Contextualising post-16 GCSE Mathematics: a toolkit

A guide to developing contextualised teaching and learning resources

Innovators in Mathematics Education

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About this guide

This guide is part of a toolkit to support practitioners in developing contextualised resources to support post-16 GCSE Mathematics in four different vocational areas. It offers information and ideas to help you to make use of the idea of context in your teaching of GCSE Mathematics and suggests how you can develop your own resources for your own particular contexts and share them with other maths teaching practitioners.

Some ways of using context

There are several different ways in which context can be used in the teaching of maths:

Consolidation

Learners can be helped to consolidate skills they have already acquired by presenting them with a realistic problem to solve that draws on those skills. Consolidation learning in this way using realistic ideas helps to show that the maths that has been learned is useful.

Business, administration and entrepreneurship

In 2013/14 the total number of cases of work related stress was 487 000 out of a total of 1 241 000 cases for all work-related illnesses. What is this as a percentage?

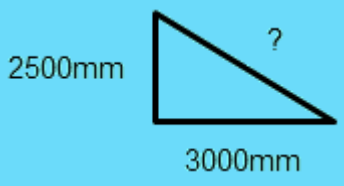
Learning new skills

Learners can be given a realistic problem to solve in order to learn new skills. They start with the problem and try to solve it. The practitioner facilitates discussions and approaches that help the learners to work their way towards a mathematical solution.

Construction

Calculating the length of a handrail on a staircase

The total rise of a staircase is 2500mm and the total going is 3000mm. What will the length of the handrail be?



Appreciating the usefulness of maths

Learners might be given a contextualised example to help them to see the point of the maths they are studying. This can help to motivate and engage them.

Health, social care and childcare

A play area is to be built for a nursery. Guidelines for nursery schools say a sandpit of area 12cm^2 should be provided

Suggest one shape and measurement the sandpit could be?

Enhancing understanding

A realistic context might also be used to help learners to practise and understand maths.

General life and personal interests

Looking at an electricity bill, checking it is correct and splitting it among the people who are sharing the house.

Pseudo-contexts

A pseudo-context is one that at first sight looks as though it refers to real-life, but is not actually a realistic problem to pose. When presented with such a use of context, learners might ask, “Who would want to know this?”

There are four pipes leading into a well. The first fills the well in $\frac{1}{2}$ a day, the second in $\frac{1}{3}$ of a day, the third in $\frac{1}{4}$ of a day and the fourth in $\frac{1}{5}$ of a day. If they are all filling the well together how long will it take?

Learners may realise this is not realistic and may not see the point of doing the question.

Identifying suitable contexts to use

Suitable contexts should be chosen that are likely to interest and motivate learners and so help them to become more confident and competent in using maths. It is important that they are relevant and meaningful to learners: that they relate to some aspect of the learners’ everyday experiences, for example from their chosen vocational subjects or general home or personal interests. It is also important that they are authentic, and seen to be so- so that learners can easily appreciate that there is a genuine purpose for the maths they are learning.

Everyday contexts should relate to aspects of life that are relevant to 16-19 year olds. Most learners of this age will still be living at home, but may be starting to gain more

independence, and so are likely to be interested in their own finances, and organising travel and social events, as well as general interest such as sports, music and the media. They may have part-time jobs unrelated to the vocation they are studying, such as working in a shop or waiting in restaurants.

Naturally, vocational contexts should relate to the vocational sector that the learner aims to work in and/or the work experience that they will participate in as part of their Study Programme. They should draw on the experience of the learners and mirror that experience. Colleagues who teach vocational subjects may be able to suggest suitable contexts to use, and may even be able to offer pre-prepared materials that you can adapt and use.

Work experience forms an important element of 16-19 Study Programmes and may present opportunities for your learners to identify ways in which maths is used in the workplace. You might even ask them to note examples of applications of maths during their placement and bring them back to share with other learners. The MEI guide Maths at Work: *Integrating work experience and maths provision in 16 to 19 Study Programmes (including Traineeships)*[1] provides further examples of ways work experience can be used to enhance the learning of maths. You could also approach the employers you already work with directly and ask them to suggest examples.

