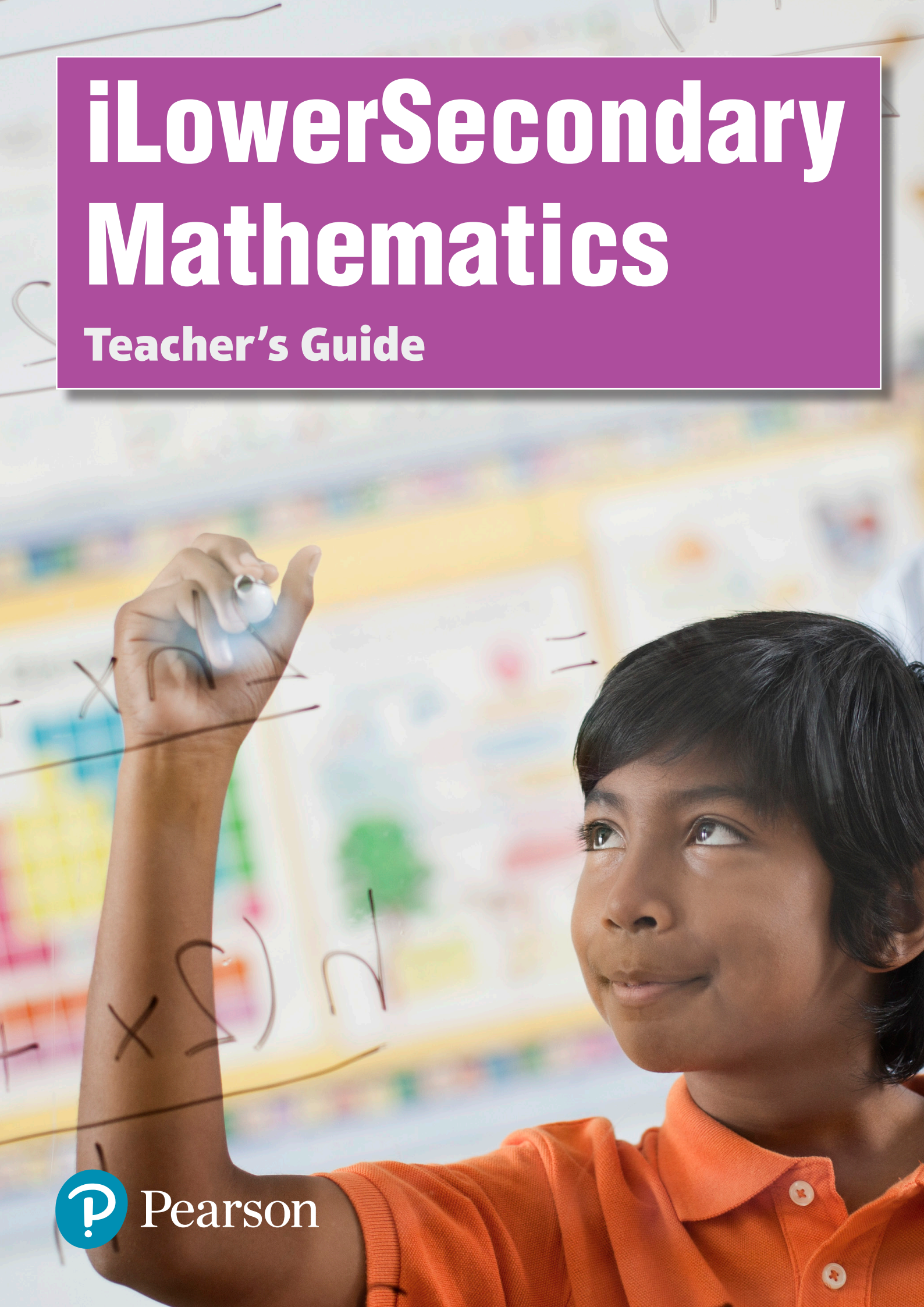
iLowerSecondary Mathematics

Teacher's Guide



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Contents

Welcome to your *iLowerSecondary Teacher's Guide*

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

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

This guide will give you:

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

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

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

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

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

HOW TO USE YOUR *iLOWERSECONDARY TEACHER'S GUIDE*

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

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

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

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


Mathematical reasoning p. 51

can link to…


Developing thinking skills p. 27

SUPPORTING YOUR iLOWERSECONDARY DEVELOPMENT

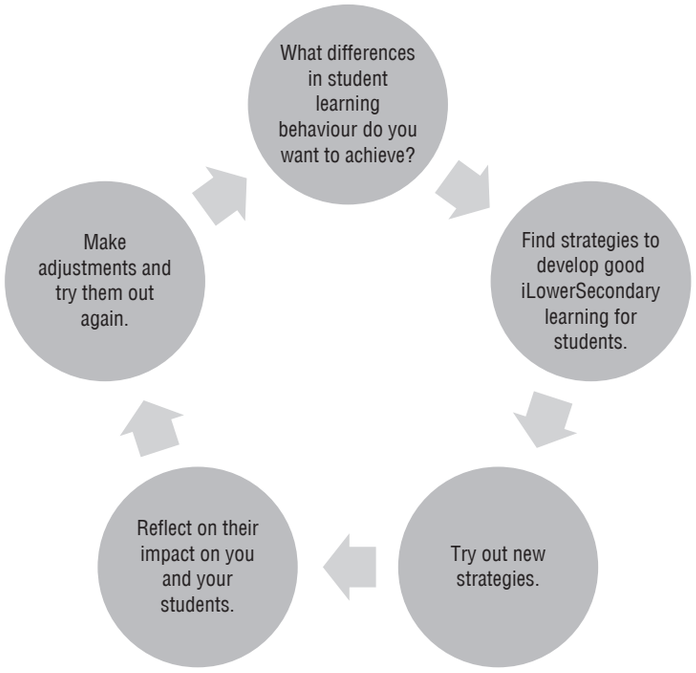
An important part of being an iLowerSecondary teacher is that you demonstrate the habit of developing and assessing your own practice. Focusing on your own development can directly help outcomes in the classroom, which means students learn more effectively and achieve more highly.

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

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

Reflective teaching practices

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



Tools and templates at your disposal

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

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

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

Where to go for help

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

Creating an iLowerSecondary classroom environment

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

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

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

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

ACTIVE LEARNING

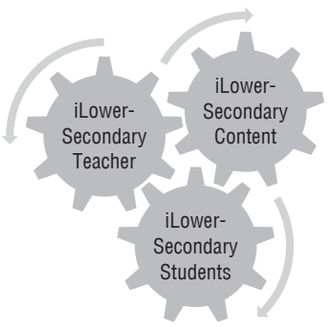
Broadly, a positive classroom environment will involve the teacher leading what can be called 'active learning strategies'. Active learning can sometimes mean that students are literally more physically active, but it *always* means that all students are required to think about what they are doing. As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

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

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

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

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



Strategies for implementing active learning

Engaging everyone p. 15
Collaborative activities p. 24
Developing thinking skills p. 27

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**.

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 iLowerSecondary classroom environment will bring the following benefits.

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

Strategies for implementing positive behaviour management

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

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

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

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

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

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

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

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

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

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

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

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

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

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

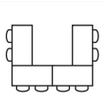
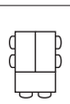
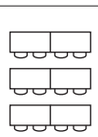
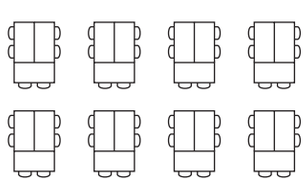
   For example, if you know that Luka is interested in fishing, say: *Luka, how have you learned to be so patient that you can wait hours at a time to catch a fish?* Or make reference to a cultural event that will involve the students and may be occupying their thoughts (such as an end-of-term event, a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

SEATING ARRANGEMENTS

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

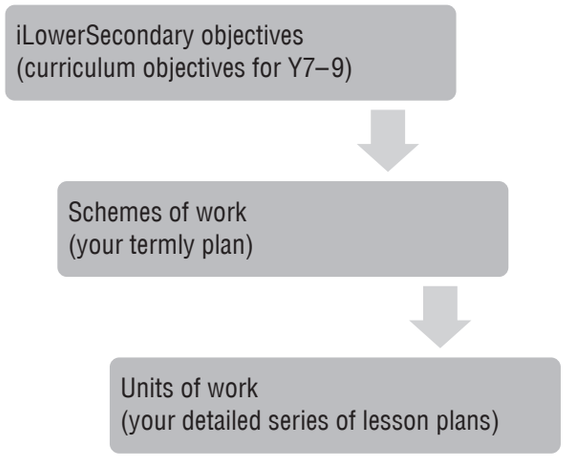
Examples of seating arrangements to use in various classroom situations

Here are some examples of seating arrangements you may try:

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

iLowerSecondary planning

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



THE iLOWERSECONDARY CURRICULUM OBJECTIVES

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

The curriculum objectives cover the knowledge, understanding and application that students are expected to demonstrate in clear detail. Further guidance or examples are provided as appropriate. For example, a curriculum objective might say: *Reduce a ratio to its simplest form.* This will be accompanied by notes and guidance for teachers, for example: *Relate to highest common factors and cancelling/simplifying.*

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 8, Spring Term 1 of the iLowerSecondary mathematics curriculum, contains objectives that have been grouped together because they focus on skills for the translation, rotation, enlargement and reflection of 2D and 3D shapes.

MATHEMATICS iLowerSecondary Pearson

Year 8 Mathematics Scheme of Work

Teaching week	iLowerSecondary Mathematics objectives	Activities
Year 8 Spring Term 1	**G7.5A** Translate 2D shapes. **G9.2D** Understand and use column vectors in translations. **G7.5B** Recognise and carry out reflections in a mirror line. **G7.5C** Reflect a shape on a coordinate grid; describe a reflection on a coordinate grid. **G7.5D** Recognise and draw rotations about a centre of rotation. **G7.5E** Rotate a shape on a coordinate grid; describe a rotation on a coordinate grid. **G7.5H** Enlarge shapes using positive integer scale factors (without a centre of enlargement). **G7.5I** Work out the scale factor given an object and its image. **G9.2A** Work out the scale factor of an enlargement. **G9.2C** Describe an enlargement on a coordinate grid. **G9.2B** Enlarge shapes using positive, negative and fractional scale factors, about a centre of enlargement. **G7.5F** Transform 2D shapes by combinations of rotations, reflections and translations. **G7.4C** Identify reflection symmetry in common 3D solids.	Describe and carry out translations; Describe and carry out reflections; Describe and carry out rotations; Enlarge a shape; Describe an enlargement; Enlarge a shape using negative scale factors; Enlarge a shape using fractional scale factors; Transform 2D shapes using a combination of reflection, rotation, enlargement and translation; Identify planes of reflection symmetry in 3D solids; Find the perimeter and area of 2D shapes after enlargement; Find the volume of 3D solids after enlargements.

