fully. The latter is a key starting point for teaching.

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*.
- At iPrimary level, 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 time intervals we have decided to take a measurement of something, for example, after one minute, two minutes, three minutes, etc.
- Introduce the dependent variable as 'the factor that *depends on* what we *changed* or *decided'* and 'it is what we look for 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

Often the idea of 'fair testing' is introduced at too early a stage at the expense of the students' clear understanding of the concept of one independent and one dependent variable. 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.

The above explanation of what is meant by a 'fair test' may help prevent students giving 'it wasn't a fair test' as a default examination answer when a more specific description of which variables may not have been controlled is required.

More able students could be questioned to test their understanding that there are some variables which 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. They could also consider ways to control the temperature of a room if that might affect their results.

USING PRACTICAL TASKS FOR FORMATIVE ASSESSMENT

Feedback
p. 30

Students who find written tasks challenging may be quite dextrous at practical tasks, and vice versa. Practical activities can be used for formative assessment in very simple ways. This may provide an opportunity for students with weaker English-language skills to get positive feedback.

Checking progress in science practical work

To check students' progress in practical work, set up a circus of four to six simple measuring activities in one area of the classroom and direct students to this individually over the course of one or more lessons. The other students do a written task or activity that requires minimal teacher input. Activities might include an individual student:

- measuring out a particular volume of water stated on a randomly selected card, which the teacher checks for accuracy of volume and for reading at eye level
- recording the temperature of a beaker of hot liquid, which the teacher checks as above
- measuring the length of an object shown on a randomly selected card, which the teacher could check later
- weighing out a specified mass of paperclips, grains of rice, etc. then the teacher checks scale reading
- determining the mass of a randomly chosen pre-weighed object, which the teacher could check later
- determining the area of a randomly allocated leaf, which the teacher could check later.

For the tasks above, the advantage of having random selections is that students cannot tell a friend what the answer is when they return to their seat.

Tips to help manage practical assessments

- Combining activities that require immediate feedback with those written on paper that can be checked later will reduce the amount of time the teacher has to direct to these activities at the expense of managing the majority of the class.
- Some aspects of practical work can be informally assessed by asking students to write answers to simple questions on a practical worksheet. This could be carried out by students before they start work on a practical investigation. When giving details of the practical task to students, leave out key information and reformulate as questions to be answered, such as the following.
    - What is the independent variable and the dependent variable in this investigation?
    - What piece of equipment is missing from the list?
    - Give two variables that should be controlled to make this a fair test.
    - Do you think it would be better to measure in centimetres or millimetres? Why?
- Alternatively, the same style of questions could be used for an unfamiliar practical from a past examination or test paper to give a more formal context.

RECORDING RESULTS

When students carry out investigative work they can sometimes become so absorbed in watching what happens or recording measurements that, if left unchecked, they may record their results in a fairly haphazard format. Later they may find that they omitted to record a result or needed more data.

Enabling students to construct results tables

Continually reinforce the idea of an independent and a dependent variable as this will help students to display and interpret data from investigations with much greater ease. An understanding of independent and dependent variables also assists in constructing results tables.

The youngest students will need help in constructing a results table. To support them, try providing younger students with results tables containing column headings and units so that they only need to write their results in the correct column.

Tips to help students construct successful results tables

Students could start to draw their own results tables without help once they have been introduced to the following tips 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.

  For example: included below is part of a table used for an investigation where the temperature of a beaker of liquid is being taken every minute.

Independent variable with unit

Dependent variable with unit

Time in minutes	Temperature in °C
0	60
1	56
2	52
3	49
4	**51**
5	
[etc.]	

- By completing the table as they obtain the results, students should be able to see, even before they write it down, that their result for the time interval of 4 minutes (shown in bold) seems to be unusual – it does not follow the pattern of decrease. You could discuss with them why it is unlikely to be correct and what to do about this result.

Processing results p. 42

PROCESSING RESULTS

Recording results p. 41

The previous page (Recording results) showed ways of teaching younger students to draw conventional results tables. It also touched on the idea of looking for results that do not fit the emerging pattern as they are being recorded. When planning the investigation, the class may have discussed the need to repeat the investigation. This could now be revisited once the students have one or more sets of results from their investigation.

Examples of how students might process results

- Younger students could be asked to look for a pattern.
  - Are the numbers they have recorded increasing or decreasing?
  - Do the values increase and then decrease, or vice versa? When is this change?
  - Is there anywhere where the values stay the same or very similar? When is this?
- Students could calculate a mean average if they have repeat data or if the class results have been pooled, for example, see the table below.

Dependent variable with unit

Independent variable with no unit

Liquid tested	Time taken for object to fall to the bottom of tube in seconds			
	Trial 1	Trial 2	Trial 3	Mean average
Vegetable oil				
Olive oil				
Water				
Wallpaper paste				
Sugar solution				

Units not repeated in any other rows

In this example, you could point out the following to students.

- The liquid being tested is the *independent* variable and time taken is the dependent variable – unlike the example on the previous page, where the time taken was the independent variable.
- The result for each trial is recorded as well as the mean average of the three values.
- When they look at the three results for a particular liquid, they should decide if the three times are similar. If the three results are similar in value, 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, give similar values each time.

Watch out for…

Students, when asked in a test or examination to ‘describe the pattern in the results’, are being asked to describe the results in a similar way to the examples above. Many students misinterpret this instruction and start to calculate differences between each of the values, as they would in maths if completing a number sequence.

