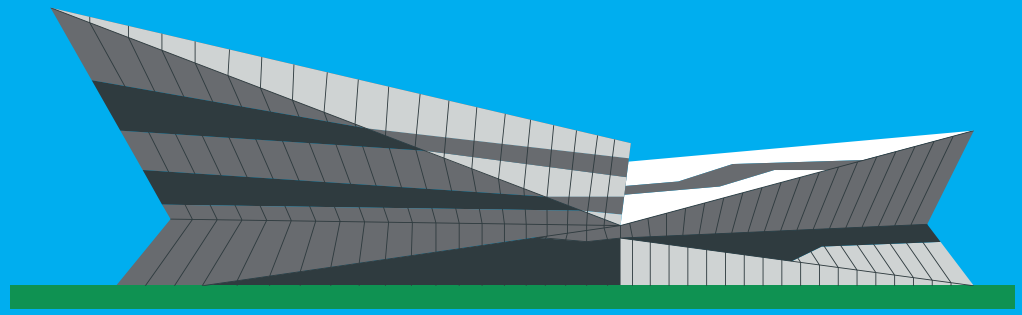
MAYOR OF LONDON

THE LONDON CURRICULUM

MATHS KEY STAGE 3

HEALTHY LONDON AIR



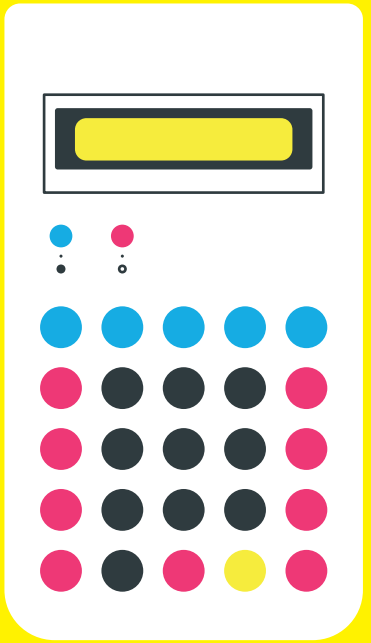
UCL
Institute of Education

THE LONDON CURRICULUM

PLACING LONDON AT THE HEART OF LEARNING

The capital is the home of innovations, events, institutions and great works that have extended the scope of every subject on the school curriculum. London lends itself to learning unlike anywhere else in the world. The London Curriculum aims to bring the national curriculum to life inspired by the city, its people, places and heritage.

To find out about the full range of free resources and events available to London secondary schools at key stage 3 please go to www.london.gov.uk/london-curriculum.



STEM in the London Curriculum

London provides numerous historical and contemporary cutting edge examples of scientists, engineers and mathematicians who have worked in their fields to create innovative solutions to problems throughout the world. Population growth, trade, communication, transport, health, food, water supply and many other aspects of life in London have driven technology-based innovations. London Curriculum science, maths, design & technology teaching resources aim to support teachers in helping their students to:

- **DISCOVER** the application of their subject knowledge to the life of the city.
- **EXPLORE** their neighbourhood and key sites around London, learning outside the classroom to see and understand how STEM subjects have shaped many aspects of the city.
- **CONNECT** their learning inside and outside the classroom, analysing situations and using their subject knowledge to create and present solutions.

CONTENTS

CLEAN AIR IN OUR CAPITAL OVERVIEW

UNIT AIMS AND OBJECTIVES

London is one of the most exciting cities in the world, with a large population, significant economic activity and a thriving tourist industry. London's size and success also create challenges, however, which can threaten the quality of life in the city. One such factor is air quality, with air pollution contributing to a number of health problems. Unsurprisingly, many substances which cause health problems in humans also negatively affect the health of the planet, so it is important to understand the causes of air pollution and to work to reduce it, both through everyday changes that we can all make and also longer-term strategic decisions.

Statistics is the study of collection, organisation, analysis, interpretation and presentation of data. It deals with all aspects of data, including the design of surveys and experiments to collect data. It also includes describing mathematical relationships between variables and presenting these to an audience in a way that best conveys meaning.

The purpose of this unit is to revise and consolidate students' statistics knowledge and to illustrate how statistics are used in the analysis of real-life problems in order to create solutions. Students will then investigate professional roles that contribute to improvements in air quality and identify how maths is used in these careers.

TRAFFIC IN SMOG AT NIGHT, 1956

KEY STAGE 3 NATIONAL CURRICULUM

This unit addresses subject content requirements within the statistics part of the key stage 3 national curriculum as follows:

Statistics

Pupils should be taught to:

- describe, interpret and compare observed distributions of a single variable through: appropriate graphical representation involving discrete, continuous and grouped data; and appropriate measures of central tendency (mean, mode, median) and spread (range, consideration of outliers)
- construct and interpret appropriate tables, charts, and diagrams, including frequency tables, bar charts, pie charts, and pictograms for categorical data, and vertical line (or bar) charts for ungrouped and grouped numerical data
- describe simple mathematical relationships between two variables (bivariate data) in observational and experimental contexts and illustrate using scatter graphs

In meeting some of the requirements of the national curriculum, this teaching unit also contributes to the following areas of working mathematically:

Develop fluency

- move freely between different numerical, algebraic, graphical and diagrammatic representations

Reason mathematically

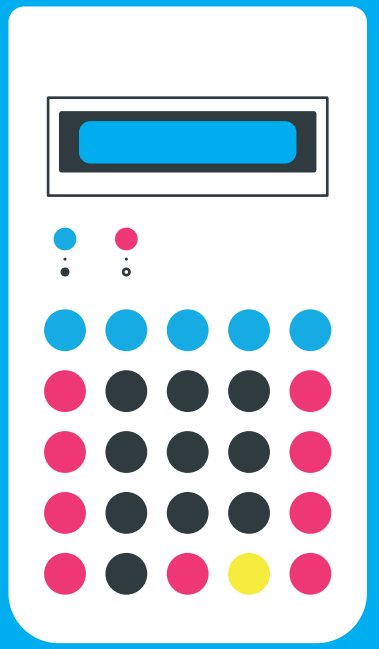
- identify variables and express relations between variables algebraically and graphically
- explore what can and cannot be inferred in statistical and probabilistic settings and begin to express their arguments formally

Solve problems

- begin to model situations mathematically and express the results using a range of formal mathematical representations

DISCOVER

Students will revise and consolidate their understanding of statistical techniques. They will then identify how these same techniques are being applied to the problem of air pollution in London in order to create a richer, more connected understanding of statistics and their application to problems in real life.



LESSON 1
USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

THE BIG IDEA

Statistics are a vital tool that can be used to define and solve a wide range of problems in everyday life. In this lesson students will revise and consolidate statistical techniques and then look at how these techniques were used to identify and overcome problems of air pollution in London in the 1950s and how they are used to monitor air quality in London today.

LEARNING OUTCOMES

Could calculate lists of numbers which satisfy a number of generalised requirements of mean, mode, median and range, explain why the air quality monitoring stations use the mean, and use the idea of outliers to explain why it is permissible to exceed the set limits on a given number of occasions.

Should be able to calculate lists of numbers which satisfy given numerical requirements of mean, mode, median and range, explain how statistics were used to show that the smog caused an increase in death and give examples of the statistics that the air quality monitoring stations produce.

Must be able to calculate mean, mode, median and range for a given set of numbers.

LESSON 1
USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCES

Resource 1.1: Venn diagrams

Resource 1.2: Discussion questions

YOU WILL ALSO NEED

- One mini-whiteboard, pen and cleaning cloth for each student in the class
- Post-it notes (if possible, a different colour for each group)
- Access to computers

EXTERNAL LINKS

londonair.org.uk/LondonAir/Default.aspx

londonair.org.uk/london/asp/publicdetails.asp?region=0

londonair.org.uk/LondonAir/guide/WhereShouldILive.aspx

LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

SETTING THE SCENE

London has had problems with air pollution throughout its history. The earliest recorded complaint about air quality in London was in 1272, when King Edward I (1272 – 1307) banned the burning of sea-coal and threatened offenders with torture or execution. Even these harsh penalties failed to deter Londoners and subsequent attempts to restrict the burning of sea coal were made by Richard III (1377 – 1399) and Henry V (1413 – 1422) as well as several attempts by non-royal advocates.

The problems caused by burning coal continued through the centuries, mainly because there was no real alternative to coal. The industrial revolution exacerbated these problems, and by the early 1800s London was suffering fogs saturated with coal smoke, which hung over the city for days.

By 1952 London was regularly experiencing heavy smogs, which were air pollution events caused by burning large amounts of coal with the city.

In December 1952 London suffered the 'Great Smog'. Visibility was reduced to a few yards, making driving impossible and the smog even started to creep inside buildings, leading to concerts and cinema screenings being cancelled.

Initially, there was no panic, as Londoners were used to such smogs. However in the following weeks, statistics compiled by medical services showed that the smog had killed 4,000 people, mainly the very young and old and those with existing respiratory problems. Recent research has placed this figure closer to 12,000 people.

