

Using the mathematical tools for the job

Becoming proficient in the use of a ruler,
protractor, compass and calculator



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Which tools do learners need to use and how?

Time and time again the *Reports on the Exam* tell us that learners struggle to use the mathematical tools for the job – using a ruler, protractor, pair of compasses and a calculator.

Here are a few quotes:

The angle for QPS was often incorrectly drawn.

Nov 2019 Q13 Paper 2

Weaker students stated the distance AC was 2 cm or 4 cm or 6 cm using the vertical distance or the number of squares crossed or the distance across and down.

Nov 2019 Q20 Paper 2

Some students either did not use or show the working from their calculator

Nov 2019 Paper 3 general info

This question was not well answered and there were a large number of non-attempts. The majority of students correctly used the scale to draw an 8 cm line. Correct constructions commonly used intersecting arcs, the same radius as their base, although some students used lengths out of tolerance. The most common incorrect answer was to draw an equilateral triangle without any construction lines.

Nov 2019 Q24 Paper 3

The added complication of the Covid pandemic, has compounded an already difficult situation for many struggling maths learners. As a result, maths skills were not used enough, if at all. Learners weren't at home during that time with their geometry sets practicing drawing and measuring angles, creating circles, bisecting angles, switching from decimal to fraction mode and to a certain extent these skills have been forgotten.

This teaching guide is pertinent for GCSE Maths resitters as well as those who struggle with maths in any way, at any level and at any age from year 7 onwards.

Practice, not until you can get it right, but until you can't get it wrong

Using any mathematical tool requires fine motor skills. Using a ruler to measure a straight line can cause worry if unsuccessful and it should really be a skill that has been mastered long before a resit year. The same can be said for the use of any of the tools. Learners have either not used the tools enough or there may be some underlying additional learning difficulty.

Part of our challenge is that we're showing learners things that they have seen many times before, yet they still struggle and they know it. Evidence from

[Robey and Jones](#) tells us that post-16 learners struggle with confidence in their own ability as well as understanding what relevance this all has to them.

Let's consider each tool individually with suggestions of how to reacquaint your learners with the tools and then to get them to practice, practice, practice. As Doug Lemov says 'practice may not make perfect but it may make permanent!'

Using a ruler

Difficulty to measure remains a constant with a struggling maths learner. Lining up the ruler correctly and using the zero at the start of the scale, not at the start of the ruler, may seem obvious to most, but unless it's been specifically taught, why wouldn't they do this? Find a YouTube clip or an animation to model it. Get the visualiser out and demonstrate it. Find a learner who can be the expert at this skill, let them share their ideas and methods.

Learners rarely have any sense of the relative size of things, to estimate a distance, estimate the length of things or the distance from themselves to the nearest door, the height of a tree or width of a house. This skill underwrites the effective use of a ruler. Use every opportunity to ask for sensible estimations of lengths, in a variety of metric measures. Going into the vocational setting and doing this may make it all the more relevant for learners.

The ability to recall the conversions between millimetre and centimetre, in fact any conversion from millimetre to kilometre remains a struggle for a lot of learners. The etymology of the root word may help cement these conversions. Knowing the relationship between milli, centi and kilo and how they relate to the standard metre measure allows learners to see these words with meaning, second time around.

For example, centimetre relates to 100 of them in 1 metre. Where else do they see the root word 'centi'? Centipede, century, centurian, cents and dollars... things that they can relate 100 to perhaps. [Mathsisfun.com](https://www.mathsisfun.com) has some good graphics and YouTube video to support this.

Assessment Objective 1 refers to 'recall of facts and figures' and 'routine maths' and this may require the learner to convert between metric measures. Converting between millimetres, centimetres, metres and kilometres requires practice to ensure that these skills become fluent.

Think about relevance too. This is one of the barriers that post-16 learners struggle with. Ask your learners for suggestions as to where their vocational course may use metric measures. For example, in construction they measure and convert between millimetres and metres, skipping centimetres. In art and design they may be measuring for an art gallery display.

Top tip: Typical resources that show learners how to use a ruler to measure a line may refer to KS2. This isn't what a post-16 learner needs to see. Choose something more adult that doesn't reference primary maths skills as this could undermine their confidence. [BBC Skillswise](#) for example has some excellent non-age defined material.

Key consideration: Use any opportunity to estimate length and measure accurately, practice until they can't get it wrong.

Protractor skills

Used from Year 5 onwards, protractors are common-place in schools yet they come in a variety of forms from whole circles to opaque semi-circles. From incorrectly lining the protractor up in the cross-hair to using the wrong scale on the outer edge, misconceptions abound.