Some examples of vocational applications of maths

Construction and the built environment

- Geometry in building designs
- Ratios in cement or concrete
- Use of scale in building plans

Health, social care and childcare

- Measurement of height, weight, fluid intake and temperature
- Ratio of staff to children/residents

General life and personal interests

- Managing a budget
- Interest rates
- Designing a rota
- Time sheets
- Salaries

Business, admin, and entrepreneurship

- Shopping
- Personal finances
- Running a car
- Mobile phone contracts
- Ratios in recipes
- Planning a holiday

[1] See http://www.mei.org.uk/files/pdf/Maths_at_Work-Integrating_maths_provision_and_work_experience_in_16-19_SPs.pdf

The context grid provided in this toolkit is designed to help you to identify suitable contexts for teaching mathematical topics. Other places you might look for inspiration include books, magazines and similar publications about the vocational subject, as well as on the internet. The specifications for the relevant vocational programme will also contain suitable contexts to use.

When to use context?

Context can be used throughout a maths course from initial assessment through to preparing for examinations - but is most useful in the early stages of a course, where it can be used to help to engage learners.

Group and individual discussions with learners based around contextualised applications of maths can also allow assessment for learning to take place through discussion of what learners already know and so enable teaching to focus on what learners need to know.[2]

At some point in their studies, learners will need to break away from familiar contexts and move on to other contexts that they may not be familiar with. If they are going to be entered for the GCSE Mathematics examination then they will also need to experience examples that are not contextualised to help to prepare them for the types of question likely to arise in the examination papers.

What makes a good contextualised resource?

Ideally, a resource should be sufficiently flexible to meet the needs of learners working at different levels of attainment. Understanding differences and differentiating instructions are important as students in a GCSE resit class may be working at these different levels within one classroom. Resources should also support you in assessing the level at which each learner is working, whether as part of initial or formative assessment.

It is also important that resources are designed to be inclusive – appealing to different genders, ethnicities and cultures. For example, whilst construction is traditionally a male-dominated vocation, it is important that resources should stimulate interest for both genders. They should not always use names and images of males. You might, for example, in a construction resource use a female first name and also include images of both male and female construction workers. Similarly health, social care and childcare is traditionally seen as a female vocation, but it is important to include examples of male workers. In a similar way, avoid stereotyping in resources that use contexts from general life –females can follow and/or play football and males can bake cakes.

While it is not the primary consideration, with a little additional thought and effort a carefully designed resource can also contribute to other skills, including English and employability skills. For example, a task that involves working in a group to create a video or provide a presentation about an application of maths can help to develop team-working and communication skills.

Ideally, resources that start by using maths in context will lead onto demonstrate how the same maths can be used in different contexts, and possibly then on to doing the maths

[2] Dudzic, S. (2013). *GCSE Mathematics retake for vocational students: GCSE teaching from 2015.* Available at http://www.mei.org.uk/files/pdf/gcse-vocational-students.pdf

without the context. Contextualising absolutely everything may not best prepare learners for the examinations.

A really good context will present possibilities for connecting mathematical ideas rather than focussing solely on one topic. It should encourage learners to learn maths meaningfully – to understand by making connections rather than just engage in rote learning.
The checklist below can be used when creating a contextualised resource:

Is the task…	Explanation	Check
Authentic and realistic	Is it a genuine example? Can learners see how the task relates to real life?	
Useful	Does it draw on the learners' own experience?	
Purposeful	Can learners see why they are using the maths?	
Effective	Are learners learning from the task?	
Motivating	Do learners want to tackle the problem?	
Relevant	Can learners see where they could use the maths in their vocational area or personal interests?	
Challenging	Do all learners feel they have had to work to solve the task?	
Accessible	Can all learners tackle the problem when they see it or are they overwhelmed?	
Inclusive	Can all genders, ethnicities and cultures relate to it?	
Creative	Does the task help learners develop confidence and independence?	
Differentiated	Can it meet the needs of different learners?	
Encouraging	Do all learners feel they have achieved something?	
Inspiring	Do learners want to carry on and do more maths?	
Holistic	Could it develop other skills without compromising the learning of maths?	

Strategies for prioritising topics to contextualise

Some topics in GCSE Mathematics lend themselves more obviously and easily to using contextualised resources than others. Sometimes it is difficult to contextualise in a meaningful way, without resorting to pseudo-contexts – that is putting together an example because it has some relevance to the vocational subject, but not in the end producing something that learners would use themselves.

