The Royal Institution Science Lives Here
Masterclass network

OTS Masterclass - Big and Small

Session Leader Notes

Inspiration:

This session will test students' skills at estimation - comparing the sizes of objects with known quantities like their own height, and understanding numbers in context. We'll discuss how it's possible to approximate, write down and easily compare very large or very small numbers using powers of ten, and try some ways of estimating quantities by sampling small amounts and multiplying up.

Overview of Activities:

- Estimation activity - What's bigger or smaller than me?
- Big Numbers and Zeroes worksheet activity
- Ping-pong balls in a bucket estimation activity
- Hundreds-and-thousands estimation activity
- "How many words in a book?" activity
- Powers of ten – video

General Masterclass resources needed:

- Register of children
- Consent forms and emergency information to hand
- Stickers and markers for name badges
- Adult register
- Ri child protection policy
- Paper and pencils/whiteboards for workings
- 2 different coloured post-it note pads
- Drinks and biscuits

Specific resources needed (printable worksheets in worksheet folder):

- Bucket full of ping-pong balls
- Jar of hundreds-and-thousands cake sprinkles (not spherical shaped ones), and a marker pen to mark on the tub
- A calculator for yourself
- Small clipping of a newspaper column - should be entirely covered in words - per student; if you can make this be a neat fraction of a page in your book, such as a quarter, that will help
- A book, to hold up as an example and estimate how many words it has in it
- Ruler for each student
- 2 worksheets printed for each student
- Cosmic Voyage: The Power of Ten video, at bit.ly/powerof10video

Support resources:

- Helper notes: An overview of the Masterclass content and activities
- Supporting notes: Extra information and background on the content of this Masterclass
- Session script: Suggested wording for each section of the session

Things to prepare in advance

- Print worksheets and resources as detailed above
- Gather general Masterclass resources
- Count the balls in the bucket so you know total
- Find out details for your book/newspaper samples for the book exercise

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

Feedback

We would very much welcome your feedback on this session. If you have time, please collect feedback from the students at the end of the Masterclass and send it through to us. We would also appreciate feedback on how you have used the session, what you think worked well and what improvements would be useful.

Time plan of Masterclass:

Slides & Time	**Overview**	**Activity**
Slide 1 5 minutes (5)	Introduction Instructions on screen. Helpers and Speaker: hand out Bigger and Smaller worksheet then circulate and chat with students	Settling activity - What's bigger or smaller than me? **Bigger and Smaller worksheet** Students should write down as many examples as they can think of in each category, and if they want they can draw diagrams, or estimate how many times bigger or smaller each thing is (how many of you would fit in the space it takes up, or how many of the thing would fit in the space you take up). If they're not sure of the precise answer, encourage them to guess.
Slides 2-7 5 minutes (10)	Introduction to the Ri *[Only include these slides for the first session in the series – otherwise remember to hide the slides before you start the Masterclass]*	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: • 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).

Slide 8 10 minutes (20)	Discussion of introductory work Estimation of how much bigger or smaller something is Discussion of quantities in context	Discuss the answers given in the first activity. Students should be given a chance to compare their answers with other students, and discuss why they chose the answers they did. Discuss how what one person considers big might be considered small by someone else. Write up the answers on the board in two lists - 'bigger than' and 'smaller than'. Split the students into two groups - one group working on the 'bigger than' ideas and one working on the 'smaller than' ideas. Each group should try to order all the items in their list by size, and estimate how much bigger or smaller things are. They can make an assumption about their own height - maybe 1.5m, or 150cm - and work from there.
Slides 9-13 5 minutes (25)	Estimation and assumptions - slides	Introduce the ideas of estimation and assumptions. Ask students to name a way to visualise a hundred of something. A pair of hands is 10 fingers, and 10 people each holding up 10 fingers is 100 fingers; you could put 100 things in a 10 by 10 square. Show the examples on the slides. The grid of photos of people contains lots of people - how could we estimate how many? Count the height and width of the grid, and multiply those numbers together (16×20 = 320). Now discuss how to work out how many people can fit in a stadium. Show the photo of the National Stadium in Warsaw, and discuss what kind of estimate you could get by looking at these photos, and what you would need to count in order to do this. (The stadium holds about 60,000 people). How many stadia would it take to hold a million people?
Slides 14-15 5 minutes (30)	Numbers and zeroes (worksheet)	Many of the numbers we've been working with have zeroes on the end - 100, 1000, 10,000, 100,000, a million. -These numbers have names too. Do you know them all? Get students to attempt the 'numbers with zeroes' worksheet, and write down how many zeroes are in each number, and what this number is called if they know. -There's space for them to write their own examples if they have spare time.
Slides 16-33 10 minutes (40)	Keeping track of numbers	Show the slide with the newspaper article - 'one gram of water contains more than 30 000 000 000 000 000 000 000 water molecules'. -Is this number written in a useful way? Would anyone understand by looking how many this is? -You can remind students that we sometimes put a comma after every third zero from the right to keep track of how many zeroes there are. But even this sometimes doesn't help.