The Great Smog is known to be the worst air pollution event in the history of the United Kingdom. It led to a number of changes, including both legislation and practice and was the catalyst for the Clean Air Act of 1956. The Act introduced a number of measures to reduce air pollution and was an important milestone in environmental legislation.

In 1961 the UK established the world's first national air pollution monitoring network. The data obtained from these sites shows that levels of black smoke and sulphur dioxide concentrations have declined dramatically. However, air pollution is still a problem in London, with nearly all boroughs failing to meet the EU's air pollution limit for the toxic gas NO_2.

BATTERSEA POWER STATION, 1950 –1959

LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

ACTIVITIES

STARTER

Give each student a mini-whiteboard, pen and cleaning cloth. Explain to the students that they will be asked a question, given a set amount of time to write their working and the answer on their mini-whiteboard and then they will all be asked to hold up their whiteboards at the same time (this bit is important!) Discuss the answers and if students have different answers, ask them to try and convince the others that their answer is correct until they reach a class consensus. Repeat for the median, mode and range.

MAIN 1

Put the students in small groups and give each group a copy of Resource 1.1: Venn diagrams (pages 11–18) and also some small post-it notes. Explain how Venn diagrams work, including the space outside the circles, then tell the students that once they have found sets of numbers for as many regions as possible on a particular diagram, they are to write the lists on a post-it note and then and stick them on the large diagrams around the room. Ask the students to fill in either two or three of the diagrams and let them choose the ones they would like to answer. Explain, that where possible, they should aim to find lists that no other group will have. Once they have had a while to work on this, bring the class back together and discuss what strategies they used to find the numbers, which diagrams or regions they found particularly easy or hard to answer and to justify their reasoning for any regions they think cannot be filled in.

Differentiation

Seat students according to those who work together well and/or ability.

Suggest to students who are likely to struggle that they fill in the double diagrams.

Suggest to students who are likely to find the task more straightforward that they fill in the triple diagrams.

There are blank Venn diagrams included in Resource 1.1: Venn diagramms (pages 11–18) which can be used to make easier or harder questions as required.

To test students' understanding, ask them to find more than one list of numbers for any given region.

Extension

Ask students to create their own Venn diagram as an extension task (either double or triple).

Ask students if they are able to create a quadruple diagram for this topic.

MAIN 2

Explain that students are now going to look at how statistics can be used outside of the classroom. Start by asking students to volunteer and discuss what they already know about air pollution and whether they think it is a recent problem. Explain that air pollution in London has been a problem for many years and that in 1952, the Great Smog caused 4,000 deaths. Emphasise that it could be shown that the smog caused 4,000 deaths by analysing the data that had been collected and comparing it to the number of deaths you would expect in a given time period. Explain that the Great Smog finally resulted in the Clean Air Act of 1956 and, as a result of this, in 1961 the UK established the world's first coordinated national air monitoring network.

Using the London Air Quality Network – Monitoring Sites website:

http://www.londonair.org.uk/london/asp/publicstats.asp?region=0&site=TH6&la_id=&network=All&postcode=&MapType=Google&VenueCode=)

introduce the idea of collecting and analysing data to establish air quality. Show students the monitoring sites in the borough and identify which pollutants are being monitored at each of the stations. Show data that is being collected and that statistical techniques are being used to analyse this data.

If the school has an AirSensa monitor then this would be a good point to introduce this and explain what it does and the data it collects. The AirSensa project is building a network of up to 10,000 monitoring stations across London and offers schools the opportunity to have their own AirSensa unit for free, along with a unique login which will allow them to gather data from their unit and access Change London's educational materials.

http://stemedlondon.org.uk/2014/10/the-airsensa-project-for-schools/

Give small groups of students a copy of Resource 1.2 Discussion Questions (page 19), or display them on the board. Students prepare answers to the questions and the teacher then pulls all the information together at the end.

Differentiation

Provide more support for weaker groups or those who struggle with the task.

Allow one student from each group to act as a 'Magpie', going round tables and looking at what others are doing without asking questions and then reporting back to their group.

Students in a group which finish quickly could be asked to support groups which are working more slowly.

Extending

What is a micron in standard form?

What percentage of deaths was caused by smog in 1952?

What percentage of deaths nowadays is attributable to air pollution?

Plenary

Which site has better air quality? Students to write a paragraph explaining their answer to the following question.

You are monitoring air quality for a month in two different sites. On one site, the overall average is well within EU limits, but there are 2 days when air pollution exceeds these limits. On the other site, there are no days when air pollution exceeds the EU limits, but it is very close to, or at the limit nearly every day. Which site do you think has more pollution? Justify your answer.

Homework ideas

Choose one of the four main pollutants and write a report about where the pollutant comes from and the damage that particular pollutant causes to health. Links to science could include the chemical formulae for the various pollutants.

Choose one of the air quality monitoring network sites – maybe nearest school / home – and find out what type of monitoring station it is and what the air quality is at that site.

Ask students to complete the relevant online homework in My Maths.

Ask students to complete the relevant exercises from their text book.

Give students homework sheets which will require them to practise finding mean, median, mode and range. Free worksheets can be found using the link below:

prethomework.weebly.com/data.html

www.mathster.com/free_worksheets.php

www.funmaths.com/worksheets/math_statistics_01.htm

www.math-drills.com

Assessment ideas

Exam style questions about averages and the types of data the different averages are used for.

Some exam-style questions can be found here:

keshgcsemaths.files.wordpress.com/2013/11/20_mean-median-mode-range.pdf

Further ideas for assessment could include giving students a list of numbers, with one number blanked out, and the mean of the numbers and then asking them to work backwards to find the missing number.

Further reading

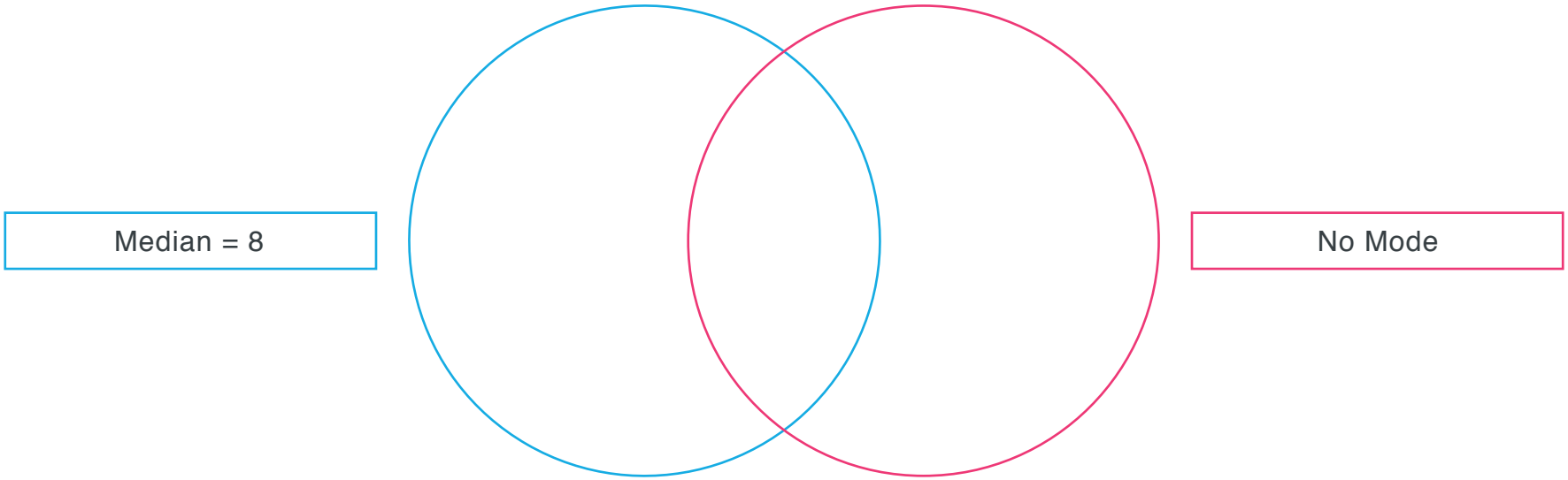
uk-air.defra.gov.uk/air-pollution

LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS

Double Venn diagram: 1

Think of a list of 4 numbers for each of the regions, including outside the circle. If you think any are impossible, be ready to convince the rest of the class!