Learners often ask when they will ever use some aspects of maths in real life. For some of the topics, this is difficult to answer positively as some of the content may not appear to be related to their future careers – for example, it is difficult to contextualise factorising

quadratics or gradients of perpendicular lines in graphs. For topics like these, it may help to explain in the following ways:

- GCSE Mathematics has two purposes: 1) to prepare people for the maths they will encounter in general life and work; and 2) to prepare them for further study of maths.
- Maths is not only about learning topics, but also about the way learners tackle a problem logically which can be an important employability skill.
- GCSE Mathematics is highly regarded by employers, and is an essential requisite for many jobs. Obtaining a grade C or better in GCSE Mathematics can open doors to employment and career progression.
- They may not find a particular topic relevant now, but it may be useful at some point in their future, for example to support the study of a higher vocational qualification.

When considering which topics to prioritise, look for the ones that are directly relevant to the vocational subject and would seem most relevant to learners. Identify examples where maths is used in the vocational subject as part of the course and adapt them to GCSE.

Here are some examples of topics that are particularly relevant to the toolkit's focus context areas:

Construction and the built environment

- Number – cost of materials, time management
- Ratio and proportion – materials for making mortar and concrete
- Measurement – fitting cabinets and decorating rooms, metric/imperial conversion
- Area and volume – estimating materials for a job
- Scale drawings – interpreting plans
- Angles, shapes – in constructing buildings and gardens

Health, social care and childcare

- Number – cost of equipment, body temperature, time management, diets
- Ratio and proportion – staff to children
- Measurements – heights and weights, health and safety limitations
- Statistics – tables and charts such as temperature, pulse or fluid intake
- Geometry – scale drawings of rooms for wheelchair users
- Probability – risk assessments and inherited diseases

Business, administration and entrepreneurship

- Number –budgeting and accounts, interest rates
- Ratio – accounting ratios
- Algebra – formulas for profit, compound interest, etc.
- Statistics – analysis of management information, such as sales figures

General life and personal interests

- Number – personal finance, mobile phones, running a car
- Ratio – using pizzas or cakes, cooking
- Geometry – designing a garden
- Probability – sports, games that use dice
- Statistics – charts and tables on subjects that interest learners

The grid contained in this toolkit provides many more examples.

There are some topics in GCSE Mathematics that are regularly tested in the examination, and for which a good, solid understanding can help learners to answer more questions. These include fractions, decimals, percentages and ratios. These also underpin other topics and are therefore well worth spending time on. Importantly, a good understanding of these topics will serve learners well throughout their lives and, not surprisingly, there are also lots of good contextualised examples of them.

Types of resources that you could develop

This section provides some examples of some different types of contextualised resources that you might develop to help you get thinking. It is not exhaustive and you may well think of other ideas. Resources that encourage discussion and collaboration can be very productive for learners. Bear in mind that active learning can provoke more thinking and discussion among learners and consequently increase their interest in maths.

Video clips

These can be used as introductory resources. These can be found on the internet or you can create your own, perhaps with help from the vocational teaching staff. They could even be made by learners or employers. You might also want to include questions to ask the learners before they watch the video, for example, “How does this carpenter make sure that the door frame is square?” and/or a question to discuss afterwards - “Can you explain why this works?”

Questions for group discussions

An example is “How would you design a staff rota that’s fair?”. Small group work can be used to support mathematical learning. Learners can ask questions, discuss ideas, make mistakes and persuade each other by the logic of their arguments.

Physical activities

Physical activities can be very successful at getting learners engaged with practical applications of maths. This might include bringing things into the classroom or workshop, for example, following the instructions on powdered baby milk to make up a feed. It might also involve getting learners out and about, for example, estimating the amount of paint needed to paint the outside of a building.

If it is not practical to do the actual activity itself, you may be able to incorporate some aspects of it, set up a scenario that mirrors a vocational task, for example, using a scale drawing; making a model of a roof; arranging Lego bricks in different brick-bond formations and estimating quantities of bricks needed for a wall; or measuring the room and estimating how much paint is needed to decorate it. These kinds of activities could tie in with a project, for example, decorating a room.