		Ask students what the notation '10^2' means - to square a number, which means 10 × 10. -Note that multiplying by 10 adds a zero to the end of a number. -So, if I were to multiply by 10 then by 10 again, how many zeroes would this add? -And how could we write this? $10^3 = 10×10×10 = 1000$, with 3 zeroes. So what is 10^4? -Explain this small number is called the index, and tells you how many zeroes are on the end of the number. Ask students to go back and write '10^n', where n is the number of zeroes, for each of the numbers on the Big numbers and zeroes worksheet, down the right hand side of the sheet. -Now discuss what happens to the index if you multiply numbers.1000 × 10 = 10,000 - an extra zero on the end. -But what about 1000 × 100? This would be 100,000, which has as many zeroes as both the numbers originally had. -Explain that you can count the total number of zeroes, or add the indices. Use the examples on the next slide and work out the answers together.
Slide 36 5 minutes (45)	Estimation - using an educated guess Working out on whiteboard or flipchart	Sometimes you don't have the answer to a question, but you need a rough answer. -How many eggs will a chicken lay in a year? -Ask the students to think for a short time, and then guess. -Is the answer closer to 100, or 1000, or 10,000? Then work out an estimate - how many eggs might a chicken lay in a day? -Pretend (or explain if true!) that someone you know has a pet chicken and it lays one or two eggs a day, depending on how happy it is - if it's sad because the weather is cold, it might not lay any eggs at all. -See if someone knows how many days are in a year - 365 - so a chicken might lay 300 to 400 eggs in a year. How many chickens would you need to feed a family of four? -Ask the students to estimate how many eggs they eat, and how many their family eats, in an average week, and use this to calculate.
Slide 37 15 minutes (60)	How many ping pong balls will go in a bucket?	In pairs, let the students discuss how they might estimate this. -They might suggest finding out how many balls fit on the bottom layer, and how many layers will fit in the bucket. Once everyone's had an idea, fill the bottom layer of the bucket with balls and count them, and then hold some balls to the side of the bucket to see how many layers will fit. -Use this to make an estimate. It will usually be lower than the actual number. Discuss this, and any other estimation methods suggested by students - what assumptions were made?

		- that all the balls are the same size - that each layer will hold the same number - that the sides of the bucket are vertical -Explain that just because the estimate was wrong, doesn't mean it wasn't a good estimate! -It's sometimes called an 'educated guess', and it's useful if you don't have time to count all the ping pong balls but want a rough answer quickly. -Discuss how mathematical models for real-world problems have to balance how much time it will take to find the answer with how accurate the answer will be - sometimes close is good enough.
10 mins (70)	BREAK	Drinks and biscuits and comfort break
Slide 38 15 minutes (85)	How many sprinkles?	First introduce the tub of 'hundreds and thousands' sprinkles. -Discuss how you might estimate how many sprinkles are in the tub. -Weigh them? The weight is written on the tub, but what other information would you need? -Count them? That might take too long. Introduce a quicker way to count the tub. First mark the initial level of sprinkles on the side. - Each student is given a teaspoon of sprinkles, and a sheet of paper to keep them on - Divide the pile in half, then those piles in half again, and continue until there is a manageable number to count - Count one of the smallest piles, and then work out how many there are by counting how many piles in total - Look at how many students counted, and consider what fraction of the tub was used, to work out how many there were altogether.
Slide 39 15 minutes (100)	How many words are there in a book?	To answer this question, we should list the information we need - how many words are there on a page, and how many pages are in a book? -Each student is given a clipping of newspaper with a standard font size. -They should count the words, then compare this piece to the size of a page of the book - they can use a ruler to measure. -You could write the number of pages, and the measurements of the text region of each page, on the board so they have the information. -Ask the students to estimate, using powers of ten, how many words are in your book. If you count 89 words, or 120 words, this is near to 100 = 10^2. How many books in a library? -You might need to know how many books fit on a shelf, how many shelves in a bookcase, how many bookcases in a room, how many rooms in the library. -How many words in a library?

Slides 40-49 5 minutes (105)	Smaller numbers	Earlier we saw that multiplying by 10 increases the index by 1. -What happens if we divide by 10? 1000/10 = 100. This subtracts one from the index. Work backwards from 1000 using the slides. -Each time you divide by 10, discuss the answer: $10^2 = 100$, but what's 10^1? This is just 10. This means $10^0 = 1$, as it has no zeroes. -What happens if we go beyond this? See if any student suggests $10^{-1} = 1/10$. -Ask students to write other numbers with negative indices, and write them as a fraction.
Slide 50 5 minutes (110)	'Powers of ten' video	To finish the session, you can watch a 5-minute video showing the scale of powers of ten going up, starting from 1 metre. -They can see how using powers makes it easier to describe very large numbers. If you have time, you can ask students to fill in a second copy of the initial 'What's bigger or smaller than me?' worksheet and see if they estimate and describe their answers differently now.
Slides 51-55 5 minutes (115)	Feedback, tidy up, pick all the sprinkles up from everywhere, questions time Ask the Ri	Recap of session contents. Don't forget to collect any questions and feedback on post-it notes, and email them to the Masterclass team at the Royal Institution: masterclasses@ri.ac.uk
Slides 56-59	Possible NRICH problems related to this session – use as extension activities or for them to do at home	• nrich.maths.org/7449 Discuss and Choose • nrich.maths.org/8170 Olympic Starters • nrich.maths.org/10629 Estimating Time • nrich.maths.org/6349 A Question of Scale (this activity is aimed at KS4, so younger students may need assistance)