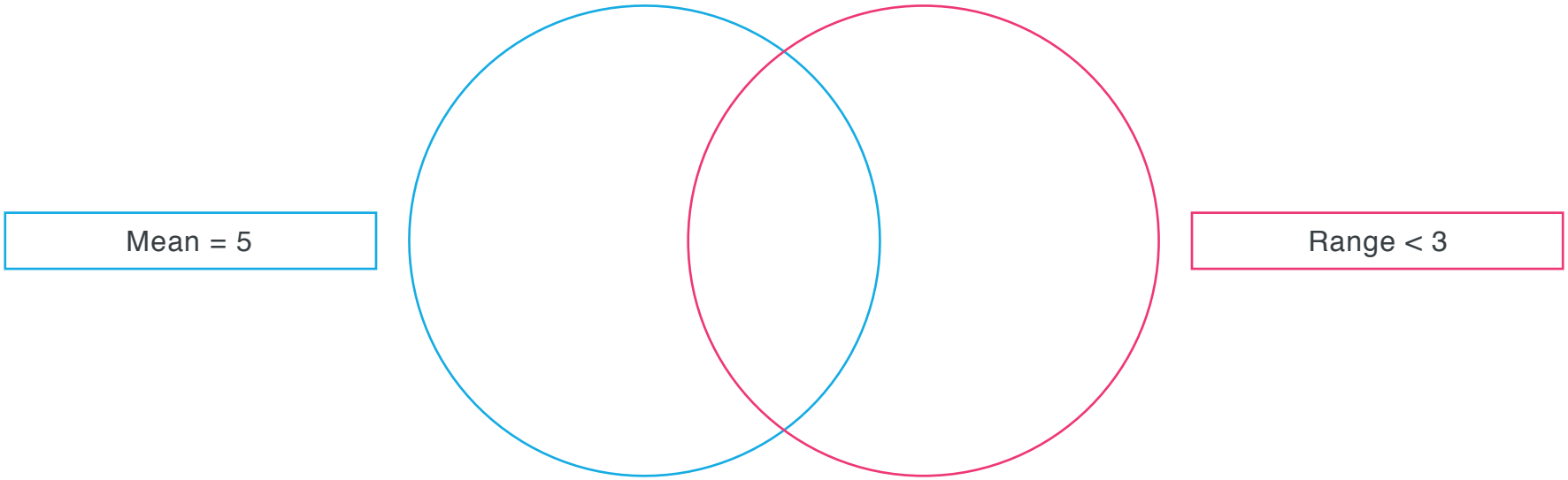


LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS CONTINUED

Double Venn diagram: 2

Think of a list of 5 numbers for each of the regions, including outside the circle. If you think any are impossible, be ready to convince the rest of the class!

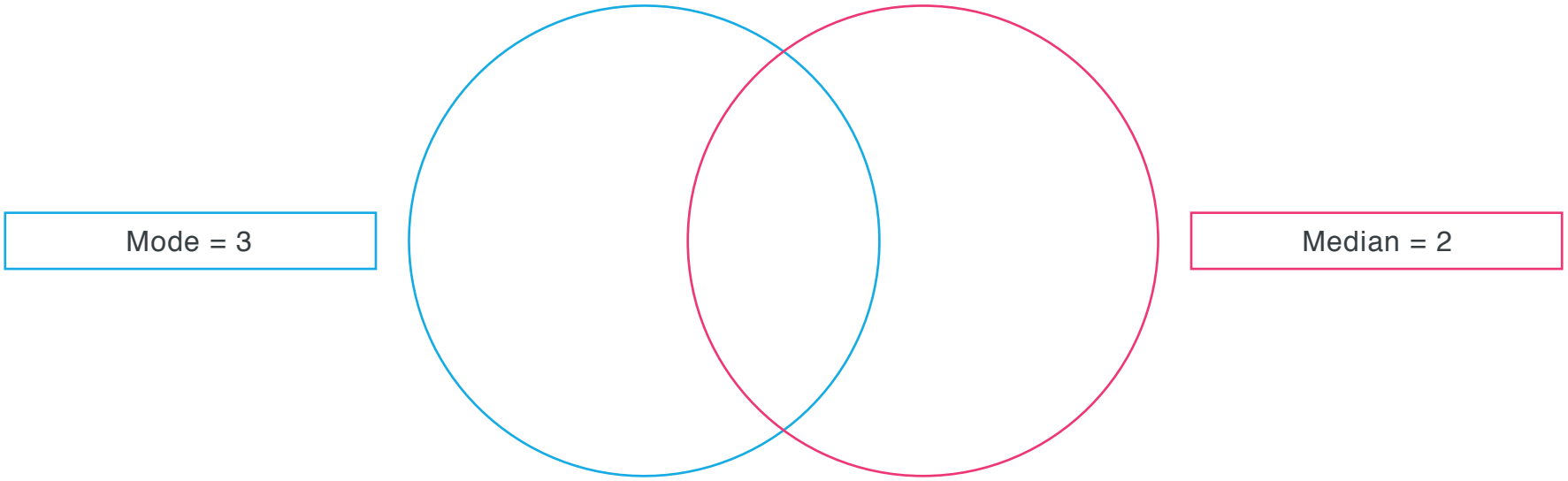


LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS CONTINUED

Double Venn diagram: 3

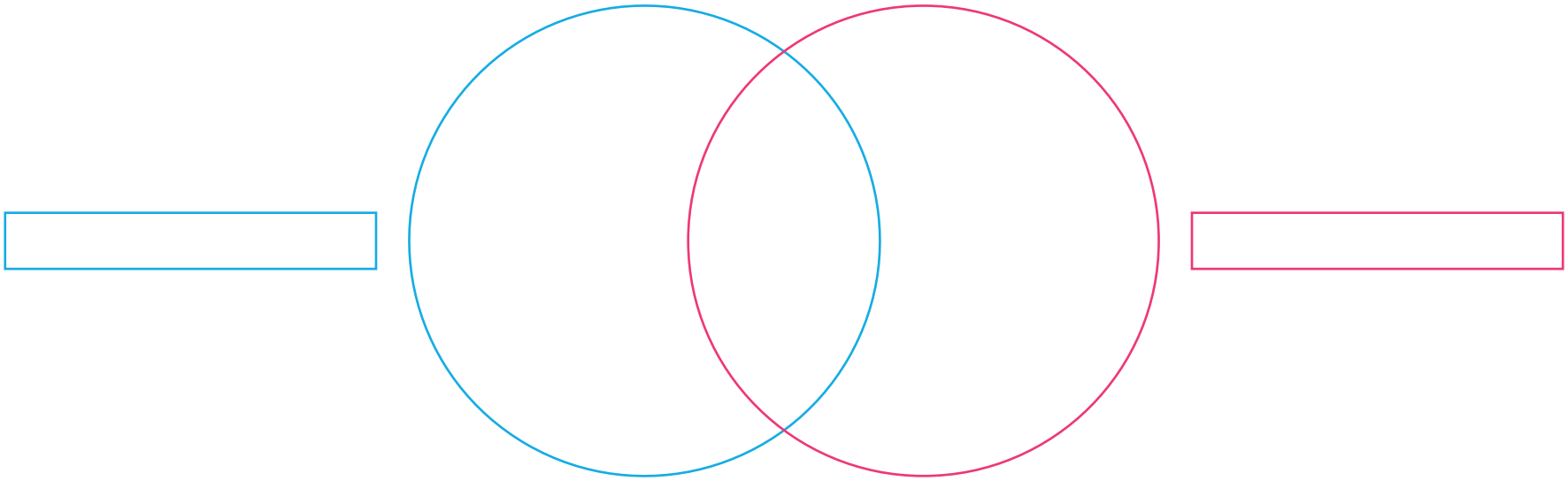
Think of a list of 3 numbers for each of the regions, including outside the circle. If you think any are impossible, be ready to convince the rest of the class!



LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS CONTINUED

Double Venn diagram

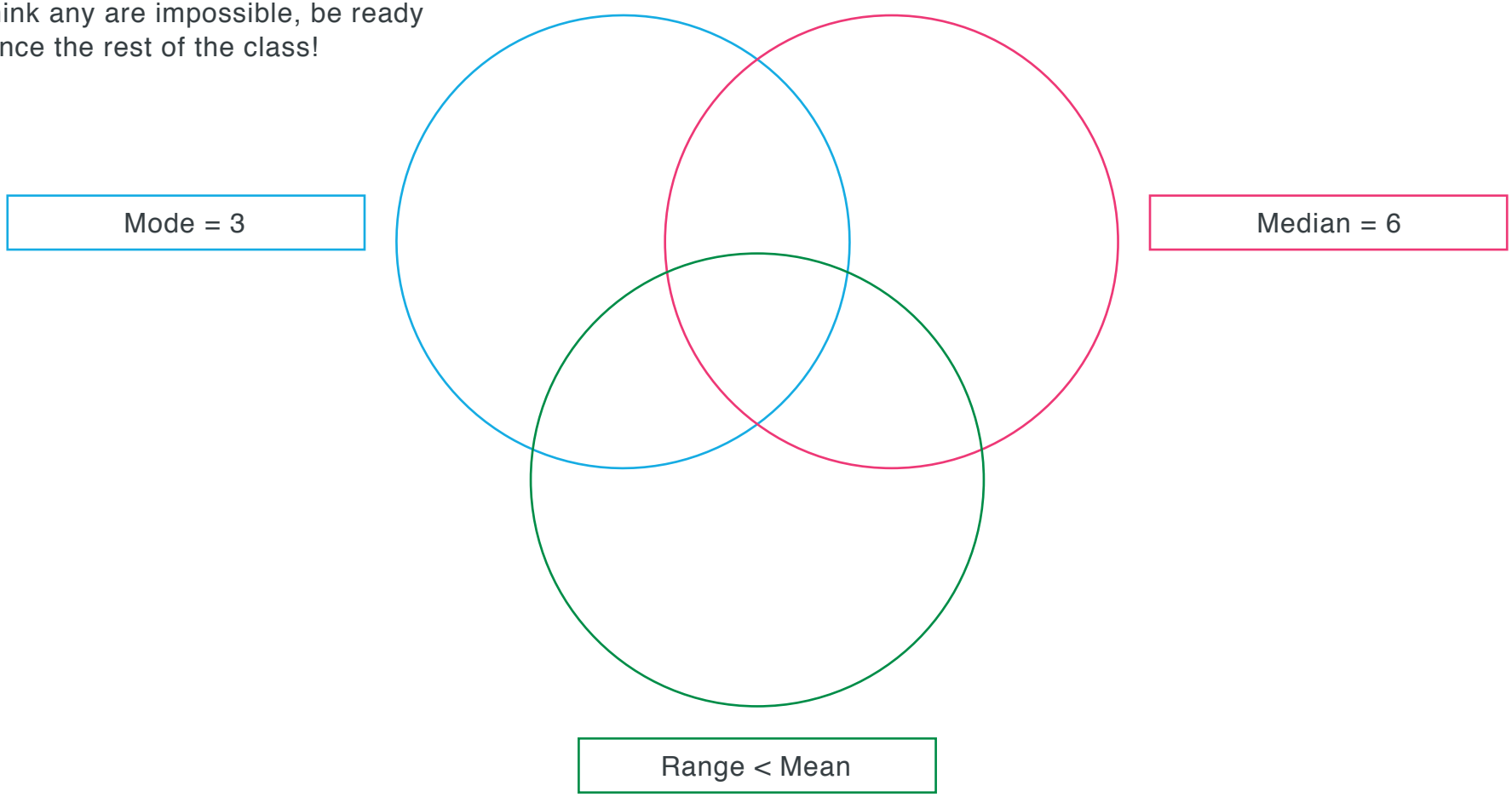


LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS CONTINUED

Triple Venn diagram: 1

Think of a list of 5 numbers for each of the regions, including outside the circle. If you think any are impossible, be ready to convince the rest of the class!

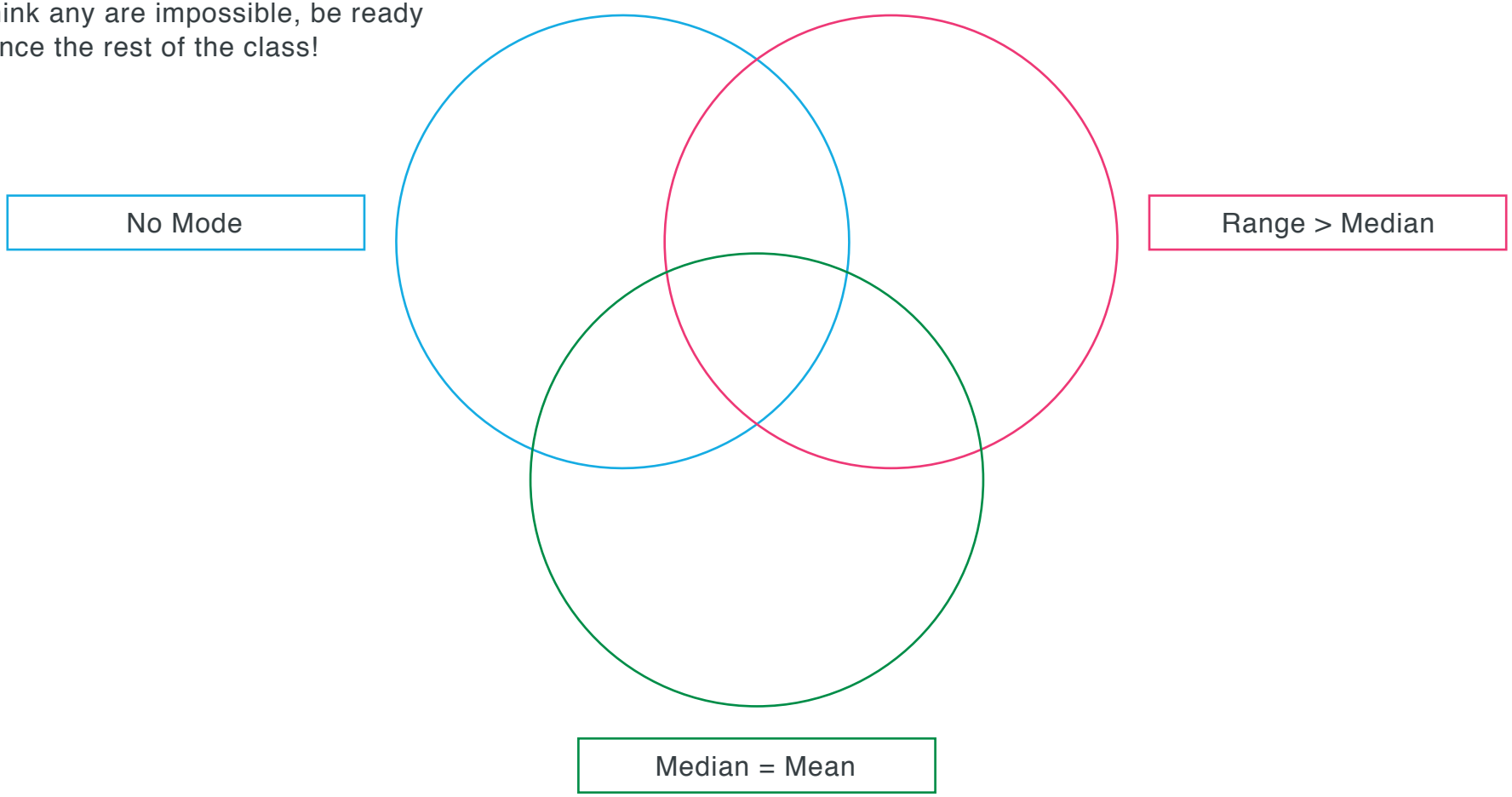


LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS CONTINUED

Triple Venn diagram: 2

Think of a list of 5 numbers for each of the regions, including outside the circle. If you think any are impossible, be ready to convince the rest of the class!