PLANNING UNITS OF WORK

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

MATHEMATICS iLowerSecondary Pearson

Year 7 Autumn Term 1 Lesson 1

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

Teaching Summary

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

Display this table of Year 7 favourite potato dishes.

Potato dish	Mashed	Baked	Chipped	Boiled
Frequency	6	3	11	5

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

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

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

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

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

Formative assessment p. 57

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

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

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

Principles for progress

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

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

ENGAGING EVERYONE

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

Teaching approaches for engaging everyone

1. Convey enthusiasm

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

Mathematical links to the real world p. 53

2. Find links to students' interests and existing knowledge

- **Create a KWL chart**

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

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

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

3. Engage everyone in whole-class discussions

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

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

- **Think–pair–share**

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

- **Use mini-whiteboards**

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

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

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

4. Work the room to engage with individual students

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

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

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

Watch out for…

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

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

DIFFERENTIATION

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

Teaching approaches for differentiation in the classroom

1. Differentiation by outcome

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

Topic: Rainforests

Outcome: Identify and explain key features of a rainforest

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

Success criteria:

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

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

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

2. Differentiation by levels of support for a specific task

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

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

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

3. Differentiation by resources

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

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

4. Differentiation by time to master key concepts

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

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

5. Differentiation by task

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

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

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

ENABLING INDEPENDENT LEARNING

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

1. arriving at a clear, shared understanding of what success looks like (i.e. the 'success criteria')

2. understanding the steps needed to achieve this success.

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

Teaching approaches for enabling independent learning

1. Communicating learning objectives

- Use student-friendly language to describe the learning objectives for the lesson, for example, *Today, we are learning to...*

- Ask students to predict the learning objectives for the lesson based on what they have learned in previous lessons. For example: *What do you think we should be learning today given what we did last lesson?*

- Once you have established the objectives of the lesson, ask students to complete the following sentences (this can be done verbally or in written form, but it has to be short and lively).

  This lesson will be successful if:

  - *the teacher*… (for example: explains clearly, gives us time to think)

  - *all the students*… (for example: listen to each other, can discuss our ideas)

  - *I*… (for example: contribute my ideas, ask good questions).

- Ask students to show red, amber or green cards following a traffic-light system to communicate how well they are meeting the objectives.

- At the end of the lesson, invite students to look back at the objectives to see in what ways and to what extent they have been achieved. You can do this by asking each student to fill out an 'exit slip' (a small piece of paper to capture their view on whether or not they met the objectives) or to add to their shared learning log for a series of lessons.

2. Developing shared understanding of success criteria

- Use student-friendly language to describe the success criteria, for example, *What I am looking for today is…* or *What we should achieve during this unit/term/topic is…*

- Encourage your students to come up with their own ideas for what success should look like once you have described the learning objectives. Ask them: *What do you think all of us should be able to do by the end of today's lesson?*

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

  You will be able to:

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

- Make sure learning outcomes are very specific. For example: *You will be able to describe to another student how to do mathematical equations*.

3. Establishing class norms

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

4. 'Three before me'

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

5. Peer evaluation

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

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

6. Encouraging a 'have a go!' attitude

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

EFFECTIVE QUESTIONING

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

Examples of questions with different purposes

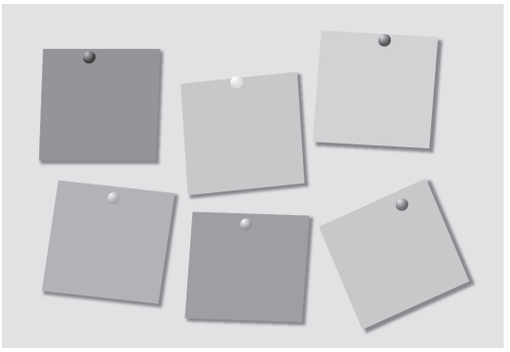
Question purpose	Examples
Make predictions	*What do you think might happen next?* *How many more of x might be needed if y happened…?*
Analyse	*What is the connection between… and…?* *What are the most important facts/issues here?*
Assess understanding	*What are the big ideas for this lesson?* *What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

Tips for effective questioning in the classroom

Engaging everyone p. 15

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

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



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

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

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

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

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

Watch out for…

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

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

TEACHER TALK

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

Tips for effective teacher talk

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

Effective questioning p. 21

Teaching approaches for teacher talk in the classroom

1. Write–pair–share

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

2. Brainstorm before presenting new content

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

Watch out for…

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

COLLABORATIVE ACTIVITIES

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

Teaching approaches for collaborative activities

1. Assigning group roles

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

2. Jigsaw grouping

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

Here are some tips for using this approach.

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

3. Using a gallery walk

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

Here are some tips for using this approach.

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

4. Hot seating/ask the expert

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

5. Developing positive relationships between students

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

TEACHER DEMONSTRATION

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

Teaching approaches for teacher demonstration

1. Modelling behaviour

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

2. Think alouds

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

You might ask aloud questions such as.

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

Students will benefit from this approach in the following ways:

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

Formative assessment p. 57

3. Teacher-led demonstrations

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

4. Student-centred demonstrations

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

DEVELOPING THINKING SKILLS

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

Enabling students to develop thinking skills

1. Critical thinking skills

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

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

2. Concept mapping

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

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

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

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

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

3. Metacognition

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

Before the lesson

- What do you already know about this topic?

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

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

During the lesson

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

After the lesson

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

In preparation for tests

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

REFLECTION ON LEARNING

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

Teaching approaches for reflecting on learning

1. Developing a growth mindset among students

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

Developing thinking skills p. 27

2. Providing reflection points during learning

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

3. Providing reflection points at the end of a task

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

FEEDBACK (IN BOTH DIRECTIONS)

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

Teaching approaches for incorporating feedback into the classroom

1. Teacher-to-student feedback

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

2. Student-to-student feedback

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

3. Student-to-teacher feedback

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

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

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

Watch out for…

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

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

Teaching in mathematics

PLACE VALUE AND DECIMALS

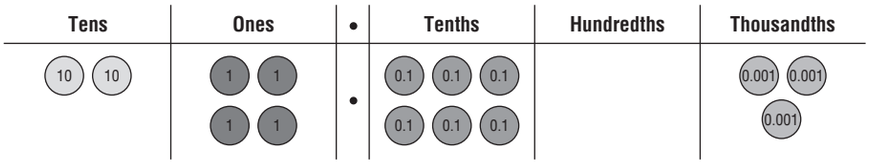
A sound understanding of place value and decimals is fundamental to success in mathematics. This is true across the mathematics curriculum. For example: rounding to significant figures or decimal places (number), reading decimal coordinates (algebra), scales of measure (geometry) or understanding probabilities (statistics).

Teaching approaches for place value

Differentiation p. 17

Ensure students are absolutely secure in place value and decimals. If necessary, offer support by using concrete apparatus and pictorial representations.

1. **Concrete apparatus:** for example, place value counters



2. **Pictorial representation:** for example, a place value table

Tens	Ones	•	Tenths	Hundredths	Thousandths
2	4	•	6	0	3

The benefits of concrete apparatus and pictorial representation for place value and decimals

- They show students that the place of a digit in a number tells you about its value. This is useful for large numbers, as well for as decimals.
- They emphasise the use of 0 as a 'place holder'.

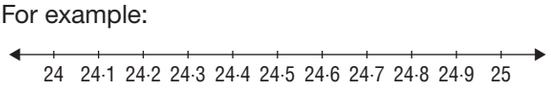
  For example, 24·603 needs a zero in the hundredths column so that 3 stays in the thousandths column. Otherwise the number becomes 24·63.
- They can be used to demonstrate that a digit one place to the left of any other digit is worth 10 times as much. As the maximum number in any one column is 9, on reaching 10, students can see and perform the exchange for 1 in the next column.

  For example: 10 ones = 1 ten; 10 tenths = 1 one; 10 hundredths = 1 tenth; 10 thousandths = 1 hundredth, etc.

Watch out for…

- Students who struggle with reading or writing very large numbers. For example, they may read 9 000 007 as ninety million and seven, or nine hundred and seven thousand.
- Students who incorrectly read numbers that include 0. For example, they may read 24·603 as twenty-four point six hundred and three, rather than twenty-four point six zero three.
- Students who think that the more digits there are, the greater the number. For example, students may think that 24·603 is larger than 24·9.
- Students who do not know which digit to consider when rounding. For example, they may round 24·603 to 24 because they look only at the integer part of the decimal. In this case, support them by using the pictorial representation of a number line.

  For example:



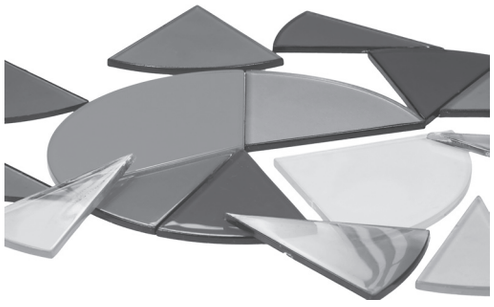
CONCRETE-PICTORIAL-ABSTRACT

Concrete apparatus (sometimes called manipulatives) support students to explore and begin to visualise abstract mathematical concepts. Pictorial representations of the concrete apparatus further reinforce that visualisation.

