

Primary Mathematics Masterclass Development

Make sure you look at the Ri's Primary Resource Book and Off-the-shelf Masterclasses for ideas.

Overall structure of the session

You could consider two or three long activities for your Masterclass or a selection of smaller activities that fit one theme.

As you develop your session, think about a narrative that will run through everything, linking each activity together and providing a thread that the students follow from start to conclusion.

Create your own time-line and remember that this is quite a long time compared to a standard lesson that the students would receive at school. Make sure you have enough to talk about and the students have plenty to do. An example plan is attached to the end of these notes.

As an introduction tell them a little about yourself, and why you are inspired by the theme you have chosen. Try to include some personal and/or humorous details. Let your enthusiasm and love of the subject shine through!

Certain activities might take longer than anticipated e.g. helping the students understand the harder theory, so it's better to overestimate times. Have activity modules that can be squeezed out if time is running out, or added in if everything runs faster than anticipated.

End the class with a bang, not a whimper. Do a brief but impactful closing talk, show them something to bring everything together, announce the results of a competition if you've included one, show a 'wow factor' video, etc.

Learn from your experience – after your first one, you can tweak the times, but remember: no two Masterclasses are the same so you will always need those modules that can be added or removed.

Plan for a Masterclass lasting from 10am-12 pm						
	<i>Warm up activity ready for early arrivals</i>	<i>Scheduled start : Introductory Activity</i>	<i>One or two further activities</i>	<i>Break for drink and biscuit</i>	<i>One or two further activities</i>	<i>Conclusion, feedback</i>
						<i>Finish and take home activities</i>
9.50am	10am		11am		11.50 am	12:00 PM

Structure and activities

- Your theme needs to be outside the normal Primary Maths curriculum: if in doubt please check with the Ri team. You can look at a pure maths topic, or an application.

- If you are looking at a pure maths topic, think about where in the real world this topic occurs, and perhaps take some time to tell them about this.
- It is best if the student can investigate and conjecture for themselves. Set up a scenario for the students to explore, but don't supply all the answers yourself. Hands on investigations with some practical equipment to play with are always popular. (Even just pencils and rulers etc., but also, for example, string, play dough, polydron, multilink cubes, coins, playing cards have also featured in recent Masterclasses.)
- Primary students can quite often need additional help with and time for practical activities – bear in mind they they may have lower levels of dexterity than you expect.
- What materials will they need for each of the activities?
 - Do you have access to these materials, or are they things you could reasonably expect the school to provide? Think about the cost of materials (if you need funding, you must run it past the Ri or your local group first. Many will not have any funds for significant contributions to expensive kit)
 - Liaise with the Organiser well in advance to ensure that they can provide any consumables and equipment you need.
 - Remember that some materials and activities will need to be included on a risk assessment, so let the organiser know what you are planning to do in advance.
 - Think about portability – can you transport the resources to Masterclasses easily?
 - Think about consumables. Lots of expensive consumables are generally not feasible in Masterclasses
 - If you have a piece of equipment or something that you want to demonstrate to students then think about how this effects the session. Consider whether you can effectively demonstrate to the whole group (maybe using a visualiser?) or whether you will need to show them in smaller groups. If this is the case the other students need something to be getting on with while you show each group. Think about whether the demo is actually providing a significantly useful addition to the session before you commit to adding it in.
 - How much of the materials do you need? This depends on whether the students are working in teams or individually. Make sure you have more than enough.
- Will they work in teams, pairs or individually? It might be a good idea to vary this across the session, for different activities. Try to get them to work with people from different schools (at least some of the time) once the ice has been broken.
- For each activity think about instructions you need to give. Make them clear but leave room for imagination and choices and diversity in approach, if possible. It is great to explicitly celebrate all the different ways a problem can be approached or thought about.
- Ensure there is enough for every single student to do throughout the whole session. We don't want any 'back-seaters' so create some additional activities or worksheets just in case (and keep groups small so that no group members become disengaged). These can be used as an extension exercise in case any students get through the activities very quickly.
- You could introduce an element of competition to some of the activities (some students respond really well to this).
- Try to have mini "wow!" moments built into the structure of the Masterclass, as well as an exciting conclusion (see next point). Primary children are good at actually articulating that "wow!" too, which is so lovely to hear!

- How will you present the information they will grasp it quickly? Will you have a PowerPoint presentation? Use clear, colourful diagrams in a presentation, and not too many words on a slide.
- Can you include audience participation (ask them questions rather than telling them things, ask them to draw answers/ write solutions on a whiteboard or flipchart, get the group to vote, ask for estimates, ideas or conjectures)?
- Look for ideas on the internet for how to present the theory of your topic to school students. There are lots of good ideas out there. The TES website and the NRICH website are particularly rich sources.
- Try to have something they can take away with them: a worksheet, a drawing, a model, a work book. This will help them to talk about what they've done with their family and also hopefully spreads the information to their schools/classmates
- Create add-on activities for them. These are really useful – you can add them in or remove them to help you manage the time in the class. Provide answer and hint sheets to the teacher helpers present so they can refer to that, get a quick handle on what is required and support the students much more efficiently. These can also go to the students at the end of the session.

Advice from other speakers

"In developing the material, put down as many ideas for activities or things to cover as you can related to the topic, and then prune it back to things that work and fit together. If possible, try out sections of the Masterclass with appropriate age groups and see what works, or what needs making easier/harder. Don't be upset if you have to leave something out you really like, if it doesn't go with what you're doing or there's no time. You can always put it in another Masterclass!"

"Prepare material in modular sections, so you can drop things out if you're overrunning or expand on/add in material if the class get through things quickly. While the groups should in theory be at a certain level of ability, 'the best students from each school' can vary wildly in their level of ability - even if they're keen!"