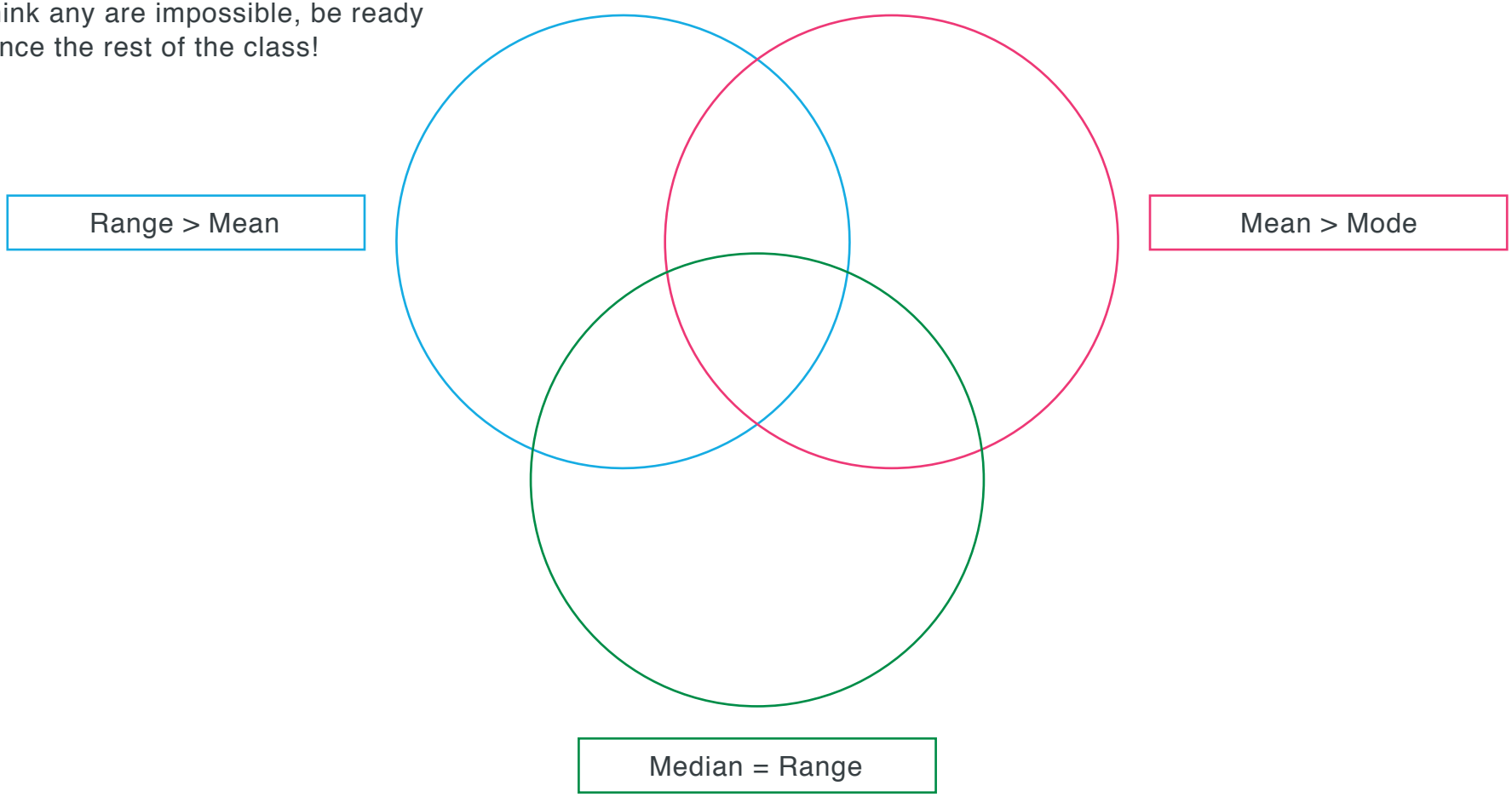


LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS CONTINUED

Triple Venn diagram: 2

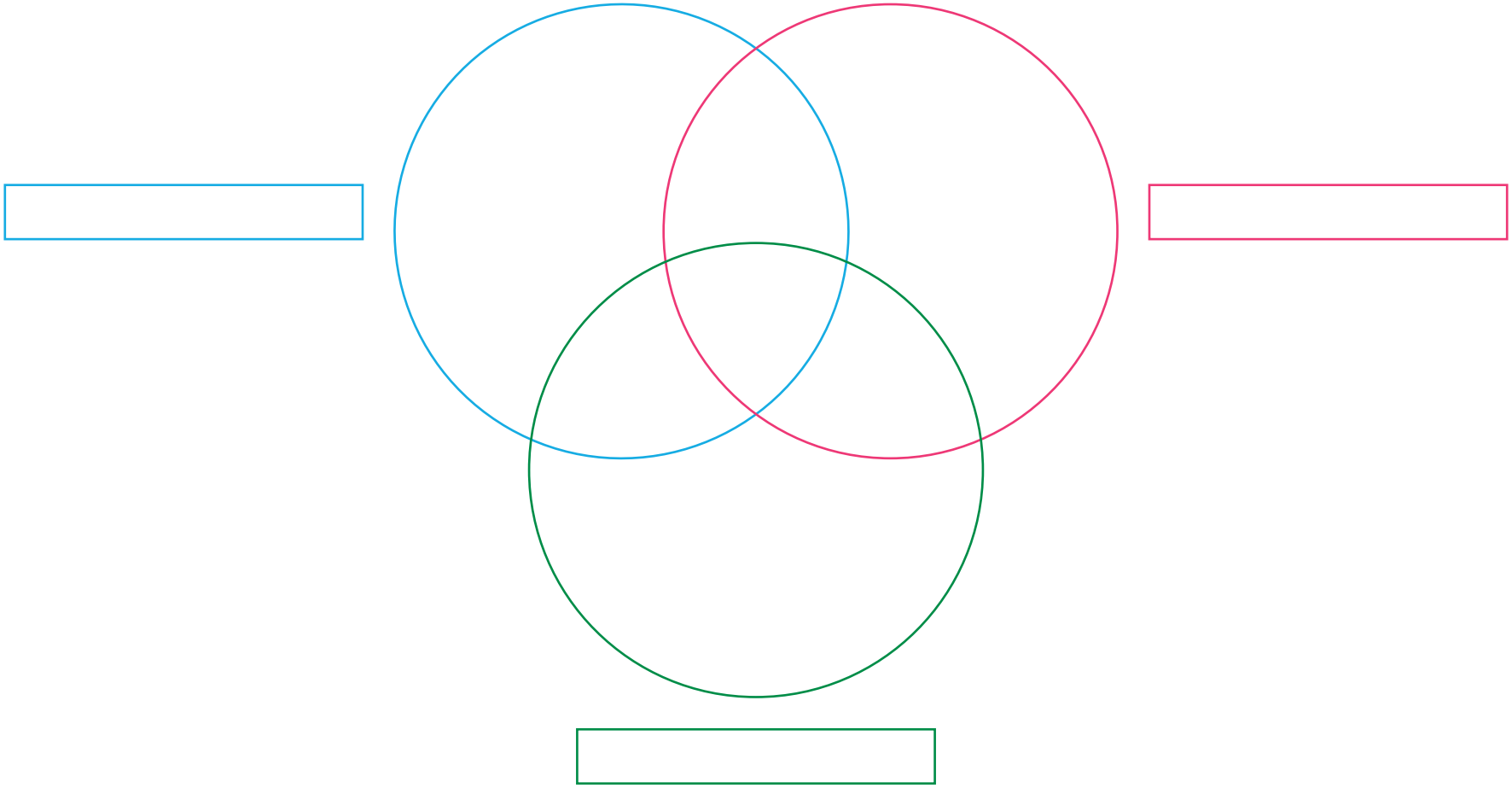
Think of a list of 5 numbers for each of the regions, including outside the circle. If you think any are impossible, be ready to convince the rest of the class!



LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.1: VENN DIAGRAMS CONTINUED

Triple Venn diagram



LESSON 1: USING STATISTICS TO UNDERSTAND WHY AIR POLLUTION IS A PROBLEM

RESOURCE 1.2: DISCUSSION QUESTIONS

1. What are the four main types of air pollution in London and where do these pollutants come from?

2. Give examples of the ways in which the four main types of air pollution can damage your health.

3. Is London currently meeting EU regulations with regard to pollution?

4. What are the different averages most suitable for measuring?

5. Why do you think the mean has been used as the average in the monitoring stations?

6. Why do you think the pollutant levels are allowed to breach the set standards on a given number of times per year?

7. What does the notation used in the data from the monitoring stations mean?

8. What is a microgram?

9. Give an example of the space occupied by a cubic metre.

LESSON 2
INVESTIGATING AIR POLLUTION IN YOUR LOCAL AREA

THE BIG IDEA

Data collection is an important part of statistics. In this lesson, students will be collecting their own data and then going on to analyse and interpret this data using scatter graphs to determine the relationship between two variables.

LEARNING OUTCOMES

Could be able to explain the concept of causality and determine whether there is merely a correlation in this case, or whether one event is causing the other.

Should be able to plot a scatter graph and determine whether the correlation between the number of soot particles in a sample and the distance from the nearest main road is weak or strong, explain what the relationship is and use their graph to predict further results. Give examples of the statistics that the air quality monitoring stations produce.

Must be able to plot a scatter graph and use it to determine whether there is a positive or negative correlation between the number of soot particles in a sample and the distance from the nearest main road.

RESOURCES

Resource 2.1: Graphs and correlation

YOU WILL ALSO NEED

- Sticky tape
- Map with a known scale of the local area or a plan of the school which is both large enough and accurate enough to take measurements from.
- Ruler
- Plain paper

LESSON 2: INVESTIGATING AIR POLLUTION IN YOUR LOCAL AREA

SETTING THE SCENE

TRAFFIC IN BRIXTON, 2009
Torla Evans © Museum of London

Although air quality in London has improved since 1952, pollution is still causing health problems and premature deaths. One of the major causes of pollution in London is vehicle exhaust fumes, particularly vehicles with diesel engines. Scientific research suggests that living near roads travelled by more than 10,000 vehicles per day could be responsible for 15 – 30% of cases of asthma in children and a similar proportion of Chronic Obstructive Pulmonary Disease and Coronary Heart Disease in adults over the age of 65. One of the pollutants that diesel engines emit, which can easily be measured, is soot. In this lesson, students are going to collect their own data about one of London's main air pollutants and plot a scatter graph to determine the relationship between traffic and pollution.

LESSON 2: INVESTIGATING AIR POLLUTION IN YOUR LOCAL AREA

ACTIVITIES

STARTER

Give the class Resource 2.1 Graphs and correlation (page 25) and ask them to add a line-of-best-fit to each of the graphs and then answer the questions. When all the groups have had a chance to do this, discuss their answers, paying particular attention to points such as other factors which can affect rental prices and ice cream sales and also the fact that using the line-of-best-fit does not produce a realistic answer for the number of units of gas used for heating when the outside temperature is 27°C. Those groups which finish early could create their own scatter graphs and those groups which are likely to struggle could answer questions about two of the graphs.