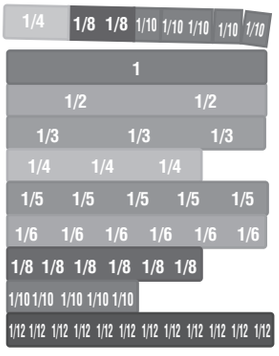
Examples of concrete-pictorial-abstract for fractions

- **Concrete apparatus** used in mathematics may include fraction circles and fraction tiles. For example:

Fraction circles

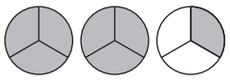


Fraction tiles

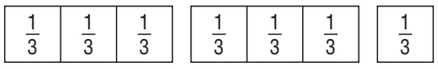


- **Pictorial representation** may include shapes, bar models, number lines or other representations. For example:

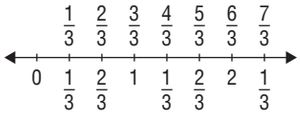
Circles



Bar models



Number line



- **Abstract representations** may include formal notation and calculations. For example:

$\frac{7}{3} = 2\frac{1}{3}$ $\quad \frac{1}{3} \times 7 = \frac{7}{3}$ $\quad 2\frac{1}{3} \div 7 = \frac{1}{3}$

Something for you to try

Perhaps you do not have, or cannot buy, concrete apparatus. If this is the case, try making your own versions using different-coloured card.

FRACTIONS, DECIMALS AND PERCENTAGES

Fractions, decimals and percentages lead on from an understanding of place value and decimals.

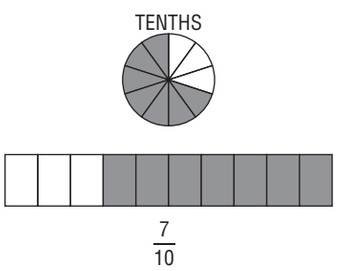
Teaching approaches for fractions, decimals and percentages

Differentiation p. 17

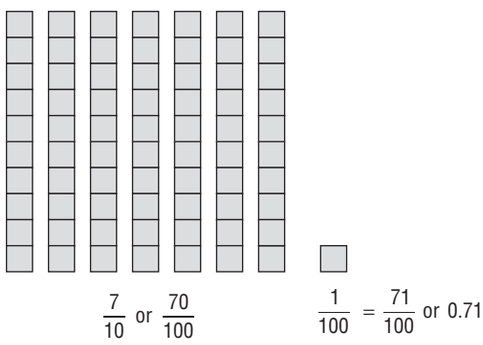
- If necessary, support students with equivalence of fractions, decimals and percentages by using concrete and pictorial representations.

  For example:

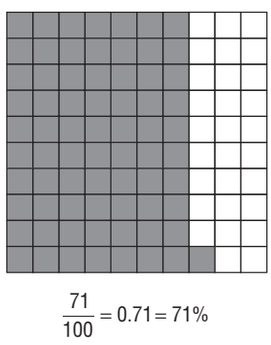
  Fraction circles and fraction tiles



  Base-10 cubes



  100-square

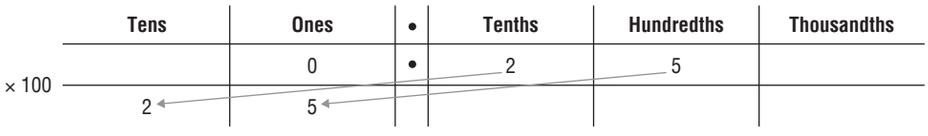


- Frequently move between the representations of fractions, decimals and percentages, so that students develop a sound understanding of the relationship.

- Use a place value table to support multiplying and dividing by 100 for converting decimals to percentages, and vice versa.

  For example:

  0·25 as a percentage



Watch out for…

Fraction and decimal errors and misconceptions

- Students who find it difficult to understand a fraction and decimal equivalence because the digits are different. For example $\frac{2}{5}$ uses the digits 2 and 5, but is NOT equivalent to 0·25.
- Students who associate $\frac{1}{3}$ with 0·3, $\frac{1}{4}$ with 0·4, and so on.

Decimal and percentage errors and misconceptions

- Students who associate 0·3 with 3%, 0·4 with 4%, and so on.
- Students who struggle with decimal percentage. For example, 0·5% is not 0·5.
- Students who believe that percentages are never greater than 100%.

Fraction and percentage errors and misconceptions

- Students who do not identify factors of 100 when they are denominators of a fraction, and so cannot use this method to efficiently change from a fraction to a percentage.

PATTERNS

The number system is based on patterns. Recognising these patterns is fundamental for students to develop a sound understanding of number and algebra.

The benefits of pattern spotting

- It reinforces understanding of place value (for example, 0·36, 0·361, 0·362, 0·363, 0·364, etc.).
- It develops an understanding of properties of numbers (for example, all multiples of 25 end in 25, 50, 75 or 00).
- It allows students to derive new facts quickly from those they already know (for example, multiplying by 99 is equivalent to multiplying by 100 then subtracting 1).
- It allows students to identify relationships between numbers (for example, the 16 times table is double the 8 times table, which is double the 4 times table, etc.).
- It helps students to recognise and describe sequences (for example, 2, 6, 10, 14, etc.).

Teaching approaches for pattern spotting

- Give students lots of opportunities to explore patterns on a 100-square.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

- Use pictorial representations of patterns.

Developing thinking skills p. 27

Something for you to try

Ask students to create and describe their own patterns using concrete apparatus, such as counters and other shaped tiles.

PROPORTIONAL REASONING

Developing thinking skills p. 27

Students engage in proportional reasoning when they recognise that quantities are related by multiplication or division. For example, $\frac{1}{2}$ is twice the size of $\frac{1}{4}$; a jug holds half the water of a saucepan; 10% is a third of 30%; a child runs three times as a fast as another child.

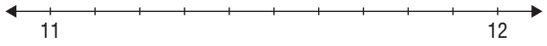
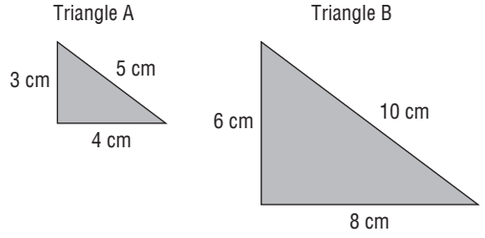
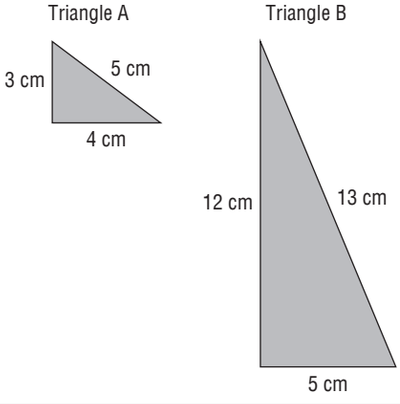
The benefits of proportional reasoning

- Proportional reasoning applies to many mathematics concepts across the curriculum. For example: multiplication, division, fractions, decimals, percentages, ratio, proportion, rates, linear functions and graphs, conversion of measures, scale diagrams, enlargement, etc. This means that students who have a good understanding of proportional relationships do better at mathematics.
- Many other subjects require an understanding of proportional reasoning too, such as science and music.
- In everyday life, students will need to engage in proportional reasoning. For example, understanding a '3 for 2' deal in a store or scaling a recipe for a specific number of people.

Teaching approaches for proportional reasoning

- Give students opportunities to explore proportional situations across mathematics, other subject areas and everyday life.
- Encourage students to experience proportional situations. For example: discussing which shape is shaded with more grey or creating a pattern with a multiplication or division rule.
- Support students to distinguish between proportional and non-proportional situations.

Examples of proportional and non-proportional situations

Proportional situations	Non-proportional situations
Find the missing numbers on this number line:  	Order these numbers from smallest to largest: 11·9, 11·2, 11·5, 11·7, 12, 11·1, 11·4, 11·3, 11·8, 11·6, 11
Triangle B is an enlargement of triangle A  	Triangle B is NOT an enlargement of triangle A 

Watch out for…

- Students who have difficulty distinguishing proportional situations and non-proportional situations. These students may inappropriately multiply or divide when a problem actually requires addition or subtraction or vice versa.

ESTIMATING

Estimating allows students to develop confidence in their answers. It is also an important everyday skill.

The benefits of estimating

- In mathematics, estimation allows students to check that their answers are reasonable.
- In everyday life, estimation has many uses. For example, it allows students to determine if they have enough money to buy several items when shopping, if they have been given the approximate correct change (having paid for their shopping), how much time they may have until their bus arrives, etc.

Developing thinking skills p. 27

Examples of estimating

- When students are calculating, encourage them to think about the expected size of their answer.

  For example: if multiplying 20 by a number less than 1, ask students if they expect their answer to be bigger or smaller than 20.

- When students are calculating, encourage them to estimate an answer and assess if it is reasonable.

  For example: if calculating $20{\cdot}1 \times 0{\cdot}9$, a student should recognise that the answer should be close to $20 \times 1 = 20$ (so an answer of 180·9 is incorrect).

- When students are working with percentages, encourage them to find a close percentage that is a multiple of 10.

  For example: if calculating 21% of 40 m, then find 20% (that is $10\% \times 2$) of 40 m first.

- When students are working with money, encourage them to estimate using a close integer money denomination, rather than working with decimals.

  For example: if calculating $5 \times £1.97$, then recognise that the answer should be just less than $5 \times £2 = £10$ (and so a £10 note is enough to make the payment).

- When students are measuring, encourage them to estimate the size of their measure.

  For example: is the angle they are about to measure acute, obtuse or reflex? What information does this give about its possible size?

Feedback (in both directions) p. 30

Teaching approaches for estimating

- When students give a spoken answer, ask them to convince you it is correct using estimation.
- When students give a written answer, sometimes insist that they also show a ‘check’, using estimation, to make sure their answer is reasonable.

Watch out for…

- Students who prize speed over accuracy and do not use estimating to check that their answers are reasonable. These students are likely to make errors in assessments and tests.

THE LANGUAGE OF MATHEMATICS

Teacher demonstration p. 26

The use of accurate mathematical language is fundamental to learning mathematics. This means not only knowing mathematical words and their meanings, but also being able to use them in grammatically correct sentences.

Teaching approaches for introducing new mathematical vocabulary

Use English-language teaching techniques for introducing new mathematical vocabulary.

Teacher talk p. 23

- When introducing a new mathematical word, write it on the board, read it aloud, ask students to repeat the word and then use the word in different sentences. Write a new word in different sentences on a poster, and put the poster on your classroom wall so that you can revisit the word in later lessons. Introduce students to useful prefixes.