TEACHING ABOUT BAR CHARTS

Developing thinking skills p. 27

The terms ‘bar chart’ and ‘bar graph’ are used almost interchangeably at iPrimary level, with the former being more commonly used, particularly with younger students. Often squared paper is used rather than graph paper.

The benefits of teaching a set of rules for bar charts in science

Teaching about line graphs p. 45

Although quite young students can quickly grasp how to construct a simple bar chart with limited guidance, most of the conventions for bar charts form the foundational principles for successfully plotting and interpreting more complex line graphs. Therefore, if students are taught these basic principles from the start, they will be at an advantage later on in their studies.

Assessment p. 57

Another advantage of having a set of rules is that, in test and examination situations, the students have a mental list that they can work through to check that they have scored all the available marks.

Examples of rules for drawing bar charts in science

Here are some examples of rules for drawing bar charts that can be shared with students to enhance their progress in this area.

- Bar charts are used to represent data that is in *categories*. The height of each bar represents a quantity within each category. This may have been counted or measured.
- Categories, for example, animal names or ice cube shapes, are put on the *x*-axis (horizontal axis) because they have been *chosen* by the student.
- The horizontal axis is unlikely to have a unit, but students should check.
- A name for each category is written directly under each bar.
- An overall axis name is written below the category names once, for example, ‘Types of animal’. This should be the same wording as the column heading for the first column of their results table.
- The number *counted or measured* is put on the *y*-axis (vertical axis) with an axis label and a unit.
- The numbering on the *y*-axis should be linear, that is, in equal increments, such as 10, 20, 30, etc. Weaker students are often tempted to incorrectly number this axis using the data totals.
- The bars plotted should be equally spaced across the *x*-axis and should all be equal in width.
- The top of each bar should be perfectly level for accuracy; a ruler or other straight edge should be used.
- It is not necessary to colour in or shade the bars unless there are two different sets of data, for example, animal numbers counted in the day and animal numbers counted at night. A key would be added in this instance.
- The graph is then given a title, such as: ‘A bar chart/graph to show the number of different types of animal found in a field’.

You could make a simple checklist for (or with) your students, simplifying the rules above according to their level of English literacy and age.

Something for you to try

Differentiation p. 17

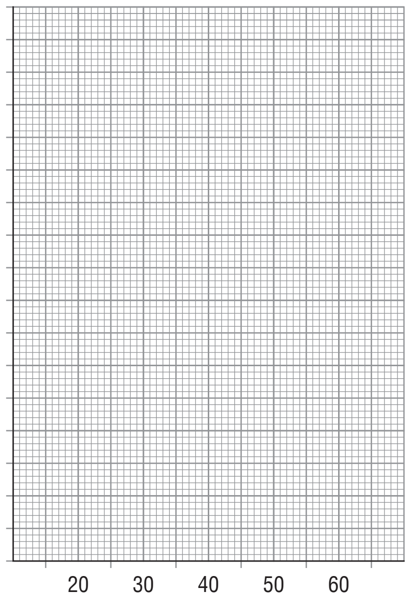
The following activities are examples of how simple plotting could be extended for students in the form of formative assessment.

1. The effect of temperature on carbon dioxide production by yeast

The data in the table below are from an investigation where five bottles of yeast and sugar solutions have been kept at different temperatures. The gas given off has been collected in a balloon secured to the neck of each flask.

Bottle	Temperature (°C)	Diameter of balloon (cm)
1	20	8
2	30	10
3	40	15
4	50	2
5	60	0

Title: ______________________



Try asking students to plot the results using a grid (see example on the right) that you have provided with just the markings shown.

This could be used as a simple assessment task.

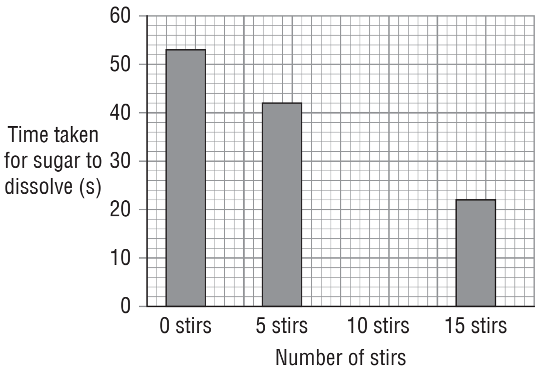
Tick which rules from the list on the previous page students have followed correctly.

Ensure that students have carried out the following:

- marked units on BOTH axes
- numbered the vertical axis in regular steps (not 0, 2, 8, 10, 15).

2. The effect of stirring on the time taken for sugar to dissolve

Ask students to look at the graph below. It shows the time taken for 2 teaspoons of sugar to dissolve in water when given different numbers of stirs. The volume and temperature of the water and type of sugar were all the same throughout.



Ask students *how they know* that it was the number of stirs that was changed in the investigation. (Answer: the number of stirs is shown on the x-axis – so time, on the y-axis, must have been measured.)

Ask students to predict a value for 10 stirs and then to *write a conclusion from the evidence* (try to use this phrase) on the bar chart.

Watch out for students who think that the sugar dissolves 'best' with 0 stirs.

Use this example to discourage the assumption that the tallest bar is always the 'best' result; in this case, the sugar dissolved fastest with 15 stirs.

TEACHING ABOUT LINE GRAPHS

Teacher demonstration p. 26

In order to make progress in drawing and interpreting graphs, students need to understand some basic rules and conventions about how graphs are plotted in science.

Some students may need clarification that the instructional phrase ‘plot a graph’ is sometimes seen written in English as ‘draw a graph’, although the former usage is preferable.