MAIN 1

Ask them whether they think there is a connection between pollution and distance from a main road. They should already know that vehicles are a source of pollution from the previous lesson and should be able to predict that pollution will be worse the nearer they are to a main road. Explain to the students that they are going to be collecting data about a pollutant called soot and distance from a main road and displaying the results in a scatter graph to show whether there is a relationship.

There are two options for the actual data collection. The first involves the students leaving the school premises in small groups and collecting data. The second involves collecting data within the school grounds.

Option 1: leaving the school premises

You will need to have picked a number of sites (approximately six) in advance that are approximately five minutes from the school and include a mixture of locations which are near a main road and those which are further away. To make this exercise quicker, you may wish to work out the distance from the nearest main road yourself, rather than expecting students to do this.

Explain to the students that they will be sent to the different locations in small groups and then each one of them will be asked to take two samples of soot particles using sticky tape. They will do this by pressing the sticky side of a length of tape (a minimum length of 2cm) firmly onto a surface, leaving it for ten seconds, and then removing it. Soot and other particles from the air will have adhered to the tape, along with other debris. Take two samples and stick the samples onto a blank sheet of A4.

Once they get back to the school, ask each student to take one further sample using sticky tape from within the school grounds. Once back in the classroom, as each student to mark a length of 2cm on each of their samples and count how many soot particles there are in their sample. Remind each group how far from the nearest main road their location was are and collect the results for all of the locations, except the school grounds in a spreadsheet.

Option 2: staying within the school premises

As Option 1, except that the sites you pick will need to be within the school premises and at a variety of distances from the main road. You will also need to pick an extra site, ideally around the middle distance from the main road, where all the students will need to take readings from. In the same way as the reading from the school grounds was not entered into the spreadsheet in Option 1, the readings from this extra site will also not be entered into the spreadsheet.

Differentiation

More able students students could be asked to use the map and the map scale to work out the distance from their location to the nearest main road themselves.

Plenary

Designate two walls of the classroom to be axes. Distance from the nearest main road will be given on the x-axis and number of soot particles on the y-axis. Ask the students to stand in a position which represents their data.

Now using the results collected in the spreadsheet, plot a scatter graph and ask the students to compare how this graph looks in comparison to how they have arranged themselves.

Finally, if you chose Option 1, tell the students how far the school is from the nearest main road and use the graph created from the spreadsheet to predict the number of soot particles they would expect to find. Once they have done this, check the accuracy of the data they have collected by asking them to check how many soot particles there were in the samples they collected.

Alternatively, if you chose Option 2 above, tell the students how far the extra site is from the nearest main road and again, use the graph created from the spreadsheet to predict the number of particles they would expect to find and then check the accuracy of the data they collected.

The students will then write a short description of what this data is showing.

Homework ideas

Ask the students to write a report of the data collection experiment. Give them a copy of the data from the spreadsheet and ask them to draw a scatter graph for themselves.

Ask the students how they think the data collection experiment could be made more accurate.

Ask the students to research how many pieces of data should be included for a sample to be accurate e.g. how many roads and surrounding areas do they think they should sample before they can safely conclude there is a relationship between particulate pollution and distance from a main road.

Assessment ideas

Give the students data sets and ask them to plot the data in a scattergraph to determine any relationships. Check their use of terminology and ability to make predictions using a trendline.

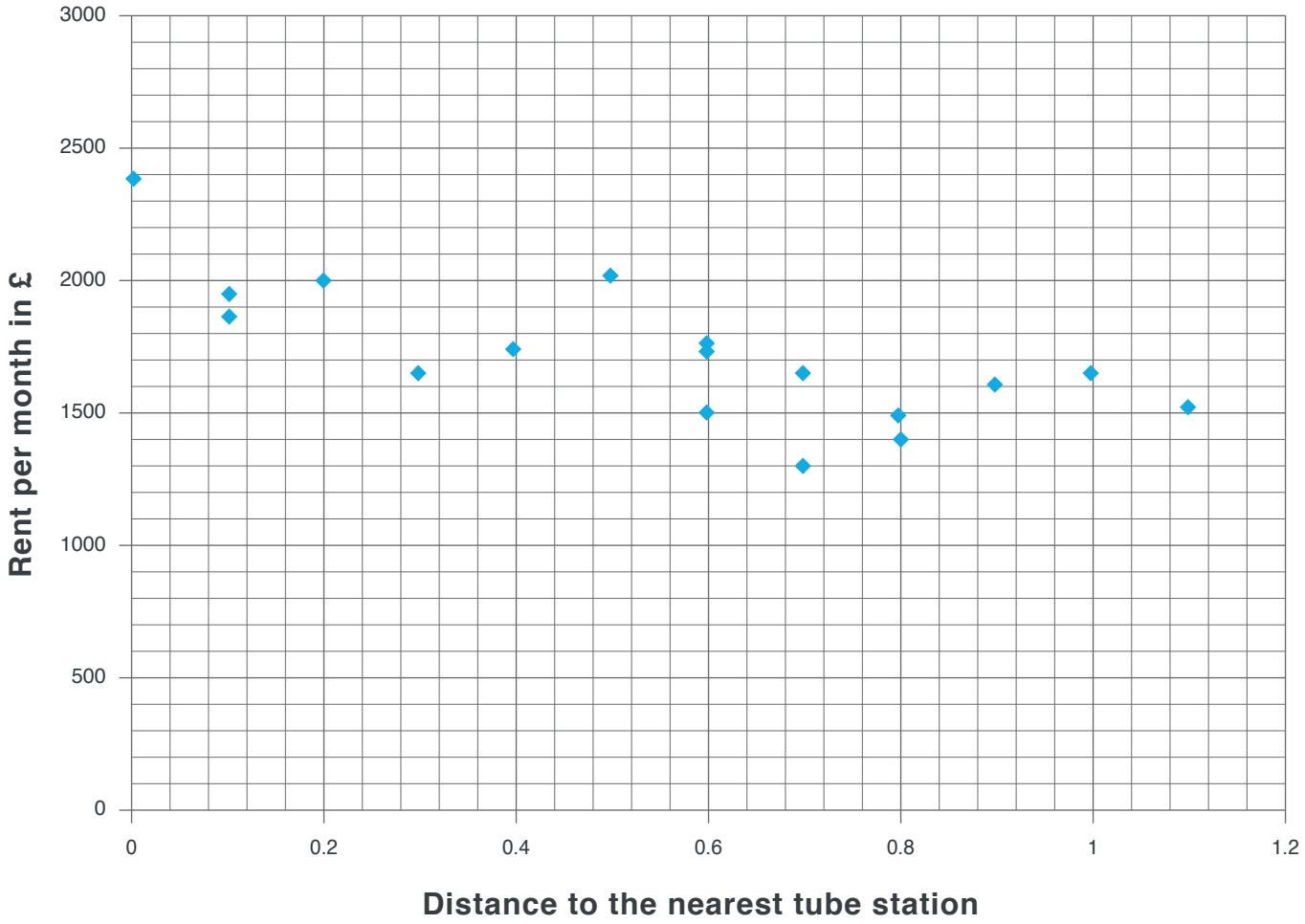
Further reading

field-studies-council.org/documents/projects/bordercrossings/Air%20pollution.pdf

opalexplorenature.org/sites/default/files/7/file/OPAL-SE-Roadside-Soot-Activity.pdf