  For example: 'cent' means '100' in 'century', 'centimetre' and 'per cent', while 'im-' usually means 'not', as in 'improper' fraction and 'improper' outcome.

- Introduce a range of mathematical words with the same meaning.

  For example: 'double', 'twice' and 'multiply by two'.

- Introduce different endings for words.

  For example: 'division', 'divide', 'divides', 'divided', 'divisible' and 'divisibility'.

- Concentrate on the spelling of particularly tricky words.

  For example: 'denominator', 'parallel' and 'hypotenuse'.

- Ensure students know English words that are useful in mathematics.

  For example: 'close', 'closest', 'closer' or 'near', 'nearest', 'nearer' for rounding numbers; 'before/after' for patterns and sequences.

- Ensure students understand that some words have more than one meaning – a mathematical meaning and an everyday meaning.

Examples of words with a mathematical meaning and everyday meaning

Word	Mathematical meaning	Everday meaning
Even	Number divisible by 2	Flat and smooth
Take away	Subtract	Ready-prepared food, taken home to eat
Face	A single surface on a 3D solid	The front part of someone's head
Scale	A way of measuring	Musical notes, or bony plates on fish skin

Watch out for…

- Students who do not distinguish between tens and tenths, hundreds and hundredths, thousands and thousandths, and so on.

- Students who do not read or say numbers accurately, for example, they read 17·831 as 'seventeen point eighty hundred and thirty-one' or $\frac{3}{11}$ as 'three over eleven'.

GEOMETRY

Students should have a good vocabulary and understanding of measure, shape and position from Primary level. It is vital to build on this and move towards a more formal geometric understanding.

Checking progress in geometry

At Lower Secondary level, students deepen their understanding of geometrical ideas of measure, angles, shape, symmetry, transformation, similarity and congruence, and engage in more geometrical reasoning and geometric problem solving. This is important as it leads into later understanding of geometrical proof.

Teaching approaches for geometry

- Provide lots of opportunities for students to make links between geometry and number.

  For example: to engage in proportional reasoning when converting measures, when using scale and when solving geometric problems.

- Deepen students' understanding of shape by asking what needs to change to make the shape another given example.

  For example: *Describe how to change one side of a rectangle so that it becomes a trapezium*; *Describe a change to two sides of a rectangle so that it becomes a parallelogram*; *What shape could you make by changing three sides of a rectangle?*

Developing thinking skills p. 27

- Give students opportunities to explore and discuss geometric ideas using geometric software.

  For example: 'dragging' vertices to change shapes and explore how interior angles change.

- Begin to introduce proof, using diagrams, to determine geometric facts.

  For example: transform a parallelogram to a rectangle, with the same base and height, to prove that the area of a parallelogram is the same as it is for a rectangle.

Watch out for…

- Students who do not recognise the need to work in the same measure units when solving problems involving measure.
- Students who use informal names for shapes, such as 'diamond' for a rhombus.
- Students who recognise shapes only when they have a horizontal base.
- Students who incorrectly reach their own conclusions about shapes. For example, having been told that rectangles, squares and triangles are all polygons, they assume all 2D shapes (including circles) are polygons.
- Students who do not recognise that a square is a rectangle, or a cube is a cuboid.
- Students who can name only regular polygons. For example, they only recognise a regular hexagon as a hexagon, and not any six-sided polygon to be a hexagon.
- Students who confuse 'regular' for 'symmetrical'.
- Students who cannot distinguish clockwise from anti-clockwise because they have had little experience of a clock face.
- Students who confuse alternate and corresponding angles.

ALGEBRA

Students should have a good understanding of using letters to represent unknown numbers from primary level. It is vital to build on this and move towards a more formal algebraic understanding.

Differentiation p. 17

Checking progress in algebra

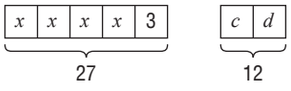
At Lower Secondary level, students deepen their understanding of algebraic representations. They should begin to appreciate the differences between, for example, formulae (where two or more quantities are connected), equations (where there are one or more unknown variables represented as a letter or letters), properties (where patterns are generalised) and functions (where two or more variables are related). Students also experience a range of algebraic actions, including simplifying, solving, expressing relationships, generalising and graphing.

Teaching approaches for algebra

Support students with pictorial representations.

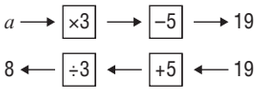
- Those used in number work, such as bar models.

$4x + 3 = 27$ $\quad$ $c + d = 12$



- New pictorial representations, such as function machines.

$3a - 5 = 19$



Enabling students to understand algebra

For students to experience success in algebra, they need to understand the nature of a variable, that is, its value is not always the same and can vary. They also need to understand the particular conventions of algebra, which are not always obvious. For example, the different uses of the 'equals' sign:

- = meaning 'equivalent to' for expanding brackets, such as $2(x - 3) = 2x - 6$
- = meaning 'equal to, for some value of x' for solving equations, such as $2(x - 3) = x - 2$

Watch out for…

- Students who think the variable stands for a word, for example, a is always for the number of apples, or n is the only letter that can be used for an unknown any number. Avoid this misconception by discussing with students whether it matters which letter is used for a variable.
- Students who find it difficult to accept the nature of variables. For example, just because you determine $x = 2$ for one particular equation, this does not mean that $x = 2$ for every equation involving an x. Furthermore, just because $x = 2$, this does not mean that it is not possible for $y = 2$ as well.
- Students who confuse x for the multiplication operation $\times$, especially when they are writing algebraic expressions or equations themselves.

GRAPHS

Students will have had lots of experience of graphical representations of information in pictograms, bar charts and pie charts at Primary level. In later Primary years, they may also have had some experience at interpreting simple line graphs. It is vital to build on this, and move towards a more formal understanding of graphs in relation to algebra.

Checking progress in graphs

At Lower Secondary level, students begin to understand the graphing of one numerical variable (on the x-axis) against another numerical variable (on the y-axis), and the relationship between them. This may be in a real-life context, like conversions of currencies or measures, or distance–time graphs. It may also be in a more algebraic context, such as the graphing of an equation. Students are also required to develop the skills to draw graphs.

Teaching approaches for graphs

Collaborative activities p. 24

If possible, give students lots of opportunities to draw graphs using computer software, and to discuss the interpretation of results. This will prevent graph-drawing skills getting in the way of developing an understanding of the meaning of graphs. Then, when students move on to drawing graphs, they will already be confident in graphical interpretation, and they are more likely to recognise any errors in their drawing (such as a point they have incorrectly plotted).

Enabling students to make sense of different types of graphs

Developing thinking skills p. 27

Help students understand the different nature of a ‘real-life’ graph and an algebraic graph.
For example, on a ‘real-life’ graph, students plot data points. What happens between those points is a conjecture, perhaps informed by a trend. However, for an algebraic graph, such as the graph of a formula, all points show the exact relationship between variables. Furthermore, an algebraic graph may naturally extend into negative values, but this may not make sense for a ‘real-life’ graph.

Watch out for…

- Students who struggle with the labelling of axes. For example, some students confuse the continuous number line of a line graph axis with a discrete set of numbers. Therefore, they treat the axis as they would a bar chart; placing numbers between axis markers rather than on them, and starting the axes at a number other than 0.
- Students who struggle with the scaling of axes. For example, they assume all scales must be in steps of ones or tens, like they are for metric measures.
- Students who misinterpret distance–time graphs, assuming the path of the graph shows the journey it represents.
- Students who misinterpret graphs that show a rate of change, thinking that a steep graph indicates high values for y, or that large numbers on the y-axis suggest a faster rate of change (that is, confusing the concepts of faster and higher).

STATISTICS

Developing thinking skills p. 27

Students should have a good understanding of collecting, organising, recording, displaying and interpreting data and using a range of graphical representations from Primary level. They will also have some experience of calculating various types of averages.

Checking progress in statistics

At Lower Secondary level, students extend their understanding of graphical representations to include, for example, stem and leaf diagrams, and scatter graphs. They deepen their understanding by reasoning with data by, for example, comparing data sets using range and averages, choosing appropriate statistical diagrams for particular data sets, explaining why some data is biased or a statistical diagram is misleading. Students are also introduced to experimental and theoretical probability.

Teaching approaches for statistics

Engaging everyone p. 15

- Choose real-life data that you know students will be interested in.

  For example: data on young people's use of technology or local, national or international sports events.

- Engage students in decision making based on real-life probabilities.

  For example: the probability of it raining tomorrow – should you take an umbrella? Or the probability of accidents on a specific road – should you take a different route?

- Find examples of representations of data and probabilities in news stories or marketing literature so students become familiar with how they are used in real life.

- Encourage students to take a particular view of statistical diagrams by looking carefully at any keys, scales on the axes and points that are plotted. Then encourage students to take a general view by looking for data trends and peaks or troughs, leading towards a wider view.

  For example: making projections beyond the data or considering the nature of the data source and if it may be biased.

- Encourage students to recognise that data handling is a process of posing questions and then collecting data, which is interpreted and used to answer those questions. Then new questions are asked.

- Look at topics covered in other curriculum subjects and find ways to use statistics or probability to support students' understanding of those topics.

  For example: the representation of data in geography or the probability of an outcome in a science experiment.

Watch out for…

- Students who begin axes at 1. These students may be relating the numbers on an axis to counting (where they start at 1), rather than a scale of measurement (where they start at 0).
- Students who use inconsistent scales on axes. For example, a scale that reads 0, 2, 3, 5, etc. These students are likely choosing the numbers on the axis that relate to the data values that they have.
- Students who use inappropriate statistical diagrams for a data set, for example, a line graph for discrete data.
- Students who, when comparing two pie charts, look at the size of sectors without considering the quantity they represent.
- Students who, when finding the median of a data set, state the middle value of the set without ordering the data.
- Students who, when finding the mode of a data set, state the number of times a data point occurs, rather than the data point itself.
- Students who base their answers for probability on experience rather than equally likely outcomes. For example, the student who thinks that a throw of a number cube will definitely not result in a 6 because it has landed on 6 twice already.

MAKING LINKS BETWEEN MATHEMATICAL CONCEPTS

Students often perceive mathematics as a collection of distinct topics. However, it is important for them to understand how mathematical concepts interconnect.

The benefits of making links between mathematical concepts

When students understand the link between two mathematical concepts, they gain a deeper understanding of both those concepts.