The benefits of teaching about line graphs from basic principles

At iPrimary level, most students are unlikely to encounter complex line graphs or be asked to plot line graphs without any guidance regarding the axes. However, by higher levels, a given cohort of students will need to demonstrate a wide spread of competency in their ability to plot a line graph unaided. It is for this reason that students with a set of transferrable graph skills have the greatest advantage in the applied questions that are typically found in summative assessment.

Enabling students to use line graphs

Class investigations 2 p. 39

A fundamental difference between line graphs and bar charts is that, unlike bar charts, line graphs are used to display *continuous* data, that is, data that is *not* in discrete categories. It is important that students understand this difference. Once that is understood, students who have a secure understanding of independent and dependent variables in the contexts of investigation planning, layout of results tables and layout of the axes of bar charts should have little difficulty in transferring these skills to line graphs.

Examples of rules for plotting line graphs in science

Teaching about bar charts p. 43

Here are some examples of rules for plotting 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.’

  Or:

  - ‘A graph to show the change in temperature of a cup of coffee with increasing time.’
  - ‘A graph to show how the temperature of a cup of coffee changes over time.’

You could make a simple checklist for (or with) your students, simplifying the rules above according to their level of English literacy and age.

Developing thinking skills p. 27

INTERPRETING SIMPLE LINE GRAPHS

If students understand the rules and conventions about how graphs are plotted they should find it easier to interpret unfamiliar graphs. The list of tips below could be shared with students to help them.

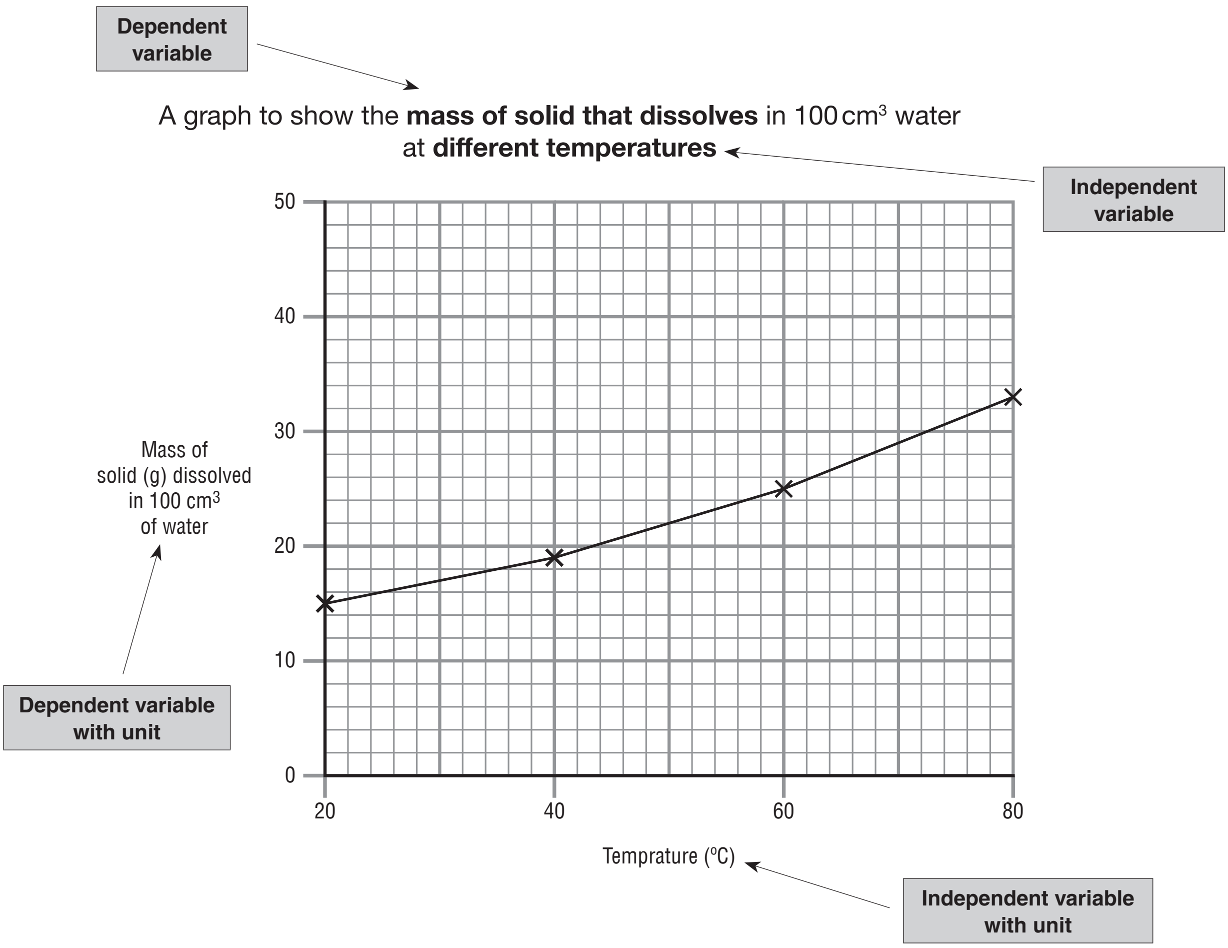
Examples of tips for interpreting line graphs in science

Here are some examples of tips for interpreting line graphs that can be shared with students to enhance their progress in this area. Encourage students to routinely work through this list *before* trying to answer questions about the graph.