LESSON 2: INVESTIGATING AIR POLLUTION IN YOUR LOCAL AREA

RESOURCE 2.1: GRAPHS AND CORRELATION



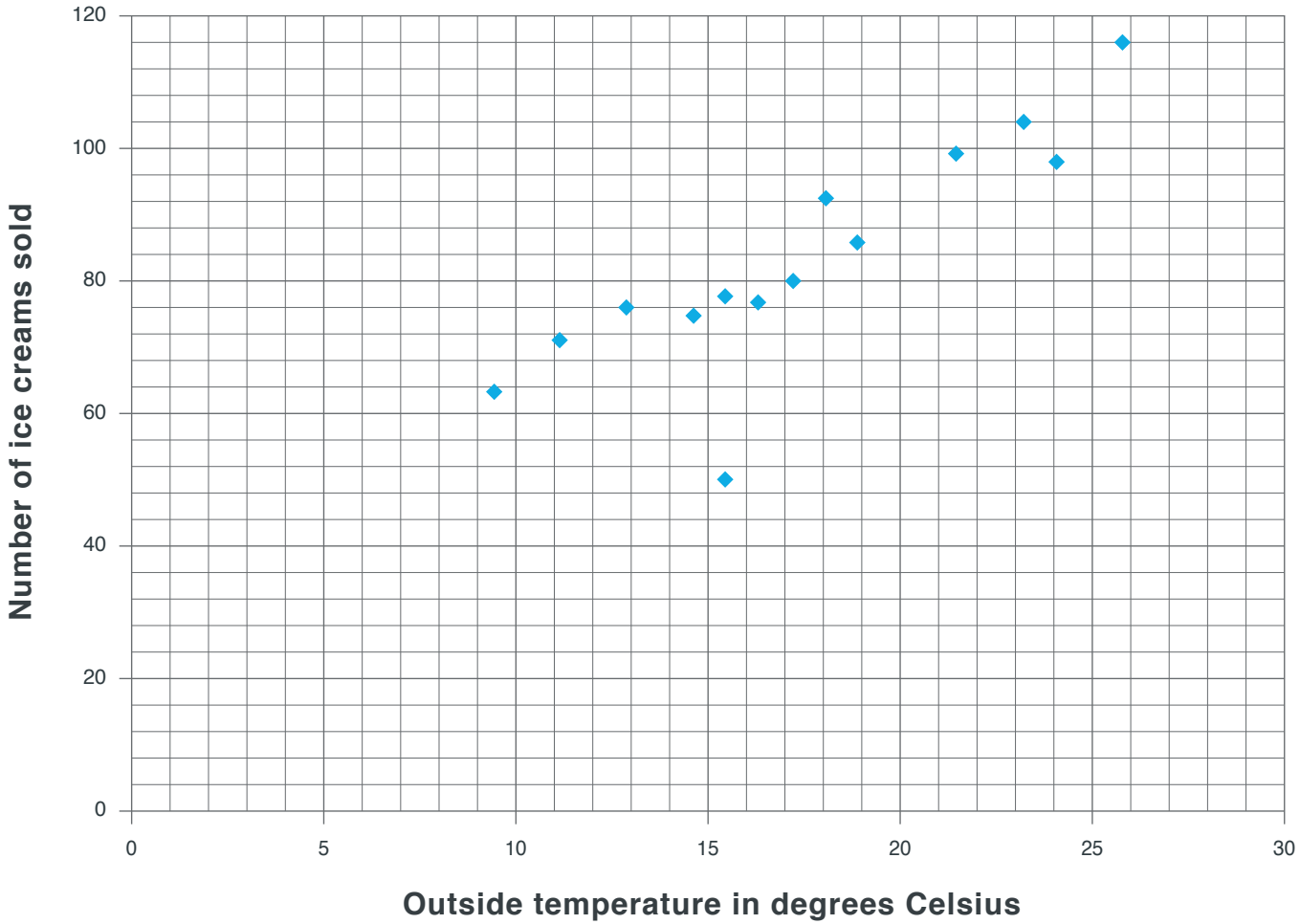
Graph 1

The cost of renting a two bedroom flat and the distance to the nearest tube station

1. What type of correlation does this graph show?
2. What is the relationship between the distance from a tube and the cost of renting a 2 bedroom flat?
3. What other factors, beside distance from a tube, could affect the rental price of a flat?

LESSON 2: INVESTIGATING AIR POLLUTION IN YOUR LOCAL AREA

RESOURCE 2.1: GRAPHS AND CORRELATION CONTINUED



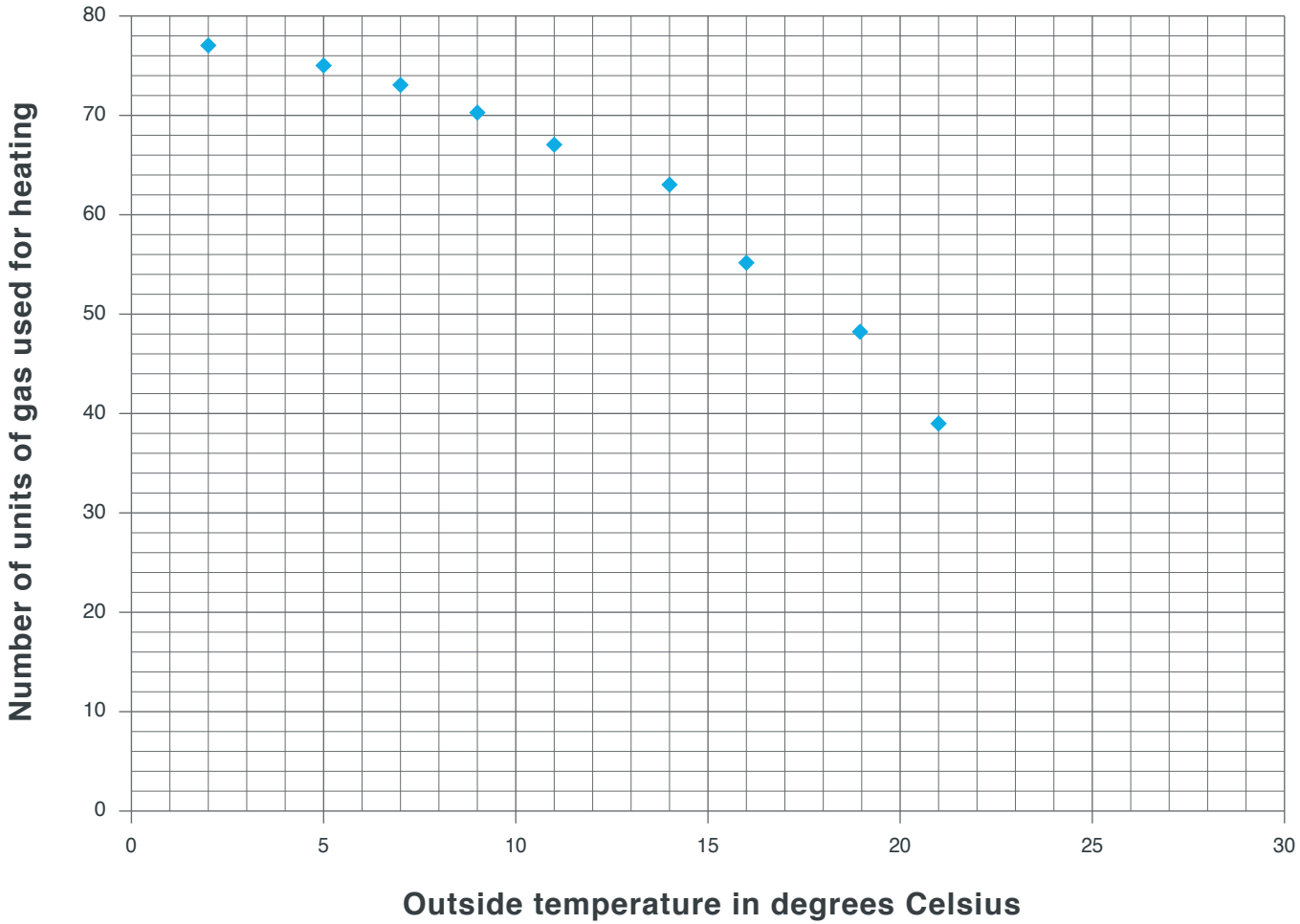
Graph 2

The number of ice creams sold and the highest daily temperature

1. What type of correlation does this graph show?
2. What is the relationship between the temperature outside and the number of ice-creams sold?
3. One of these points is an outlier. How can you tell it is an outlier and what was the temperature when this event occurred?
4. Suggest some reasons for this outlier.

LESSON 2: INVESTIGATING AIR POLLUTION IN YOUR LOCAL AREA

RESOURCE 2.1: GRAPHS AND CORRELATION CONTINUED



Graph 3

The number of units of gas sold for heating and the outside temperature

1. What type of correlation does this graph show?
2. What is the relationship between the temperature outside and the number of units of gas used for heating?
3. Predict how many units of gas will be used for heating when the outside temperature is 27°C.
4. Explain the method you used to obtain your answer.

LESSON 3
COMMUNICATING OUR DATA TO OTHERS

THE BIG IDEA

The ability to communicate ideas clearly is a very important skill for a mathematician to have.

LEARNING OUTCOMES

Could be able to construct and interpret an appropriate graph table, chart or diagram from given data; will have clearly explained what their data shows; and will have started to draw on their previous knowledge to make conclusions.

Should be able to construct and interpret more than one appropriate table, chart or diagram from given data; will have compared and contrasted what their different table, chart or diagram show; and written conclusions about why this is the case.

Must be able to construct and interpret a table, chart or diagram from given data and will have written a short explanation about what the data shows.

RESOURCES

Resource 3.1: Representing data

YOU WILL ALSO NEED

- Access to computers
- Either spreadsheet from: **data.london.gov.uk/dataset/london-average-air-quality-levels/resource/acce7f88-70f0-4fd0-9160-f02a9d96b2c3#**

EXTERNAL LINKS

howpollutedismyroad.org.uk

cleanerairforlondon.org.uk

londonair.org.uk

tfl.gov.uk/cdn/static/cms/documents/improving-the-health-of-londoners-transport-action-plan.pdf

LESSON 3: COMMUNICATING OUR DATA TO OTHERS

SETTING THE SCENE

As air pollution is a topic that concerns many people in London, it is crucial that information about air pollution is communicated clearly and effectively to interested parties. There are a number of companies, agencies and organisations which provide a wealth of information about air pollution, often via their websites (given below), including How polluted is my road?, Cleaner air for London, London Air Quality Network and Department for Environment, Food and Rural Affairs. For these and the numerous other websites and publications which provide data about air pollution in London, it is crucial to present information so that the meaning is communicated clearly and the information can be used by others.