Examples of making links between mathematical concepts

There are so many ways that mathematical topics and concepts are interconnected. Here are just a few examples:

Place value links to decimals

- ➔ decimals link to fractions
- ➔ fractions link to ratios
- ➔ ratios link to scale
- ➔ scale links to similarity
- ➔ similarity links to trigonometry

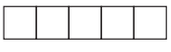
Of course, each of these concepts could also link to many different mathematical concepts.

Developing thinking skills p. 27

Tips to help make links between mathematical concepts

Use the same representations across concepts to help students visualise the links.

For example, consider this bar model:



It could be used to represent:

- multiplying by 5
- dividing by 5
- fifths
- decimals of 0·2
- percentages of 20%
- ratios of 1:4, 2:3, 4:1, 3:2
- the algebraic expression $5x$

Something for you to try

- Begin lessons with a starter activity that practises relevant previously learned concepts. This will encourage students to make connections.
- During lessons, ask students which previously learned concepts they are using.

Effective questioning p. 21

MATHEMATICAL FLUENCY

Mathematical fluency involves students knowing key mathematical facts and methods, and recalling them efficiently. This does not mean drilling until students memorise them. Rather, it means providing opportunities for students to progress from inefficient methods to more efficient ones, and then to rapid recall.

Teaching approaches for mathematical fluency

- Give students lots of opportunities to explore methods.

  For example, ask students to mentally solve a calculation such as 3251 + 149. Then, ask them to describe the method they used. Students may answer:

  Start at 3251
Count up 9 to 3260
Count up 4 tens to 3300
Count up 1 hundred to 3400

  or

  $51 + 49 = 100$
$200 + 100 = 300$
$3000 + 100 + 300 = 3400$

  or

  $3251 + 149 = 3250 + 150$
$3250 + 150 = 3250 + 100 + 50$
$= 3400$

  Discuss why each method works, and decide on the most efficient.

The benefits of mathematical fluency

- Mathematically fluent students will find more complex mathematical tasks and problem solving easier. This is because they do not have to waste 'processing power' working out, or retrieving, mathematics facts or methods. Also, working with efficient methods means that they are less likely to make errors in their working.

Checking progress in mathematical fluency

Students' progression in fluency may look like this.

Progression	Example
Using an inefficient method to work out an answer ↓	Factorising by listing all factors, circling those that are common, then identifying the highest common factor. For example, to factorise $12x + 18$: • Factors of 12: 1, ②, ③, 4, ⑥, 12 • Factors of 18: 1, ②, ③, ⑥, 9, 18 Using the highest common factor, 6: $12x + 18 = 6(2x + 3)$
Recognising there is more than a single method, and choosing a more efficient one to generate an answer ↓	Factorising by continually removing any common factor until this is no longer possible. For example, to factorise $12x + 18$: $12x + 18 = 2(6x + 9) = 2 \times 3(2x + 3) = 6(2x + 3)$
Rapid recall of the most efficient method	Factorising by removing the highest common factor. For example, to factorise $12x + 18$: $12x + 18 = 6(2x + 3)$

Something for you to try

1. Before the lesson

- Consider the mathematical fluency essential to the content of that lesson.

  For example, if you are going to be converting between different metric units of measure, students would benefit from being fluent in multiplying and dividing by powers of 10.

- Plan a starter activity to allow students to practise the required mathematical fluency.

SMALL STEPS IN MATHEMATICAL LEARNING

Students need to be offered just the 'right' amount of challenge, at just the 'right' moment, to ensure sound mathematics understanding, while also continuing to make progress.

The benefits of small steps in mathematical learning

- Small steps in mathematics learning allow *every* student, whatever their ability, to progress with confidence.

Teaching approaches for incorporating small steps in mathematical learning

- Break down mathematical concepts into small achievable steps that allow students to demonstrate their understanding. This way, students will not feel overwhelmed by meeting lots of new information about a concept all at once.
- Give students enough practice on each small step so that they can confidently tell you that they understand the mathematics. Only then move on. If students are really struggling, intervene immediately to help them to understand the mathematics. Then give them practice to build their confidence.
- If students grasp a concept and demonstrate understanding quickly, then do not introduce another mathematical concept. Rather, give the students opportunities to deepen their understanding further before moving on.

Examples of ways to intervene when students are struggling

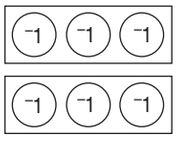
Differentiation
p. 17

- **Use concrete manipulatives and visual representations**

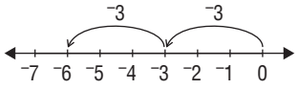
  For example:

  $2 \times {}^{-}3 =$

  Make negative number disks

  Use number lines

- **Use patterns**

  For example:

  $2 \times 3 = 6$ $2 \times 2 = 4$ $2 \times 1 = 2$ $2 \times 0 = 0$ $2 \times {}^{-}1 = {}^{-}2$ $2 \times {}^{-}2 = {}^{-}4$ $2 \times {}^{-}3 = {}^{-}6$

Examples of ways to intervene when students grasp a concept quickly

Differentiation
p. 17

- Use problem solving or reasoning tasks that require students to think more deeply about the mathematics concept and methods.

  For example, ask students: *If two numbers multiply to give an answer of ⁻6, what could the numbers be?*

- Identify questions that make links to other mathematical concepts and/or real life.

Something for you to try

1. Before the lesson

Look at the content for a lesson and plan the following:

- how you will intervene to help students who are really struggling
- how to stretch students who grasp a concept quickly.

MATHEMATICAL ERRORS AND MISCONCEPTIONS

A mathematical error may be made for many reasons, for example, misreading a question or being careless in working. Whereas, a mathematical misconception is where a student has an incorrect idea about a mathematical concept.

The benefits of addressing errors and misconceptions

- Students should understand that errors and misconceptions are not to be hidden. Rather, they are an opportunity to learn from their mistakes and progress in their understanding.

Example of errors and misconceptions

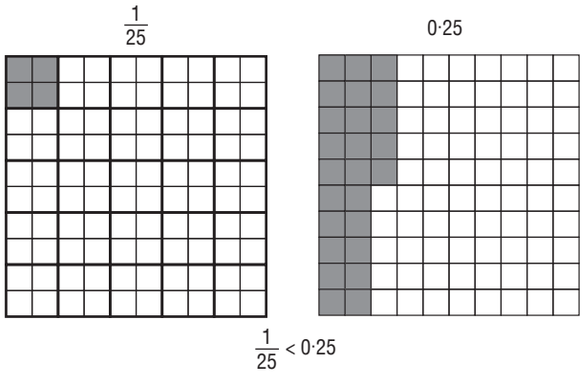
A student who is asked to compare $\frac{1}{25}$ and 0·25 may answer:

- $\frac{1}{2}$ is bigger, demonstrating an error in reading the question
- they are the same – revealing a misconception.

The misconception is that the digits in the denominator of the fraction are the same as those in the decimal part of the number. This student does not understand the relationship between fractions and decimals. This misconception can be addressed by:

Using pictorial representations,

like 100-squares:



or place value tables:

$\frac{1}{25} = \frac{4}{100} =$

Ones	•	Tenths	Hundredths
0	•	0	4
0	•	2	5

0·04 < 0·25, so $\frac{1}{25}$ < 0·25

Teaching approaches for addressing errors and misconceptions

Effective questioning p. 21

Collaborative activities p. 24

Reflection on learning p. 29

- Ask students to explain their answer – this will reveal their understanding of a concept.
- Give students a 'pretend' student's incorrect answer, and then ask them to discuss in pairs what the student has done wrong and why – this enables students to openly discuss misunderstandings without fear of judgement.
- Acknowledge that even the best mathematicians make mistakes: it is how they learn. This will encourage students to be honest when they get an answer incorrect, and seek to learn from it.

MATHEMATICAL DISCUSSION

Collaborative activities p. 24

Mathematical discussion, in pairs or small groups, allows students to use the language of mathematics and reinforce their understanding.

The benefits of mathematical discussion

Mathematical discussion gives students the opportunity to:

- explain mathematical concepts in their own words
- share mathematical ideas
- recognise mathematical errors for themselves
- have mathematical misconceptions challenged
- justify their mathematical understanding
- refine their mathematical thinking.

Examples of conceptual questions to stimulate mathematical discussion

In pairs or small groups, you may ask your students to discuss the following conceptual questions:

- *When converting between metric units of measure, how do you know whether to multiply or divide?*
- *Is 1:4 the same as 4:1?*
- *Is $x + 4x$ the same as $4x + x$? How do you know?*
- *Is $x - 4x$ the same as $4x - x$? How do you know?*
- *What is the same and what is different about the graphs of $y = 4x$ and $y = {}^{-}4x$?*
- *How many different shapes can you draw with an area of 20 cm?*
- *Why don't you need to state clockwise or anti-clockwise when rotating a shape by 180°?*

Something for you to try

1. Before the lesson

Decide on two different questions you will ask to stimulate mathematical discussion.

2. During the lesson

Walk around the classroom and listen to the students' discussions. Pay attention to the mathematical language they use and the mathematical understanding they reveal.

3. After the lesson

Choose three individual students. Reflect on how these students' learning may have benefited by engaging mathematical discussion. Consider what gaps they may have in their knowledge and plan how to address these in future lessons.

WRITING MATHEMATICS

Writing mathematics is a fundamental part of learning mathematics. It is also how students will need to demonstrate their understanding in homework, written assessments and tests.

The benefits of writing mathematics

Writing enables students to clarify their understanding and to communicate their mathematical thinking. Clear mathematical writing should be a habit that is instilled in children from an early age.

Enabling students to write mathematics

- Encourage students to write clearly. For example, do not accept answers where a 3 is written back to front as Ɛ, or 7054 where the digit '7' could be read as 1054.
- Encourage students to record every step of their mathematical working. Model and explain this when you demonstrate answering mathematics questions on the board.

Teacher demonstration p. 26

- Encourage students to draw neat diagrams, even if they are a sketch. Where appropriate, they should use a ruler.
- If a student makes an error, encourage them to neatly cross it out rather than erasing it. This will give you, as their teacher, an insight into the flow of their thinking.
- Always correct errors in mathematical working, such as misuse of the equals sign. For example, having asked students to convert 15 m to kilometres, correct those who write $15 = 15 \times 1000 = 15\,000$ km.