Card sorting/matching activities

One example of such a resource is to prepare two sets of cards: one with amounts on them (£100, £25 000, etc.), and one with different details about bank accounts (e.g. interest rate, simple/compound interest, annually/monthly/quarterly, time).

£100

- 0.7%
- Simple interest
- Annually
- 3 years

Then ask learners to match the best bank account to the money cards.

Relays

In relays, learners need to get the first answer right before they move onto the second answer. For example, consider a project about designing a room:

- What is the width of the room? This could be given or measured.
- What is the length of the room? This could be given or measured.
- What is the area of the floor?
- What is the height of the room? This could be given or measured.
- How much paint do you need for the biggest wall?

Relays can be a useful resource for revision.

Manipulatives

Many learners relate better to physical things than drawings or verbal descriptions. You might find it helpful to use manipulates (a physical object that can help clarify a concept), such as connecting cubes to represent quantities, or strips of paper to represent the whole that can be divided into fractions.

Although such resources do not provide a structure for a contextualised activity in themselves, they may be useful to incorporate as part of an activity.

For example, the ratio of a mortar mix is 3 parts sand to 1 part cement. The teacher might say: “You need to make 8 spadefuls of mortar. How many spadefuls of sand and how many of cement will you need? If it helps, you can use the cubes to help you to work it out”.

Posters

Learners could be encouraged to summarise their knowledge of a subject or to provide alternative approaches to a problem. You might pick a topic that learners have been studying and ask them to design a poster explaining all they know about the topic.

An example might be to produce a poster to show at least three ways of finding 35% of an amount.

You could also combine card-sorting and posters: learners could be asked to produce a poster that shows important temperatures in healthcare based on a picture of a thermometer drawn to scale. It could include: safe room temperature, which is 18-24°C; bath water, which should be above 37°C but must be below 43°C; body temperature, which should be within two degrees of 37°C; fridge temperature, which should be 1-4°C; and typical outdoor temperature in the UK, such as 8°C for January and 20°C for August. These facts could be presented on cards. You could then encourage the learners to order them before making their poster.

Critiquing and marking

A resource might involve giving learners some materials to critique and/or where they have to identify errors. Such materials might include files, documents, spread sheets, instructions, news articles and infographics. There may well be others that are particularly relevant to a vocation.

An example of this might be to produce a financial spreadsheet containing some deliberate mistakes that the learners need to identify and correct.

Critiquing infographics can be a particularly helpful resource for revising statistical topics, such as representing data. There are lots of infographics available on the internet; however, they do not always present data in a clear way, so it is not difficult to find aspects that can be improved on - as well as aspects that work well as a means of communicating data. You could also use an article from a newspaper or the internet that discusses data. Look at what is good about it and what is poor. There are many examples of misleading statistics that could be used.