Tom Francome is a Lecturer in Mathematics Education at the University of Birmingham. In an [article](#) he wrote for the Association of Teachers of Mathematics (ATM), he focuses upon the five main misconceptions in skills. He advocates the use of an empty protractor too, which is a novel approach. With protractor use we should go back to basics, such as the types of angle, estimating angle size, to understanding that an angle is a measure of turn. We should also try to tackle misconceptions head on, in order to head them off. For example, lining up the vertex of the angle with the crosshair helps to give an accurate measure of the size of the angle, as does putting the zero line on the protractor onto one leg of the angle. You can see here the importance of correct geometric vocabulary. You could ask learners to produce a set of instructions on 'how to use a protractor' which includes a vocabulary listing.

For some learners just drawing stick men in a picture and getting learners to measure all of the angles between arms, legs, head and body may alleviate some of the stress involved in revisiting skills that they should know.

Transum maths has some brilliant exercises at varying levels which allow for practice using the tools.

Top tip: Build up from the basics – what an angle is, types of angle, geometric notation on angles, and estimating angle size. Estimating the size of an angle before it's measured gives a clue as to which scale to use. Even asking yourself is the angle bigger or smaller than 90° will help the learner identify which scale to use.

Key consideration: Knowledge organisers may be an excellent way for a resit learner to gather their notes and focus upon particular skills and topics.

Compass skills

The compass can be used to draw full circles, part circles or arcs. They can also be of variable quality. A poorly manufactured compass will hinder learners. Emphasise the importance of good quality equipment from the start of the course.

In some instances, the tools for the job may be used in conjunction with one another and this may be an issue for some. To bisect an angle, learners will use a compass in conjunction with a ruler. Arc marks are crucial to certain constructions so it's important to allow opportunities for practice once the skill has been mastered. There are plenty of TikToks and informative videos on YouTube that will demonstrate to learners what to do as well as what you do in the classroom to model the processes.

Top tip: Try to find the best circle drawer in the class. Hold a freehand circle drawing competition. Talk about the importance of accuracy in drawing circles such as in engineering design work and why they should master the compass.

Key consideration: Vocational relevance is again key to engagement. On an art course it may be good to look at artists who use perfect circles in their artform. Find other examples by asking your learners where they see and use perfect circles – in construction, engineering, architecture, sculpture.

Using a calculator

Observing a learner using a calculator can yield many clues as to how confident they are at using one. For example, some learners hold a scientific calculator in their left hand and then start entering numbers and using it with their thumb, rather like texting. The thumb is not long enough to do this and input errors can occur. They may then get an answer which they often can't read out to you so they show you the screen instead. This tells you a lot about their skill level.

The calculator will only do what you ask it to do. It's a tool in the same way that a hammer or pair of scissors is, but it's a very powerful tool to be able to use. Make the link with learners on vocational pathways about the necessary tools used in trades.

There are many resources to assist learners in learning the skills – from YouTube, to TikTok and BBC Bitesize. Having a calculator available may be more of an issue in post-16 classes. Post-16 settings often provide the tools at great expense to themselves as learners are at too much of a disadvantage if they do not have them.

Classic misconceptions with calculator use should be tackled head-on. This is one of the [8 Effective Principles of Malcolm Swan](#) which we would do well to be reminded of.

Top tip: Setting the tone at the start of the course will pay dividends. Learners should be able to provide the maths equipment in the same way that they have to provide their chef whites or their hairdressing toolkit on a vocational course. Having the right calculator and being able to use it is crucial to exam success.

Key consideration: Two of the three exam papers allow learners to use a calculator. That's three hours of testing where they have a very powerful tool to use. Emphasise the fact that it will only do what they tell it to do.

Revision approach

Learners have seen all of these tools before; it's just that they can't use them well enough... yet.

They haven't used them since their last exam in June. Prior to this they will rarely, if at all, have used them during the pandemic. Revision means to look at these tools again, perhaps with a different lens, to revision the maths so that learners use the tools differently. There are exercises and fun competitions that can challenge learners whilst they practice. Don't forget that the [Robey & Jones research](#) shows us that learners struggle with seeing how these things are relevant to them. Make that explicit too, especially by perhaps finding a vocational link.

Exam technique

There are many clues to what learners do well, and not so well, within the *Reports on the Exam*. Time and time again we read that learners struggle with the tools for the job – ruler, compass, protractor and using a calculator. Command words may add confusion. Knowing the difference between 'draw' and 'sketch' may seem obvious. What does 'construct' mean in terms of angles and triangles? Which of the command words relate to using any of the mathematical tools for the job? Showing them how all of this exam focus will impact on their exam performance will be another incentive to engage them better.

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We understand the trust you put in us to provide great assessments for your students and we're committed to delivering on this.

E: maths@aqa.org.uk

T: 0161 957 3852

X [@aqamaths](#)