Feedback (in both directions) p. 30

- Ensure students write answers accurately, with unit measures where required.
- Encourage students to write full sentences when answering a word problem or when asked to explain an answer.

Examples of writing tasks to develop mathematical understanding

- When students meet new mathematical symbols, ask them to write a translation of them in words.

  For example, red : blue = 3 : 2. This means the ratio of red to blue is 3 to 2, or there are 3 reds for every 2 blues.
- When there is a mathematical diagram, ask students to write a sentence that describes it.
- After students solve a word problem, ask them to write a similar one in their own words.

Feedback (in both directions) p. 30

- Give students a 'pretend' student's written working and ask them to tell you what is good and what is bad about it.

Watch out for…

- Students whose mathematical written work largely comprises single number or word answers. These students are not getting enough practice at communicating by writing mathematically.
- Students who forget to include the unit of measurement (when required) in their final answer.

MATHEMATICAL QUESTIONING

Effective questioning p. 21

Mathematical questions may be *closed*, with a single answer, or *open*, with many possible answers. Both types of questioning should be used in mathematics lessons.

The benefits of using both types of mathematical questioning

Answers to closed questions allow you to quickly check that students have a correct answer. Whereas, answers to open questions allow you to get more insight into students' mathematical thinking.

Examples of open and closed mathematical questions

Closed	Open
• Work out: $3 \times {}^{-}4$ $\quad {}^{-}4 \times 3$ $\quad 6 \times {}^{-}2$	• **How many different ways can you** multiply two numbers and get a total of $^{-}12$?
• Is 12 a cube number?	• **Give me an example of** a cube number. **Can you explain why** it is cube?
• How many sides does a regular hexagon have?	• **What is the same and what is different about** regular and irregular shapes?
• What is the order of rotational symmetry of this shape?	• **How can you change this** shape so that its order of rotational symmetry is one less (or one more)?

Note the beginnings of the open questions, written in bold. These could be used for the beginnings of many different open mathematics questions.

Tips to create open mathematical questions

- Decide what mathematical understanding you want students to demonstrate when they answer your question.
- Pose a mathematical question with enough openness to allow students to find different answers, but not so open that students could get frustrated.
- A good way of devising open questions is to give an answer and ask students for the question.

  For example: *A number is rounded to 3·2 to 1 decimal place. What could the number be?*
- Plan two types of prompt questions.

  1. Questions to help students get started.

  For example: *How could you use a number line? What numbers would you put on your number line?*

  2. Questions for students who finish quickly.

  For example: *What if a number is rounded to 3·25 to 2 decimal places? What could the number be then?*

Something for you to try

1. Before the lesson

- Write down three closed questions you may ask. Write down the answers. Now adapt each closed question to make it an open question. Write down possible answers.

MATHEMATICAL PROBLEM SOLVING

Developing thinking skills p. 27

Mathematical problem solving involves students deciding on the step (or steps) they need to take to tackle a problem. Practice in mathematical problem solving enables students to demonstrate their language and communication skills as well as their mathematical understanding.

Enabling students to problem solve

Collaborative activities p. 24

Students must learn some problem-solving strategies in order to become successful problem solvers. Encourage students to work in pairs and discuss possible strategies before beginning work on a solution. As students become familiar with different strategies, list them on a poster for your classroom wall. That way students will always have a reminder of an approach to try when faced with a mathematical problem.

Examples of problem-solving strategies

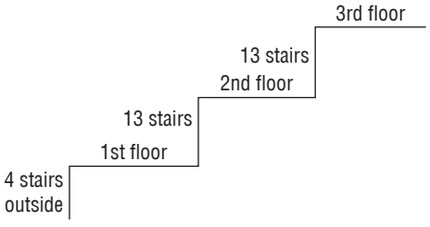
Teach students a variety of strategies for problem solving, including the following.

- **Read one sentence at a time and decide on the maths to do**

  For example: *Nenet has a puzzle book. She does 14 puzzles each day. She does this for one week. There are 17 puzzles on every page. What page is Nenet on at the end of the week?*

- **Draw a picture**

  For example: *Ali lives on the 3rd floor of an apartment block. To get to his apartment, he goes up four stairs outside. He enters the block on the 1st floor. Then there are 13 stairs between floors. How many stairs to Ali's apartment?*

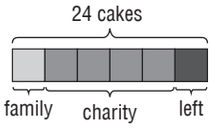


- **Draw a bar model**

  For example: *Sophia makes 24 cakes. She shares them in the following ratios:*

  for family : for charity sale : leftovers = 1 : 4 : 1

  How many cakes does she give to the charity sale?



- **Work systematically**

  For example: *Sam has a red coat, a blue coat and a grey coat. He also has a green cap, a white cap and a black cap. How many different ways can he wear his coloured coats and caps?*

Red coat → green cap	Red coat → white cap	Red coat → black cap
Blue coat → green cap	Blue coat → white cap	Blue coat → black cap
Grey coat → green cap	Grey coat → white cap	Grey coat → black cap

Watch out for…

- Students who are struggling with the English language, rather than mathematics. Check they understand *every* word in a problem.

MATHEMATICAL REASONING

Developing thinking skills p. 27

Mathematical reasoning involves students being aware of *why* they used some mathematical knowledge, skill or method.

The benefits of mathematical reasoning

- Students may be able to state what they know, and show what they can do, mathematically. However, when they can also reason *why*, you gain an insight into their thinking and understanding.

Examples of mathematical reasoning

- Consider the queston: *Which is larger* $\frac{3}{5}$ *or 53%?*

  Students may give the correct answer of $\frac{3}{5}$, but you have little insight into their understanding. You do not even know if they have guessed.

- Now consider this question: *Which is larger* $\frac{3}{5}$ *or 53%? Explain.*

  Students must not just give the correct answer, but also state why it is correct, thus demonstrating their understanding of the relationship between fractions and percentages.

Teaching approaches for mathematical reasoning

Developing thinking skills p. 27

- Support students by encouraging them to, first of all, vocalise their reasoning in pairs.
- Then support their writing by giving them the beginning of a reasoning statement and asking them to complete it.

  For example: $\frac{3}{5}$ *is larger because* _____.

Watch out for…

- Students who may need additional help with their English language in order to describe their reasoning either in spoken or written English.

Something for you to try

1. Before the lesson

- Consider some of the questions you plan to ask students. Choose at least three where you could ask them to reason. You may also ask them to explain their answer or the method that they used.

MATHEMATICAL LINKS TO OTHER SCHOOL SUBJECTS

There are many links between mathematics and other school subjects. Sometimes these links are obvious, such as those to science or geography. At other times links to mathematics may not be so obvious, such as when building the set for a school drama performance, or recording the fastest time in a school sports event.

The benefits of making mathematical links to other school subjects

Helping students to become aware of the links to other school subjects not only gives a purpose to the mathematics they are learning, but also helps them to progress in both subjects.

Examples of mathematical links to other subjects

- In science, students use number, algebra (in particular, formulae), geometry (in particular, measure) and statistics (in particular, handling data).
- In geography, students use number and statistics.
- In ICT (computing), students may use number, algebra, geometry and statistics.
- In art and design, students may use geometry (in particular, shape).
- In music, there are mathematical patterns and sequences.

The benefits of linking mathematics and English-language learning

In mathematics there are numerous opportunities for learning and reinforcing English-language learning. For example:

- the use of mathematical vocabulary
- interpreting word problems
- discussing and writing explanations of methods and answers
- developing an understanding of conjunctive adverbs, like ‘therefore’ and ‘thus’
- developing an understanding of ‘if…then’ clauses.

Enabling students to make mathematical links to other subjects

- Consider the curriculum and schemes of work for other subjects. Look at the timing for when concepts that link to mathematics are to be taught.
- Ensure the necessary mathematics has already been covered to support the learning in the other curriculum subjects.
- Discuss with the teacher(s) of those subjects how they can reinforce what has been learned, or what is needed (in the case of English language) in mathematical learning.

Something for you to try

Plan a display somewhere in the school that shows how the learning of different curriculum subjects link and support each other. Include students’ work in the display as examples.

MATHEMATICAL LINKS TO THE REAL WORLD

Links between mathematics and the real world demonstrate the usefulness of mathematics to students. It also makes the mathematics more relevant.

The benefits of making mathematical links to the real world

The purpose of mathematics becomes clear to students when they are given a real (rather than a contrived) mathematics problem. This often further engages them in the mathematics.

Examples of making mathematical links to the real world

Engaging everyone p. 15

Use contexts that are of relevance to the students. For example:

- populations of local villages, towns and cities, when working on very large numbers or percentages
- costs of local goods and services when working on decimals and money
- pizzas, cakes and bars of chocolate when working on fractions
- distances to places students may travel to when working on measure or distance–time graphs
- product logos (for products you know students like) when working on symmetry
- packaging design when working on transformations
- data on local sports teams or local weather when working on statistics
- cost of entry for a family to local leisure facilities, when working on solving problems.

Tips for collecting resources for making links to the real world

- Photograph examples of mathematics in everyday life.

  For example: a timetable at a bus station, a sale percentage sign in a shop window, a news headline that includes a very large number or a street sign showing a speed limit.

- Save the photographs with the name of the mathematical concept they could be used for, and put them in a folder called ‘mathematics photos’. Look at your folder regularly to see what photos you could use in a lesson.

Something for you to try

1. Before the lesson

- Look at what you will be teaching and decide how you can make a mathematical link to the real world.

2. During the lesson

- Watch how students respond to the real-world link. Reflect on whether they all seem more engaged.

REFLECTION ON MATHEMATICAL LEARNING

Reflection on learning p. 29

Reflection on mathematical learning involves students thinking about how they learn mathematics. Students may do this alone, allowing them to develop insights into their own learning without being influenced by others. However, reflection can be enhanced through discussion too.

The benefits of encouraging students to reflect on their mathematical learning

Reflection enables students to become aware of their own mathematical knowledge and skills, their thinking processes, their progress and their attitudes. This enables them to become better, and more independent, mathematics students.

Developing thinking skills p. 27

Teaching approaches for reflection on mathematical learning

1. Awareness of mathematical knowledge and skills

- When beginning a lesson, share the learning objectives with students. Discuss what mathematical knowledge and skills they already have that may help them during the lesson.