"Even better, have an activity you can give them to work on at the end of the Masterclass, maybe something you've covered briefly but you know they wanted to do more of, so you can turn over the last few minutes of the session to that. This can expand to fill any extra time, or be omitted if needed."

"Use teaching techniques like waiting for silence before you speak."

"Presentations should not be too wordy and you should not be talking for too long. Get the pupils to investigate things rather than telling them! Primary children can be so much more enthusiastic than secondary but also have much shorter attention spans."

"Pupils like to see some notation, but make sure you explain it clearly. It's surprising how much depth you can go into with primary pupils, so don't be afraid of approaching big topics – it's all about how you present it."

"Don't forget to factor in time for clearing up before your big finish. Don't finish on a clear-up; leave them with something to think about at the end."

Useful websites:

NRICH: <https://nrich.maths.org/>

TES: <https://www.tes.com/teaching-resources/hub/primary/mathematics>

Example of a detailed time plan for Masterclass: Magic Squares

Slides & Time	Overview	Activity
Slides 1,2 10 minutes (10)	Introduction Instructions on screen. Helper and Speaker circulating and chatting with students	Working in pairs, students make a magic square (3x3) total of columns, rows and diagonals are all 15. How many different squares can they make? Add solutions to whiteboard. How many solutions are there? (Essentially 1, but others are transformations of one another; discussion of rotation and reflection) There are 8 versions of this unique solution, obtained in this way.
Slides 3-7 5 minutes (15)	Introduction to the Ri <i>[Only include these slides for the first session in the series – otherwise remember to hide the slides before you start the Masterclass]</i>	Use these slides to introduce the students to the work of the Ri and other ways they can get involved – see notes on the slides for more detail. In particular: <ul style="list-style-type: none"> • The Ri is a science communication charity which has been around since 1799. We've got a huge amount of history and lots of famous scientists lived and worked at the Ri. Most importantly, we've always been about communicating science to the general public – and that's something we still do today. We do talks and activities for the public as well as with schools all across the UK. • There are lots of family events at our building in London, including family fun days and holiday workshops just like the Masterclasses. • The CHRISTMAS LECTURES are for young people and are on television at Christmas time, looking at a different topic every year. We've got an archive on our website of all of the recent series plus many of the older ones. The CHRISTMAS LECTURES are what started the Masterclass programme. See slide notes for links. • We have a YouTube channel with lots of videos for people interested in science (and maths engineering, computer science...), especially our ExpeRimental series which is all about doing experiments at home. • Students are part of a big family of Masterclass attendees – we have been running Masterclasses since 1981. • Students at series running within reach of London will be invited to a Celebration Event at the Ri in June/July. • You can become an Ri Member to get more involved with what we do (and enter the ballot to buy tickets to the CHRISTMAS LECTURES filming).
Slides 8-10 15 minutes (30)	Discussion of introductory work, and variations to work on if some children are ready to progress	Work on 2-10 square. Think about other challenges. <i>Conclusion that there is essentially only one 3x3 magic square, can be transformed by rotation and reflection.</i> <i>Concept of complementary magic square. Some children see the link as transformation. Another way is n maps to $10-n$ in each square.</i>

Slides & Time	Overview	Activity
Slide 11 5 mins (35)	Magic square in history Lo Shu	Students recognise the magic square. Tell myth of tortoise with this pattern on its shell (see supporting notes).
Slides 12, 13 10 minutes (45)	Introduce idea of 4x4 magic square via Melancolia There are an amazing number of ways of making 17!	Magic squares could be larger... Give students copy of Melancolia. What mathematical things of interest can you see?(notes have some ideas) Look more closely at the magic square. What do you notice? What is the total (34) Find pairs sum to 17 What year do you think this was painted in? (Remind them of Durer's dates)(1514, at bottom!)
Slide 14 10 mins (55)	Examples of 4x4 magic squares	Complete examples. Make your own. 4x4 1-16 magic square solution is not unique! (880 actually! How crazy is that??)
10 mins (65)	BREAK	Drinks and biscuits and comfort break
Slides 15, 16 10 minutes (75)	Another example of a real magic square. Look at it in detail, for itself Then discover the amazing link between Durer and SF squares!	Copy of the Sagrada magic square or cryptogram. What is magic total? How many ways can you find it? Do we like it as much as the 3x3 versions earlier? Link to Durer square (see supporting notes for information)
Slides 17, 18 20 minutes (95)	Impressive "trick" to construct magic square with any given total. Let numberphile take the strain, or learn how to do it yourself, and try it out on the kids (I did this, it was great!!)	Demonstrate or use YouTube numberphile https://www.youtube.com/watch?v=aQxCnmhqZko Show how this is done and let pupils construct their own: this means they need to choose a value for n and substitute it. Some will grasp this quickly, but some may need lots of help.
Slide 19 15 minutes (110)	Concluding activity: take them through the algebra for today's date. Then let them do one for their birthday. This is a lovely take home activity	Finish by making a special magic square for today's date. Look at NRICH example for how it works. (nrich.maths.org/1380) Instructions to go away and make one for your birthday.
Slide 20 10 minutes (120)	Feedback, tidy up, questions time Ask the Ri	Don't forget to collect any questions which arise, and email them to the Masterclass team at the Royal Institution: masterclasses@ri.ac.uk
Slide 21	Possible NRICH problems related to magic squares – use as extension activities or for them to do at home	https://nrich.maths.org/6215 Different magic square https://nrich.maths.org/87 Magic constants https://nrich.maths.org/1205 Domino magic rectangle