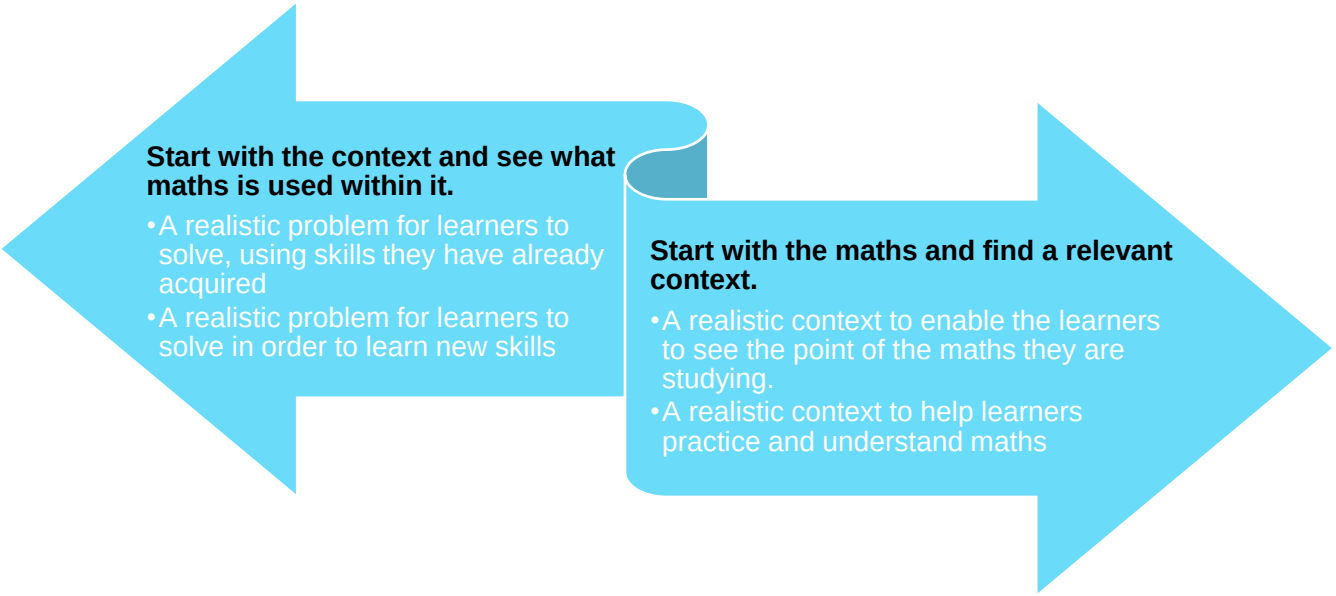
A similar activity involves learners marking other learners' answers to contextualised questions, where some of the answers contain errors or are not well explained. Learners enjoy marking others' work, but if you do this you need to make sure that they are fully anonymised. Learners should be encouraged to write comments and not simply mark the answers as right or wrong, explaining why any answers are wrong and providing solutions.

Worksheets

Learners often find traditional worksheets off-putting and boring, but they can be approached in a less traditional way. For example, you could present them in the form of vocational documents, such as a copy of an email requesting a quote for a job. You could also ask learners to write their answers on a mini white board or on post-it notes placed on a wall and then take the rest of the group through the examples.

Hints and tips on developing resources

There are two starting points for developing contextualised resources – the context or the maths. If we look back at the section on ways in which context can be used, four useful ways can be identified under each of these headings:



A pseudo-context is more abstract and it is difficult to find an authentic context to use it in.

When designing a new resource it may help to start by thinking about the purpose of the resource. Are you aiming to introduce a new skill, or to practise or revise something that has already been covered? Is the main objective to engage learners in maths before you move on to tackle something more challenging?

Introducing new skills

If the resource is to be developed to help learners learn new skills, then a starting point needs to be considered. What is the new skill that is to be learned? This could be a realistic problem that needs an answer.

Physical activities can be particularly useful for introducing new skills. They can help learners to identify problems and think about how they might be solved. With careful questioning techniques, it may be possible to help them to figure out some of the maths themselves. It can also make them more receptive to explanations of mathematical approaches that can help them to find practical solutions. This is an excellent opportunity to allow learners to work together, perhaps through class discussions, using the whiteboard to share ideas and possible approaches.

Worksheets that give suggestions to learners, and lead them through stages in a process of self-discovery, can also be helpful and may be more practical for one-to-one or blended learning situations.

Practising or revising

If the purpose of the resource is to help learners practise skills then a card-sorting exercise may be useful. Using card sorts can often be used for checking learners' understanding and for consolidation. Real examples can be put on the cards and they can be matched or sorted into some order. A useful tool for card matching activities is Tarsia. This can be used for creating jigsaws, dominoes and rectangular cards.

You might also incorporate some critiquing or marking activities, and some considered use of worksheets.

Motivation

It is particularly important to motivate learners at the start of their course and also at the start of each lesson. A starting point could be as simple as showing a short video clip showing someone doing a job that involves the maths that you are going to cover in that session. This helps to focus the learners on the relevance of maths.

To motivate learners it is important that the context is completely relevant to the vocational area and it is a genuinely realistic scenario. It may be here that the maths to be used comes from several different topics. For example working out how much space 50 reams of A4 paper takes up uses volume, but it may then be possible to incorporate percentage – how much money will you save with a 10% discount for buying in bulk?

To check the context is realistic consult, a vocational colleague or an employer. In some cases learners can be consulted and take ownership for their own learning. This would ensure genuine relevance of the contextualisation.

If the resource is to build on learners' understanding, the context must be familiar but able to be generalised.