- Read the title, if there is one.
- Read the *x*-axis label first – this will tell you the independent variable and its units.
- Read the *y*-axis label – this will tell you the dependent variable and its units.
- Look at the divisions on each axis scale and see how much each square represents.
- If there is more than one line, look at the labels or key to see which line is which.
- Look at the overall shape of the graph to see what it is telling you. Think of this as 'when the [*x*-axis variable name] does [x], the [*y*-axis variable name] does [y]'.

Something for you to try

Take a simple line graph, such as the one below:



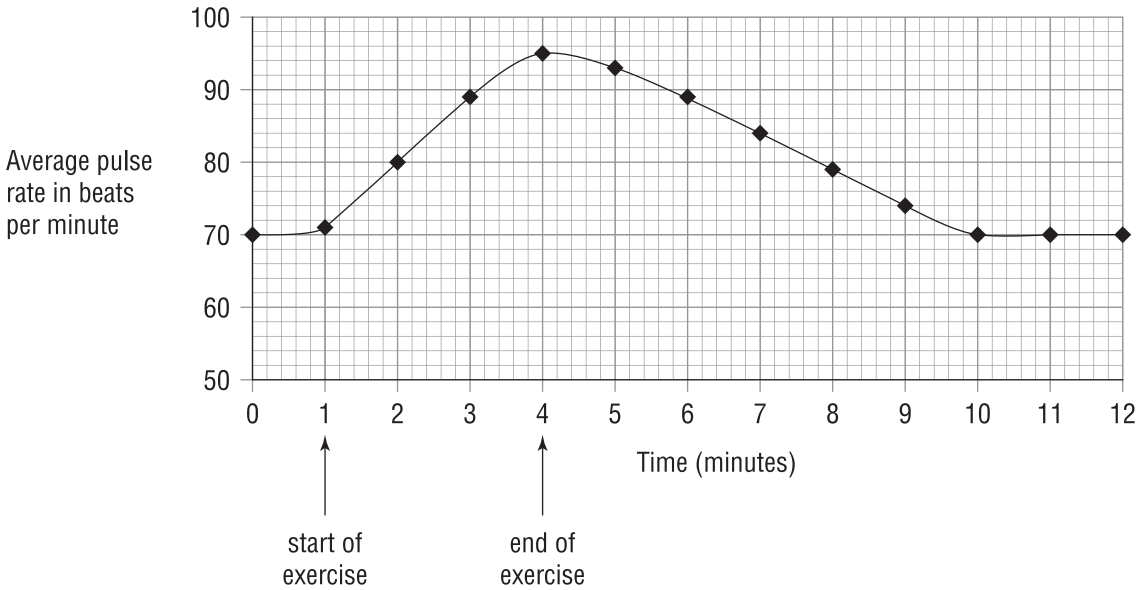
Ask a series of ramped questions about the graph, that is, start with something very straightforward and then gradually ask more challenging questions that develop in the way suggested in the bulleted points below. This could be done in the first instance as a teacher-led discussion task with the whole class to encourage a systematic approach. Subsequently, such tasks could be done in pairs or as formative assessment.

- First, instruct students to work through the tips for interpreting line graphs in science on the previous page.
- Then, develop the task by asking students to read off the mass of solid that dissolved at 20°C, 40°C, 60°C and 80°C. Show them how to do this accurately by drawing a thin vertical line up from each temperature to the graph line and then horizontally to the *y*-axis. Some may need help in interpreting the scale. Discuss why these lines should be as thin as possible.
- Point out at this stage how much easier it is to read off the graph when the plot points are drawn with bold but thin lines – something that students should carry over into their own graph plotting.
- Ask more able students to calculate how much more solid dissolves at 40°C than 20°C and other similar increments. Encourage them to show their working, even if they have used mental arithmetic or a calculator.
- Ask the students how they would use the graph to find out the mass of solid that dissolved at 30°C.

The benefits of *starting* a lesson with a graph interpretation

Discussion of a graphical task, such as the one described earlier or the following task, need not be placed at the end of a lesson. It could be done at the start of the lesson as a way of developing thinking skills using a systematic approach.

After looking in detail at the graph(s) provided, students could then be asked to devise their own investigation to obtain data like this for a solid of their choice, for example, sugar or salt, or for pulse rate, which they might then carry out in that lesson or the next.



The advantage of this ‘reversed’ approach is that students will now know how to record the results of their own investigation with minimal guidance. They can put into practice their knowledge of variables to design their investigation, to structure their results table and to plot a graph of their own results.

CONCLUDING AND EVALUATING

Reflecting on learning p. 29
Effective questioning p. 21

There are many ways to encourage students to think about what they have discovered through an investigation, or from some data, other than by telling them.

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 scientific literacy skill that requires active teaching and guidance. 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

A good place to start is by asking students to draw a 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 goes up, the number of bubbles produced goes down.*

Students should then be encouraged to write a general summary using comparative terms, that is, words ending with *-er* or words such as *more* or *less/fewer*:

For example:

- *the high<u>er</u> the temperature, the <u>more</u> bubbles are produced*
- *the great<u>er</u> the mass, the long<u>er</u> the elastic*
- *the <u>more</u> owls, the <u>fewer</u> mice*

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 as scaffolding to guide students' thoughts; challenge increases as you work down the table.

This task is very likely to show differentiation by outcome. Some students will be able to identify more sources of error than others and to explain them in greater depth. This is where collaborative work with mixed-ability groups would help to generate more sophisticated discussion, which could be shared with the whole class afterwards.