2. Awareness of thinking processes

- When demonstrating working through a mathematical problem at the board, vocalise your thinking so that students begin to understand that being good at mathematics does not necessarily mean knowing what to do immediately. Encourage students to sometimes vocalise their thinking processes too, in pairs.

- When students are working through a mathematical problem, ask if their method is working well and if there is a different method they could try. Encourage them to compare the methods and decide which is best and explain why.

3. Awareness of progress

- After completing a mathematical problem, or even a test, ask students to write down whether or not they feel confident in their answer(s). If not, why not?

Enabling independent learning p. 19

- Discuss with students what to do if they get stuck on a mathematical question. (This should be addressed early on with students, so that they have practised their strategies before they take formal assessments and tests.)

4. Awareness of attitudes

- Discourage phrases such as ‘I don’t know’ and ‘I can’t’. Instead, encourage students to think about what mathematical knowledge, skills and understanding they already have that may enable them to overcome their difficulty.

Examples of reflection on mathematical learning

- Ask students to reflect on the prior knowledge and skills they have used when learning a particular concept. For example, when working with percentages they may recognise that they are mostly using their multiplication and division skills.

- Ask students to write down an easy equation to solve and a hard equation to solve. Discuss with them what makes the equations easy or hard. This will encourage them to think about their understanding of the nature of equations.

- At the end of a week, ask students if they have honestly done their best this week and how they know they have done their best. If not, what could they do next week to improve their mathematical learning?

ESSENTIAL MATHEMATICAL VOCABULARY

Below is a list of some of the key mathematical vocabulary for iLowerSecondary.

Number

- **Integers:** whole numbers, zero, one, two… etc., digit, positive, negative
- **Place value:** billion, million, hundred thousands, ten thousands, thousands, hundreds, tens, ones, decimal point, decimal, tenths, hundredths, thousandths, recurring, terminating
- **Addition and subtraction:** add, plus, sum, more, altogether, total, subtract, take away, minus, difference
- **Multiplication and division:** remainder, left, multiply, times, times table, lots of, groups of, product, double, twice, divide, share, factor, highest common factor, multiple, lowest common multiple, prime, prime factor, square number, cube number, reciprocal
- **Comparing numbers:** order, smallest, largest, greatest, inequality
- **Rounding:** round, close, near, between, halfway, decimal places, significant figures, upper and lower bounds
- **Laws of arithmetic:** brackets, inverse, operation, power, root, indices, index notation, standard form
- **Fractions:** fraction, denominator, numerator, equivalent, proper fraction, improper (vulgar) fraction, mixed number, simplest form
- **Percent:** percentage, simple interest, percentage increase/decrease, percentage change
- **Ratio and proportion:** in every, for every, unit ratio, proportion, direct proportion
- **Sequences:** term, rule, next

Algebra

- **Algebraic terms:** algebra, variable, term, expression, equation, function, identity, formula, unknown, linear, quadratic, simultaneous, inequality
- **Algebraic actions:** simplify, solve, factorise, expand, substitute
- **Sequences:** generate, terms, term-to-term, position-to-term, nth term, arithmetic, geometric
- **Graphs:** axis, axes, origin, x-axis, y-axis, coordinates, plot, midpoint, linear, gradient, rate of change

Geometry

- **Measure:** unit, metric, scale, length, height, mass, weight, capacity, volume, temperature, conversion, compound measure
- **Units:** millimetre, centimetre, metre, kilometre, gram, kilogram, litre, millilitre, degrees Celsius
- **Time:** second, minute, o'clock, am, pm, half past, quarter past, quarter to, hour, day (including days of the week), week, month (including months of the year), year
- **Lines:** straight line, horizontal, vertical, perpendicular, parallel, side, diagonal
- **Angles:** right angle, acute, obtuse, degrees, protractor, vertically opposite, adjacent, corresponding, interior, exterior

- **2D shapes:** rectangle, square, circle, triangle, trapezium, parallelogram, rhombus, kite, polygon, regular, irregular, quadrilateral, compound shape, congruent, similar
- **Triangles:** equilateral, right-angled triangle, scalene, isosceles, Pythagoras' theorem, trigonometry, sine, cosine, tangent
- **Circles:** radius, diameter, circumference, arc, compass
- **Construct:** construction, bisector
- **Perimeter, area and volume:** surface area volume, squared, cubed
- **3D shapes:** solid, cuboids, cube, cylinder, pyramid, prism, right prism, face, vertex, vertices, net
- **Symmetry:** mirror line, line of symmetry, reflection, rotational symmetry, coordinate grid
- **Transformation:** translation, reflection, rotation, enlargement, scale factor
- **Maps and bearings:** scale, bearing, scale drawing
- **Position:** left, right, clockwise, anti-clockwise, up, down, top, bottom, in front, inside, outside
- **Money:** coin, note, change (students should also know the names and values of local currency coins and notes)

Statistics

- **Table:** two-way table, tally chart, frequency tables
- **Bar chart:** bar-line chart, dual bar charts, compound bar charts
- Pie charts
- Stem and leaf diagram
- **Scatter graphs:** correlation, line of best fit
- Frequency polygon
- **Spreadsheets:** column, row, cell
- **Data:** information, grouped data, continuous, discrete, primary, secondary, questionnaire, data collection sheet, outlier
- **Averages:** mode, median, mean, range, modal set
- **Probability:** probability scale, outcome, equally likely outcomes, event, mutually exclusive event, independent event, experimental, theoretical

General words

- amount, calculate, classify, compare, continue, convert, describe, estimate, express, order, pattern, simplify, solve, sort, work out

iLowerSecondary assessment

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

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

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

FORMATIVE ASSESSMENT

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

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

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

1. Where is the student going?

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

2. Where is the student now?

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

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

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

The benefits of formative assessment

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

- clear, 'actionable' feedback helps students to improve future work and achievement
- in 'formative assessment' classrooms, students become better all-round students and may do better in examinations

- where formative assessment is used consistently, students take more responsibility for their own learning and have good learning conversations with teachers.

Examples of formative assessment strategies

Assessment in mathematics p. 63

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

SUMMATIVE ASSESSMENT

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

Summative assessment can include:

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

The benefits of summative assessment

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

The iLowerSecondary summative assessment programme

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

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

1. iLowerSecondary progress tests

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

This helps the teacher to:

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

This helps students to:

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

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

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

Question types may include:

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

2. iLowerSecondary end-of-year tests

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

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

Preparing students for summative assessment

1. General tips to prepare students

- Go through an example test so that students know what the actual test papers will look like. You might choose to look at a past year's papers, or a combination of progress tests.
- Practise test conditions in the classroom (silence, rules for asking questions if needed, etc.).
- Teach students techniques for time management when carrying out tests, for example, moving on if an answer is difficult and coming back to it at the end.
- Explain the importance of attempting all questions in the test; there are no penalties for incorrect answers, so they have nothing to lose.
- Model answers for the class and encourage students to share in this process by getting them to model answers to the whole class too.

- Students should be writing in **black** ink for externally marked assessments, not blue ink or pencil. It is advisable to encourage them to plot graphs or join boxes lightly in pencil first. Then check it and go over their final answer in black ink.
- Explain the importance of reading questions carefully.
- Reassure students not to worry when they don't know an answer but to 'have a go'.
- Explain that if they change their mind they can cross out their first answer and write the answer they want to be marked clearly.
- Discourage students from writing alternative answers. These cannot gain a mark because the student has had *two* attempts at the answer.
- Explain to students that the space provided for an answer on the test paper gives a clue as to what type of answer is needed. For example, if the space provided is a short line or a box, only a few words are needed. For a space consisting of two or three lines, students should write a longer answer.
- Remind students to read over their answers.

2. Revision techniques

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

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

3. Setting practice tests

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

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

- If possible, use the same room, desk arrangement and seating plan as for the real test.
- Give students all the equipment they can expect to have for the real test. For example, for mathematics this might consist of a ruler graduated in centimetres and millimetres, pen, HB pencil, eraser and tracing paper.
- Do not allow students to have anything other than the specified equipment for the real test, and the face-down question paper, on their desk.
- Set up a clock on the wall that all students can see.

- Give students the same instructions as you will give at the beginning of the real test. For example, tell them:
    - how long they have to do the test, and the end time on the clock
    - to keep the test paper face down until they are told that they may turn it over
    - to put their name and any other required details in the spaces for these on the test paper
    - that they must keep their eyes forward and on their work
    - there is to be no talking or trying to communicate with other students
    - if they have a question, raise their hand, and a teacher will come to them
    - to read each question carefully before they start to answer it
    - to try to answer every question
    - to check answers if they have time at the end.

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

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

4. Reviewing test results

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

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

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

- Having completed the marking, work through each answer to test questions with the whole class, offering explanations and discussing reasoning as you go. Advise students to make a note of any question numbers where they still feel unsure (even if they got it correct). Encourage students to discuss the question with other students, or you, as their teacher.

- Give students time at the end for going through a test to decide on the concepts they need additional practice with. Use this decision to inform the work students do as part of their revision programme.
- Make testing a positive experience! When reviewing test results, try to offer two pieces of praise for every criticism. A returned test paper full of red marks will not encourage students to continue practising.

5. Useful assessment vocabulary

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

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

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

Assessment in mathematics

WAYS OF ASSESSING IN MATHEMATICS (FORMATIVE ASSESSMENT)

Assessment should be an ongoing and integral part of your mathematics classroom, informing both your teaching and your students' learning. This does not always mean using a written test to check that students understand a particular concept, or concepts.

It may mean:

- Assessing students' **mathematical fluency**:

  Check students can quickly and accurately recall, not just number facts (like $\frac{1}{3} = 0{\cdot}3\dot{3} = 33\%$), but mathematical procedures.

  For example: check students know efficient ways to subtract from 90, 180 and 360 before they do work on angles.

- Assessing students' understanding of **mathematical language**:

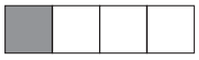
  Give students a list of mathematical words relevant to the concept they are learning, and ask them to write down, or explain to each other, what they mean.

  For example: when working on graphs, check students know words such as 'title', 'axes', 'horizontal', 'vertical', 'origin', 'scale', 'coordinate' and 'plot'.