Remember that contextualisation should be used as a starting point that leads onto more general applications of the same mathematical skills. For example, it is important that learners can work out ratios in general and not just in context.

Evaluation

When developing your own resources, you will want to check that it is of good quality and effective in achieving it aims.

It might be helpful to try it out with a vocational colleague before you use it with learners. Ask for constructive feedback – is the context realistic? Was it engaging? What could be improved? Are there any other suggestions to add to it?

It's also important to encourage learners to give feedback on any resources you create. Listen to what they say and watch how they responded to the resources you have offered them. This could be as part of a discussion on the activity. At the end of the lesson ask, what they have learned and if they enjoyed the task. Did they know what the task was all about and recognise the significance of the maths? Did it all make sense and did they know when they had found the solution to the problem presented? You might ask "What would make this more realistic or more relevant?" They could use post-it notes for this, if any are shy about speaking or you could have a texting window at the end of the class where they can respond directly to the teacher. Focus groups could also be used with another teacher or learners keeping notes. You might like to create a questionnaire for learners to complete – the toolkit provides one that you can use as a starting point for your own.

Involving learners in the creation of contextualised resources and activities to improve their maths skills can be very positive. You can use the maths they have encountered in work experience or in real life to improve resources. When learners are involved in both creating and feeding back for improvement, they may feel more enthusiastic and motivated.

When you use your resource with your learners, you could ask a colleague to do a peer observation – perhaps a vocational tutor. This would provide you with feedback and would also help your colleague to learn about the resource.

If you intend to share your resource with others you should also consider whether it is

complete. Is it fully documented with notes that explain how to use it? If you shared it with someone would they have all the information they needed about it to use it themselves? Would it help to include some photographs or video clips of a physical activity that you've used? Would it help to have some links to websites that supply materials that you found useful?

Adapting existing resources

There are some excellent websites that provide resources that can be used as they are or can be adapted for specific contexts areas:

- Mr Barton Maths
  This has a selection of free resources including a Tarsia bundle which you will find after clicking on the teachers' tab. The GCSE resources are the first ones.

- National Research Centre for Career and Technical Educations
  This US website has some interesting ideas, but be aware that finance examples are in dollars and these resources may use different terminology in places.

- NRich
  This has some good resources which can be adapted

- Standards Unit Improving Learning in Mathematics resources
  These resources encourage a more active way of learning through the use of group work, discussion and open questioning.

- The Nuffield Foundation FMSQ teaching resources
  These include some good context-based resources.

Sharing resources with others

You time is in short supply and it is the same for your colleagues and other teachers at different establishments. If you have developed a good resource, share it with others and encourage them to do them same with you. Look at how others have gone about creating resources. Can you learn from them? Can you adapt what they have produced to be relevant for your learners?

Sharing resources with your colleagues

How can you let your colleagues know about your resource? Could you email them or make an announcement on your intranet? Do you have meetings at which you can discuss and share resources? Are there opportunities for maths specialist and vocational practitioners to come together to exchange ideas?

Do you have a shared space, either electronic or a physical where you can share resources? Is it well-organised and easy to search? You could use a VLE, for example MOODLE to provide easy access for tutors and learners to respond to.

You could invite your colleagues to offer suggestions, amendments, variants and extensions after they have looked at any resources.

Sharing resources with other practitioners

There are a number of mechanisms for sharing resources with practitioners in other establishments:

- Local network meetings

  Network meetings of groups of other practitioners, e.g. FE MESH, often present opportunities to share and discuss resources with others. If you don't already have it, perhaps you could suggest a regular agenda item that encourages this. Your network may also have a mail group that you could use to send your resources to your fellow practitioners.

- Maths Hubs and other networking opportunities

  Maths Hubs have been set up across England to help to improve maths education by meeting the needs of local maths teachers. Each is led by a school or college. The hubs are designed for schools, colleges, universities, maths experts and employers to work together to share excellent practice and support all schools and colleges to achieve excellent results.

- Online forums

  There are many online forums that provide opportunities to upload and share resources. Here are a few examples:

  - TES Connect Teaching Resources
  - Mr Barton Maths
  - Jorum
  - XtLearn

- Social media

  If you have the opportunity to upload your resources to the internet, then you could use social media to let others know about them.

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