Aspect to consider	Questions to ask
Are the results reliable?	• *Were there repeats?* • *How many repeats? Was this enough?* • *Did all the results for each repeat look similar?*
Are the results accurate?	• *Was the same measuring equipment 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? Is there evidence of this in the results?*

(Continued from previous page)

Aspect to consider	Questions to ask
Is there a result that does not fit the pattern of the other results?	• *Is it 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 the 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 different result happens again?*
Could the equipment have been improved?	• *Would it have been better to use a different piece of equipment, for example, a measuring cylinder instead of a beaker?* • *Would a measuring cylinder with a finer scale have been better?*
Was it a fair test?	• *Was it possible to control variables, for example, the temperature of the room?* • *Did the room become warmer or colder? By how much?* • *In what way could this change have affected the results – would they become greater or lower in value?*

Were enough values of the independent variable chosen?	• *Was the range of values of the independent variable to 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?*

BIOLOGY

Teacher talk p. 23

Of the three sciences studied at iPrimary level, biology poses the greatest challenge in terms of vocabulary when working in English, both as a native language and as an additional language. It is 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.

Watch out for…

1. Misconceptions in early primary

The following biology topics, covered in the early years of iPrimary, lay the foundations for understanding living things:

- introducing living things using humans, animals and plants as examples
- healthy lifestyle for humans
- how living things interact with their environment
- features of invertebrates
- animal adaptations, including teeth
- feeding relationships.

Many later misunderstandings can be avoided by clear and correct use of ideas and language from the beginning, for example:

- **'Dead' vs. 'non-living':** ensure that students are clear that non-living things have never lived and that the term 'dead' is *only* applied to things that were once living. Otherwise, later on in science, students often incorrectly refer to enzymes that have been heated as being 'dead'.
- **'Balanced diet' vs. 'unbalanced diet':** ensure students have a clear understanding that someone with an unbalanced diet could still have a large food supply. Using more sophisticated vocabulary, this individual would be described as being 'malnourished', as opposed to 'undernourished'. However, it is not necessary to introduce more sophisticated terminology than just 'balanced diet' versus 'unbalanced diet'. It is more important to convey the *difference* between the two terms, for example, a person eating a burger and chips for every meal has plenty of food but has an unbalanced diet.

Some of the elements contained in the topics for the earlier years of iPrimary are included again in the later years of iPrimary to ensure that key ideas and vocabulary are in place and have been retained. For example, the concept of a balanced diet is introduced with younger students as part of work on healthy lifestyle, which is then revisited with older students as part of a simple introduction to the digestive system in Year 5. By this stage, fluency in English will also have improved thus enabling the more basic vocabulary learned earlier to be extended.

2. Misconceptions in later primary

The following biology topics, covered in the later years of iPrimary, build upon the work covered in earlier years, but also lay the foundations on which further study will be built at iLowerSecondary level:

- variation and classification
- growing plants
- skeleton and muscles
- plant adaptations
- living things in danger
- diet and digestion
- micro-organisms
- plant life cycles
- heart, lungs and circulation.

Within the topics outlined above there are biological terms with precise meanings that students should understand:

- **'Breathing' vs. 'respiration':** a distinction here need not go into any detail about cells. It is more important at this level for students to understand very simply that 'breathing' is the way in which air containing oxygen is taken into the body whereas 'respiration' is the way the body uses this oxygen once it reaches the organs.
- **'Endangered' vs. 'extinct':** students should understand that the term 'extinct' has a very precise meaning, that is, there are no longer any living individuals of this type of organism anywhere in the world. More able students could be directed to the IUCN (International Union for Conservation of Nature and Natural Resources) Red List of Threatened Species™ website where the stages leading up to extinction are discussed in more detail. This is beyond the scope of this specification but might provide useful project or extension work for the most able students.

Differentiation p. 17

Enabling independent learning p. 19

- **'Pollination' vs. 'fertilisation':** students often misunderstand that these terms have separate meanings and are not interchangeable. 'Pollination' is about pollen being moved by insects or the wind, whereas 'fertilisation' takes place *after* the flower has been pollinated and involves the growth of a pollen tube. To help students make the distinction, try showing them a pollen tube growing, either under a microscope or using a video clip.
- **'Pollination' vs. 'seed dispersal':** students commonly confuse these two aspects of a plant life cycle because both may be done by the wind. As with 'pollination'/'fertilisation', this is best prevented by showing real examples of pollen and seeds. Students who confuse pollination and seed dispersal often interchange the words 'pollen' and 'seeds'. Fertilisation takes place between pollination and seed dispersal.

CHEMISTRY

Class investigations 2 p. 39

At iPrimary level, the three sciences may be taught separately or as part of an integrated science scheme. Chemistry topics provide many opportunities for hands-on investigations. Chemistry is therefore particularly suited to allowing students to pose scientific questions relating to everyday life and then to design appropriate investigations.

Enabling students to make short, effective comparisons

Chemistry topics on materials provide good opportunities for ensuring that students know how to make effective comparisons in science. This will help younger students to develop the correct use of language and will benefit them in future tests and examinations.

When teaching the topics in the earlier years of iPrimary, try encouraging students to use formats such as:

- *The sugar crystals dissolve faster than the sugar cube.*
- *Paper towel A absorbs more water than paper towel B.*
- *Rock 1 is harder than rock 2.*

Teacher talk p. 23

Watch out for…

1. Misconceptions in early primary

The following chemistry topics, covered in the earlier years of iPrimary, are closely grouped around the theme of understanding the properties of matter at the level of everyday usage and hands-on observations:

- sorting and grouping materials
- properties and uses of materials
- rocks and soils
- using and changing materials.