- Assessing that students can recognise **links between mathematics concepts**:

  Check students can answer questions that do not simply test their understanding of the concept they have been learning, but link to other mathematics concepts too.

  For example: when assessing their understanding of pictorial representations of ratios, check they understand the link to fractions.



What is the ratio, shaded : white?

What fraction of the rectangle is shaded?

- Assessing students' **mathematical discussion**:

  Ask students to write down three things they learned during a mathematics discussion.

  For example: having discussed whether $8(x + 7)$ is equivalent to $8x + 7$, students may write down:

  I learned:

  1. *Brackets in algebraic expressions mean the same as brackets in number expressions.*
  2. *You have to multiply the number outside the bracket by* ***everything*** *inside the bracket.*
  3. *I need to practise my 8 times table!*

- Assessing students' **mathematical problem solving**:

  When students are problem solving, assess the following areas, giving them as much (or equal) emphasis as getting the correct answer.

1. Conceptual understanding of the problem

Did the student:

- identify the important information required to solve the problem?
- discuss the problem in a way that showed that they knew what was required?
- use diagrams, pictures and symbols to explain thinking and/or working?

2. Procedural knowledge

Did the student:

- use appropriate mathematical notation and algorithms?
- accurately use mathematical language?
- check their answer to make sure it was correct?

3. Problem solving skills and strategies

Did the student:

- show evidence of trying more than one way to solve the problem?
- use means to help organise their approach (for example, listing or tables)?
- use means to help communicate their approach (for example, diagrams or clear working)?

4. Communication

Did the student:

- show all steps in their working?
- use full and correct sentences to summarise their findings, using accurate mathematics vocabulary and terminology?

- Assessing students' **mathematical reasoning**:

  Check students do not just know 'how' to reach an answer, but also 'why' it works.

  For example: give students some questions and answers from a 'pretend' student who has made common errors. Ask students to mark the work, and highlight what the 'pretend' student has done wrong, and what they should do to correct it.

Note: a student that does well in the assessments described above is likely to do well in mathematics tests.

PREPARING STUDENTS FOR A WRITTEN MATHEMATICS TEST (SUMMATIVE ASSESSMENT)

Examples of guidance for different mathematical question types

- For multiple-choice questions, check students understand exactly where to place their cross to indicate a chosen answer. Also, ensure students understand that if they change their mind, they must put a horizontal line through the chosen box, and then put a cross in an alternative box. Give students the opportunity to practise answering these types of questions. Emphasise that if they appear to choose more than one box when the question only asks for one answer, they will not get any marks.

- For questions where students are asked to draw lines (for example, on a grid or sides of a shape), check students know to use a ruler and pencil.

- For questions where students are asked to draw lines to match items in one column to relevant items in another column (for example, join angles to the labels 'acute', 'obtuse', etc.), check students know to use a straight line, and to ensure their line touches the boxes in both columns.

- For questions where students are asked to 'Fill in the boxes' (for example, to write a missing number), check students know to write their answers inside the boxes.

- For questions where students are asked to order items, check they understand the meaning of 'start with the smallest' or 'start with the largest'.

- Check students are familiar with, and know the meaning of, typical stems to mathematics questions, like 'How many…', 'Work out…', 'Find…', 'Calculate…', 'Solve…'.

Tips to help students answer the question

- When reading a test question, suggest students underline the important information. This may include any numbers or words that give clues as to how to work out an answer, and reminders of the type of answer required.

  For example: *A semi-circular window has a radius of 60 cm. What is the perimeter of the window to the nearest 10 cm?*

- If a question refers to a shape that is not given, students may wish to sketch it. This will help them to visualise what they need to do to answer the question.

  For example, they may wish to sketch the semi-circular window in the question above.

- Ensure students understand that when sketching, they do not need to use a ruler, and they should write all the information given to them on their sketch.

- If a question refers to a shape that is given, it may have the words 'Diagram NOT accurately drawn' beside it. Ensure students know what this phrase means.

- Check students know to look out for measures given in different units. For example: centimetres and millimetres.

- Encourage students to look out for plural words in test questions. They often suggest students must give more than one answer.

  For example: *Which of these are nets for a cuboid?*

- If a question includes a diagram, encourage students to point to the relevant parts of the diagram, as they are mentioned in the question. This will help students to make sense of both the words in the question and the diagram.

- If a question includes a statistical diagram or a graph, check students know to look carefully at any keys or scales on axes.
- Emphasise to students that showing working is *always* a good thing because, if their final answer is incorrect, they may still get marks for demonstrating some understanding.
- Encourage students to be aware of the space left after a question on the test paper. If it is a large space, then this means students are expected to show some working.
- Check students understand that if they go wrong or cannot finish an answer to a question, it is important not to erase their work. Again, they may still get marks for working.
- Encourage students to look at the number of marks for answering a question. If it is more than one mark, then there must be either more than one answer, or more than one step expected in the working.
- Check students know what to do if they read a question and do not understand it. First of all, encourage them to underline all the words that they understand. Then suggest they write down the maths they think the words suggest that they may need to do.
- As students answer questions on the test paper, suggest they circle the question number for any questions they are not certain they have answered correctly. If there is time after they reach the end of the paper, they should revisit and check these answers first.
- Students often feel nervous or anxious before mathematics tests. Tell them that you have felt this way too when taking tests. Encourage students to write down their worries about the test on a piece of paper. Then move around the classroom with a waste paper bin and tell students to throw their worries away, so that they do not prevent them from doing their very best.

Enabling students to revise effectively for mathematics tests

- Devise a revision programme that covers *all* topics that will appear in the written mathematics test.
- Give students practice questions, topic by topic, concept by concept. For example, do not simply give students 'Shape' practice questions, but organise the questions into groups by concept, like 'triangles', 'quadrilaterals', 'symmetry in polygons', 'translation of 2D shapes', etc.
- Give the questions in each group a difficulty rating, for example, *, ** or ***.
- Students should work on practice questions for each concept, ranging in levels of difficulty to build their confidence.
- Provide students with a record sheet, so that they can track their understanding and progress. For example:

Question number	**Topic/concept**	**Level of difficulty**	**Tick the questions you got correct**	**Notes** (For example: • If you got a question correct but you are not sure about it, write 'not sure'. • If you got an angle fact wrong in a question, write it here to help you remember it.)
	Shape			
1	Triangles	*		
2	Triangles	**		
3	Quadrilaterals	*		
4	Quadrilaterals	***		

- When you prepare practice questions, at the same time, write some ‘Further practice questions’ for those students who require additional practice. This could be given as homework.

- When a student gets a question incorrect, pair them with a student who got the same question correct. Ask the student who got the question correct to explain what they did to the other student. This type of student-to-student learning helps both students: the student who got the question incorrect has an opportunity to understand why; the student who got the question correct has an opportunity to vocalise, and so deepen, their understanding of the concept.

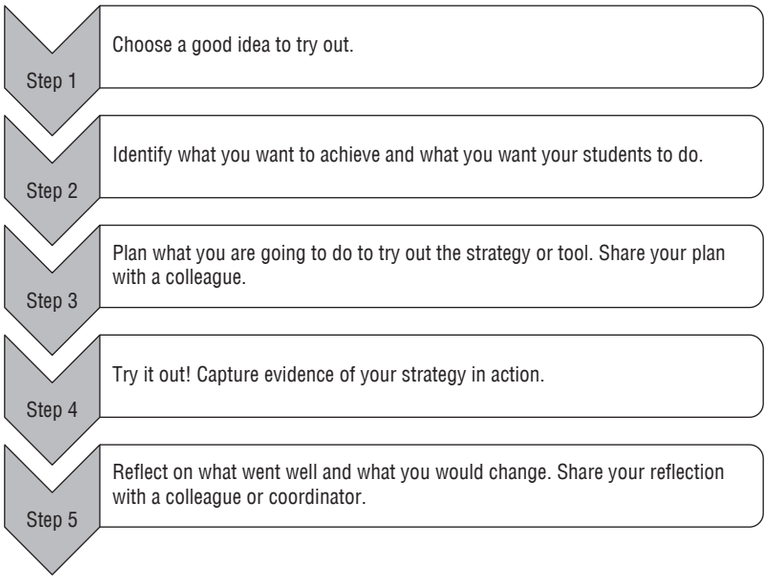
- If the student who got the question incorrect still does not understand, then you, as the teacher, should intervene to explain.

- Offer an optional mathematics lunchtime revision club for those students who are struggling with some questions, or for those who would like extra practice.

Appendices

APPENDIX A: THE *TRY IT OUT* TEMPLATE

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



Guidance

Step 1. Choose a good idea to try out

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

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

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

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

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

For example:

I have chosen this strategy or tool because:

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

I am hoping to achieve:

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

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

I expect my students to:

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

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

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

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

For example:

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

I will review the purpose of a KWL chart.

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

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

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

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

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

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

For example:

My evidence:

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

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

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

For example:

What went well?

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

How might it have been even better?

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

What are my next steps?

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

The *Try it out* template

Step 1

The good idea I shall try is:

Step 2

I have chosen this strategy or tool because:

I am hoping to achieve:

I expect my students to:

Step 3

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

Step 4

My evidence:

Step 5

What went well?

How might it have been even better?

What are my next steps?

APPENDIX B: MY iLOWERSECONDARY CHECKLIST

RAG[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 are given opportunities to conduct independent, open-ended research		
	Students will do a considerable amount of the talking during the lesson.		
	Students have opportunities to lead group activities.		
	I have planned several open-ended probing questions that begin with 'Why,' 'How' and 'When'.		
	I plan to provide enough time after asking a question for students to process and consider their answers using various methods (for example, think–pair–share).		
	I have built in opportunities to provide feedback to students on progress through, for example: whole-class and individual questioning, comments on work, one-to-one conversations, whole-class feedback, through the shared learning log.		
	I have planned how I will transition students from whole-class work to individual or group work.		
	I have planned several opportunities for 'checks for understanding'.		
	Students are given opportunities to self-assess their understanding.		
	Students are allowed to use different methods and materials to reach the learning objectives (as appropriate).		
	I have created opportunities for students to present new knowledge in creative and engaging ways to me and each other.		
	Students are given opportunities to ask questions (including asking questions to other students) about the concepts.		
	Students can freely generate ideas and create examples during the lesson.		

[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).