Many later misunderstandings can be avoided by clear and correct use of ideas and language from the beginning.

- **'Temperature' vs. 'heat':** Although heat and temperature are related, they are different concepts*. It may be inappropriate to define them to younger students, but it is important to correct statements such as 'I am using the thermometer to measure the heat of this water' before the student incorrectly considers this to be an acceptable alternative wording for measuring the temperature.

*'Heat' is the total energy of molecular motion in a substance while 'temperature' is a measure of the average energy of molecular motion in a substance.

2. Misconceptions in later primary

The following chemistry topics, covered in the later years of iPrimary, build on the basic properties of matter from earlier years. The focus is now on the behaviour of matter when, for example, it is heated or cooled, and includes:

- solids, liquids and gases
- mixing and separating materials
- reversible and irreversible change.

'Dissolve' vs. 'disappear': One of the most frequent misuses of language occurs when young students describe dissolving. Even if they do not say it aloud, many weaker students think that when salt is added to water, the salt 'disappears'. Another example is when a salt solution is left in a warm place and the water is incorrectly described as having 'disappeared'.

Using scientific terminology p. 32

As a teacher, completely avoiding the use of the word 'disappear' in the entire topic will be beneficial to students' understanding, as well as correcting their language. In the examples above, encourage 'the salt dissolves' and 'the water evaporates'. These phrases both discourage the incorrect term and give an opportunity to show how new terminology is used.

The benefits of focusing chemistry learning in later primary

As chemistry teaching moves into the later years of primary, the iPrimary curriculum concentrates on key concepts. Developing an understanding of particles is fundamental to taking many of these topics much further. At primary age, the concept of the particulate nature of matter quickly becomes beyond the capacity of many students, even if they show superficial understanding. Having a clear understanding of how matter *behaves* will enable students to quickly and accurately build on their understanding of particles at iLowerSecondary level.

The topics in the later years of iPrimary have been chosen to enhance the development of scientific literacy. Students can investigate questions that arise in day-to-day life such as the following.

- *Does a sugar cube dissolve faster in a hot drink if it is stirred?*

  This question provides opportunities for considering independent and dependent variables, controlling variables, results tables, graphs, conclusions and improvements.

- *Which type of sugar dissolves fastest?*

  In addition to giving similar opportunities to the investigation above, this question also enables students to reinforce their understanding that an event that takes a shorter time is happening quicker than one taking a longer time. This may seem very obvious to adults but is surprisingly less obvious to younger students when presented with data showing this.

Teaching about bar charts p. 43

PHYSICS

The physics section of the iPrimary curriculum provides a wide introduction to a variety of topics. In a number of places there will be a close link with chemistry. For example, the terms *transparent, translucent* and *opaque*, introduced when studying light, are valuable additions to vocabulary that might be used when describing or comparing materials in a chemistry topic. Their correct usage could then be reinforced in both topics.

The benefits of teaching physics in early primary

Many students show an early curiosity about the world around them. Many aspects of the following physics topics, covered in the earlier years of iPrimary, allow students to make observations of their own, for example, keeping a diary of the appearance of the moon:

- light and dark
- pushes and pulls
- sound
- space
- light
- forces: introducing friction
- magnets.

Young students in particular come to science lessons with a diverse range of everyday ideas about how the world around them works. They may not be aware that they hold certain views or even misconceptions – all these are just implicit in the way they have thought about things as they grow up. The topics covered in the earlier years of iPrimary provide opportunities for students to question and modify their existing ideas about the physical world and move towards the accepted ideas of the science community as a whole. This is a key benefit and explains why the *breadth* of the early years' physics content is deliberately wide at the expense of *depth*.

In the example above, where students might keep a diary of the appearance of the moon over a period of time, there is an opportunity for them to reconcile their knowledge that the moon is spherical in shape with their observation that it appears to change shape. It is here that the teacher's role is to provide support to bring this 'cognitive conflict' together first, rather than just teaching more content, which can be done more effectively later on.

Enabling students to broaden and extend their knowledge in later primary

As with the other sciences, the following physics topics, covered in the later years of iPrimary, consolidate and then build upon work done in previous years. For example, an early topic related to forces is pushes and pulls in Year 1, which is then developed in Year 3 to include friction as a force between solids. In Year 6, forces in air and water develops these basic concepts further by looking at a greater variety of interactions and motion:

- making and changing sounds
- electricity: everyday uses and simple circuits
- the Earth and space
- seeing and reflecting
- forces in air and water
- electricity: changing circuits.

The physics topics in the later years of iPrimary provide opportunities for more able students to extend their knowledge and develop their research skills. For example, when studying forces in air and water, some students could be set 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:

Differentiation p. 17

Enabling independent learning p. 19

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.

The benefits of using sports to exemplify forces in action

Learners may actively generate meaning from experiences and compare this to their existing ideas. To change their ideas, students need to develop their understanding by being exposed to a wide range of experiences. Their beliefs about the world around them and how it works will be constructed by them, not received wholly from others. Problems arise when trying to learn abstract scientific ideas without context, as this often does not engage the student nor provide a wide enough range of experiences.

Engaging everyone p. 15

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. Thus, it is a particularly good opportunity to develop thinking skills situated in sporting contexts that are relatively familiar ‘real-world’ scenarios.

Student observations and subsequent discussion made when watching curling can be transferred to ice skating, for example. Teachers might show a video clip of one or other of these sports and challenge students to explain some of the physics behind the other one.

Depending on the locality of individual centres, snow and ice may be less familiar, but track and field sports, cycling or motor racing 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. For younger students in particular, abstract concepts about forces can be taught well by situating them in more concrete scenarios. This is also true for many other topics in the physical sciences.

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.

At primary level, written assessment tasks may be limited by language, but 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

Using practical tasks for formative assessment p. 40

Ways in which formative assessment of practical skills could be incorporated into science lessons was described in some detail in an earlier section of this guide. With younger students, this type of hands-on demonstration of what they can achieve will provide feedback to the teacher and encouragement to students with a more limited English vocabulary.

Teaching about bar charts p. 43

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.

Examples of assessment styles in tests and examinations

Tests in primary 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.
- **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.
- **Open response** – students typically write two or more sentences as their answer.

iPrimary assessment

Through the iPrimary curriculum, and your teaching strategies and learning activities, your students will 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 iPrimary curriculum is designed to develop learning skills and requires your students to become adaptable learners. 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 to 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 learners* 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 indicates 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 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 that helps students to improve future work and achievement
- in 'formative assessment' classrooms, students become better all-round learners 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 *iPrimary 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'.

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 iPrimary 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 iPrimary 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 iPrimary summative assessment programme

The iPrimary programme consists of progress tests and end-of-year tests that are linked to the iPrimary curriculum objectives. The iPrimary curriculum has been written to ensure students are prepared for their end of primary school tests, and then later have a solid foundation to begin their Lower Secondary learning from Year 7.

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

1. iPrimary progress tests

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

They help 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.

They help 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.

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 iPrimary 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' or simple number answers
- short sentence answers
- finding the right answer from the text
- longer answers involving providing reasons (or showing working out for a mathematics question).

2. iPrimary end-of-year tests

The iPrimary end-of-year tests are designed to be similar in structure to external tests that students may sit at the end of Year 6 and Year 9.

These tests are longer than the progress tests and will take longer to complete. They cover a range of curriculum 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 do not know an answer but to 'have a go'.
- Explain 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 this 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 iPrimary 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 the following.

- 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 in 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 iPrimary progress tests can be used as practice for students throughout the year. These are linked to the iPrimary 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 and keep the following points in mind.

- 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 you have a question, raise your hand, and a teacher will come to you
    - to read each question carefully before you 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 in the real test. For example, if in the real test students will have one hour to answer approximately 40 questions, then make the first practice test 20 minutes to answer 13 questions, then 30 minutes to answer 20 questions, and so on.

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 their 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.
- You may wish to allow older students to mark each other's practice test papers. If so, 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 about the question (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.

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 would leave no time to intervene; the class may have moved on to a new topic, a new year group or even a new school.

Formative assessment in science allows you to monitor the following areas.

1. Concept development

Formative assessment can diagnose where on the journey to full understanding each student is as teaching progresses and therefore 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 living thing, or a list of characteristics that living things share, give them a variety of pictures of objects and ask them to group them according to whether they are living or non-living things. Use think–pair–share so that individuals first decide their own answers but then you can include items that will generate discussion, such as milk and other food items that originate from living things. Ask students to explain to one another the reasoning behind their categorisation.

Engaging everyone p. 15

2. Constructing arguments

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

For example: Extend the task above on living/non-living things to include a fallen tree or a log. Ask the pairs of students to decide if they think it is a living thing or not and to justify their decision. Ask them to reconsider their original categories of living/non-living. Is a third category (once living/dead) needed? Set students the task of producing a set of criteria for each of their categories.

This task could be extended further by careful questioning and requiring students to justify their decisions. Students could be challenged with items that seem to contradict their groups, for example, a toy might move, so is it a living thing that responds to stimuli?

3. Scientific vocabulary

Students’ confidence in their use of scientific terminology can be monitored using simple activities with flash cards.

For example: In groups, ask students to make their own flash cards. Individual sets could differ, for example, one set could contain key words that are held up for someone in the group to use correctly in a sentence, while another set could contain definitions for students to guess the word. For very young students, or those with very limited English, simplify this further to a pairs game with 20 cards where each key term appears on two cards. These are placed face down and students turn over the cards with the same words. This could progress to a matching activity where the word is on one card and the definitions are on another.

4. Progress in practical work

Setting up some simple practical tasks in which students can demonstrate their ability to weigh, measure length or select equipment will allow effective observation of practical skills. Some examples are described in **Using practical tasks for formative assessment**. When students are doing practical tasks, make observations and use a simple tick sheet or a colour-coded symbol denoting proficiency to keep track of students’ skills.

Using practical tasks for formative assessment p. 40

5. Progress in data handling skills

Give opportunities to handle data by drawing and interpreting bar charts and line graphs. Specific examples can be found in **Teaching about bar charts**.

Teaching about bar charts p. 43

PREPARING STUDENTS FOR A WRITTEN SCIENCE TEST (SUMMATIVE ASSESSMENT)

Throughout this section, the term ‘test’ applies to progress tests, end-of-year tests and the iPrimary examination at the end of Year 6 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 outside of their control. To alleviate some of their concern, teachers can guide students to learn the way in which the questions will be asked and the way 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 (often called multiple-choice)**

  At iPrimary level, 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.

  If a student knows that A is the answer right away, they 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 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, etc.

  If a student is uncertain of the correct answer, they should embark on a strategy *that they have been taught beforehand*, such as the following.

  - Read all the choices first.
  - In some cases, it may be possible to eliminate one as clearly the wrong answer, but let us assume this is not the case here.
  - Next, focus on the question stem – it asks about what happens to salt.
  - Now work through the options and see which one(s) might plausibly happen to salt, which is a solid.
  - Students may think: ‘I am familiar with liquids evaporating and freezing. I have never seen or talked about salt freezing, so those are unlikely to be the correct answers.’

- Now students are left with A and D. They may think: ‘Salt is a solid but I have never seen it melting, like ice cubes or ice cream.’ So, although salt would melt, that is well beyond their experience so is unlikely to be being tested. This therefore leaves them with A as the correct answer.

- **Matching**

  Before drawing any lines, students should work out what all the answers are using tiny dots. This reduces the need for crossing out and confusion later. Encourage students to 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.

  Once everything is matched, students should join the pairs using straight lines. These need not be ruler drawn, but should be straight, not looped.

- **Drawing or annotating**

  The frequency with which this type of question is missed is much greater than one would expect for what are often quite straightforward, low-demand items.

  Students should be guided to look at the question number sequence: a(i), a(ii), b(i), etc. Every one of these will have a question associated with it, but it is frequently a(i) or b(i) that students do not notice as it follows straight after introductory information or a table or graph.

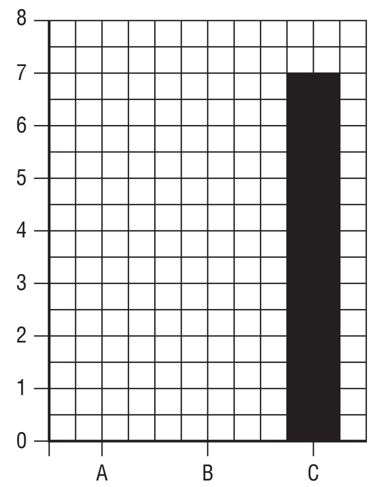
  The image on the right is of an example test question split into several parts. In this example, students are likely to miss the instruction to label both axes and go straight to drawing both bars because these are more obviously missing.

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

Complete the bar chart to show the average number of pieces needed for paper towels A and B.

(i) Label both axes. (1)

(ii) Draw both bars. (1)



- **Sentence completion**

  Sometimes words are provided. If this is the case, 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 they may reach the final space and not have an appropriate word left.

  Whether or not words are provided, students can glean additional guidance from the grammatical structure of the sentence:

Sugar will ________________ in water faster.

here a verb is needed

Wood burning is an example of an __________________ change.

here the missing word is preceded by ‘an’, so it must start with a vowel

Noticing the grammatical structure of the second sentence rules out ‘reversible’ as a possible answer (which would be grammatically incorrect).

- **Short open response**

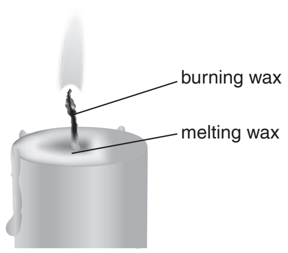
  Short open-response questions usually have one or two answer lines and are worth one or two marks.

  The intention is for students to write a brief answer as shown in the first image below. Students should not copy sections of the question stem to pad out their response as shown in the second image below. The latter wastes time that could be spent on other questions as well as making their answer 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 – in this case just one mark for each item.

When this candle burns, some changes take place.



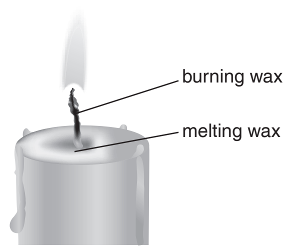
(i) What is the reversible change that takes place?

melting wax

(ii) What is the irreversible change that takes place?

burning wax

When this candle burns, some changes take place.



(i) What is the reversible change that takes place?

The reversible change is the melting wax.

(ii) What is the irreversible change that takes place?

The reversible change is the burning wax.

- **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 they 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.

- **Open response**

  At primary level, open-response questions are among the most demanding. The student requires reasonable competence in English but also has to judge what to write and what not to write.

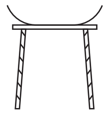
  Students should be encouraged to write in *short* statements with no attempt to use subclauses, etc. Students with limited written English should focus on giving the **scientific terms relevant to the answer** even if they cannot construct fluent sentences around them.

  The top image shows a fluent answer that gains all four marks.

  The middle image shows a less fluent answer but the students has managed to target the key points and has gained four marks.

  The bottom image shows a fluent answer but gains no marks as scientific terms have not been used.

Jenna has some salty water. She wants to make some dry salt using the apparatus below.

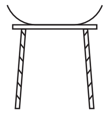


Explain how Jenna will use this apparatus to make some dry salt.
(4)

Put the salty water into an evaporating basin. Heat it to evaporate the water. The salt will remain in the evaporating basin.

4 marks

Jenna has some salty water. She wants to make some dry salt using the apparatus below.

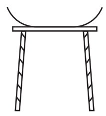


Explain how Jenna will use this apparatus to make some dry salt.
(4)

Put the water in the basin.
Heat it.
Water evaporates.
Salt is in basin.

4 marks

Jenna has some salty water. She wants to make some dry salt using the apparatus below.



Explain how Jenna will use this apparatus to make some dry salt.
(4)

This apparatus can be used by Jenna to make dry salt by putting it by a window until all the water has gone and only the dry salt that she wanted is left.

No marks

Appendices

APPENDIX A: THE *TRY IT OUT* TEMPLATE

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

Step 1 Choose a good idea to try out.

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

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

Step 4 Try it out! Capture evidence of your strategy in action.

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

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 as 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 iPRIMARY CHECKLIST

RAG[1]	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 will do a considerable amount of the talking during the lesson.		
	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.		
	I have planned how I will guide 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.		

[1] 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).