In this lesson, students will chose some raw data, either from the London Datastore or alternatively from their school's AirSensa monitor and use the most appropriate graph or chart to present this data.

'WE WANT CLEAN AIR' PROTEST BANNER HANGS IN PADDINGTON, 1956

LESSON 3: COMMUNICATING OUR DATA TO OTHERS

ACTIVITIES

STARTER

Working in small groups, give students Resource 3.1: Representing data (page 32) and ask them to look at the different representations of data and discuss which representations are helpful and which representations are less so.

As a class decide which representations tend to be more useful than others for certain situations and when certain representations do not make sense.

MAIN1

Explain that one of the skills of being a successful mathematician is the ability to explain your ideas clearly and concisely to others. This is true whether you are working with abstract concepts such as algebra or applied mathematics such as statistics.

Tell the students that they are going to be given some raw data, either from the London Datastore about average air quality, or alternatively from their own AirSensa. They are going to choose some data to present as a graph and need to write an explanation, firstly of what their graph shows and secondly, why this could be the case.

Give the students a copy of the spreadsheet or AirSensa data. Let them have a few minutes to look at the data and then discuss as a class what they think the data is showing.

Now ask them to choose some data to work with. As their previous experiment was about soot particles, it might be nice, although not essential, to continue to look at particulate matter. As NO_2 pollution is the one that exceeds EU limits it may also be interesting to look at this.

Particulate matter is described as either PM10 or PM2.5. PM10 consists of coarse particles which come from wear and tear on brakes and tyres and also activities on construction sites, whereas PM2.5 consist of smaller particles which are associated with vehicle emissions.

Some ideas could be:

- Plot monthly averages for PM10 over a period of time and decide if there are any trends. If there are, offer explanations for these trends
- Plot pollution every hour over a period of 24 hours and explain what is happening
- Plot London mean roadside PM10 against London mean background PM10 as a barchart and compare them, using the knowledge you have gained through the other lessons to explain any differences.
- Plot London mean roadside PM10 against London mean background PM10 as a barchart and compare them. Given that these figures are both mean averages make suggestions as to where you might find readings below the London mean background. Are the any pollutants where the pollutant is lower at the roadside than the background. If so, what does this suggest?

Differentiation

Those students who require support could be given a structured worksheet with explanations of how to plot a particular graph and given questions to answer about the graph.

Students could be asked to explain one of the graphs from the AirSensa data, rather than having to create a completely new graph.

More able students could be asked about a number of different data sources, eg. London mean roadside, London mean background and AirSensa.

Plenary

Students to peer assess each other's reports/presentations, giving two comments about what worked well, and one comment about how the work could be improved. Where possible, get students to assess reports that contain different data to the data that they looked at.

The reports/presentations do not need to be printed, and the feedback could simply be typed in a different colour at the bottom of the report or on a final page of a presentation.

Homework ideas

Make the corrections suggested in the peer marking.

Collect a copy of a free newspaper, and look for a graph/chart showing some statistics. Comment on whether you think the graph/chart is appropriate and the explanation clear or not.

Assessment ideas

Collect a copy of the reports after they have been peer marked.

LESSON 3: COMMUNICATING OUR DATA TO OTHERS

RESOURCE 3.1: VISUALISING REPRESENTING? DATA

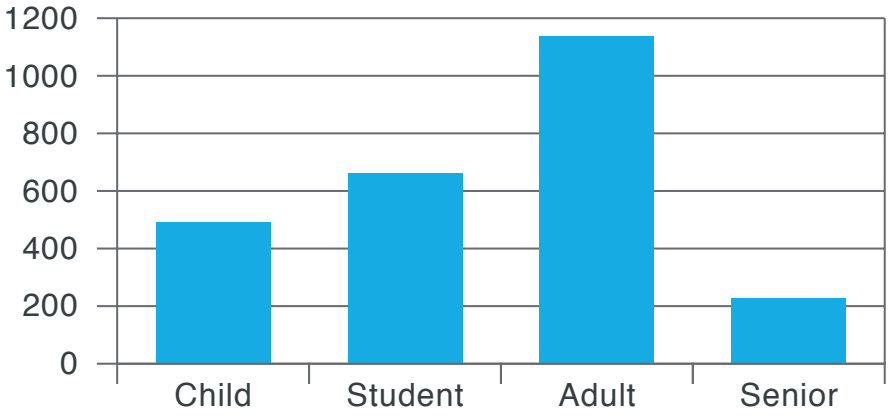
Instructions

For each type of graph or chart, provide an example of when it could be used to represent data effectively. Are there limitations of representing data in this way?

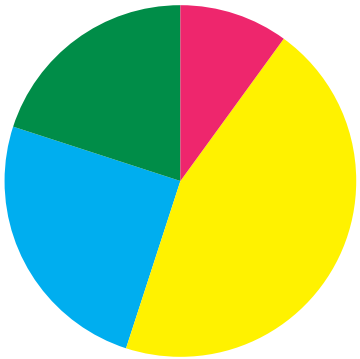
Extension

Think about finding averages for the given data in the different representations.

1. Bar chart showing ticket sales at a cinema for one week



2. Pie chart showing ticket sales at a cinema for one week



TICKET TYPE	NUMBER SOLD	KEY
Senior	222	
Adult	1136	
Student	664	
Child	4988	

LESSON 3: COMMUNICATING OUR DATA TO OTHERS

RESOURCE 3.1: VISUALISING DATA CONTINUED

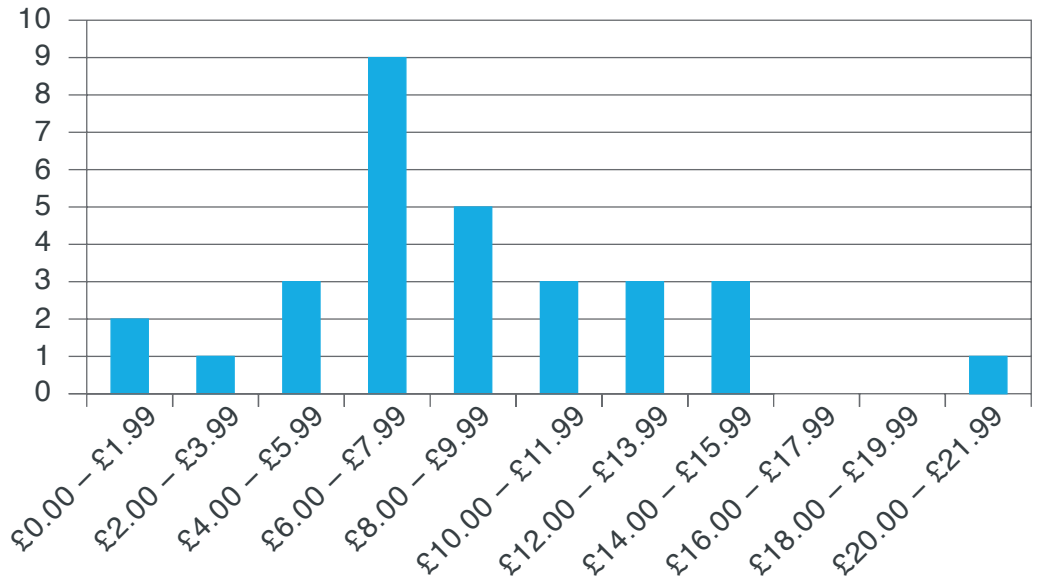
Instructions

For each type of graph or chart, provide an example of when it could be used to represent data effectively. Are there limitations of representing data in this way?

Extension

Think about finding averages for the given data in the different representations.

1. Bar chart showing the weekly amount of pocket money received by students in a class



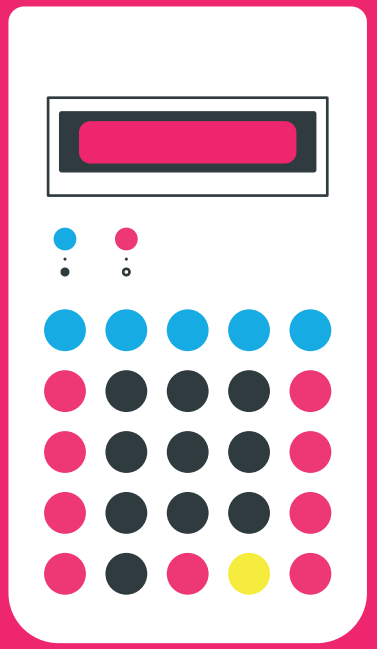
2. Table showing the weekly amount of pocket money received by students in a class

AMOUNT OF POCKET MONEY	FREQUENCY
£0.00 – £1.99	2
£2.00 – £3.99	1
£4.00 – £5.99	3
£6.00 – £7.99	9
£8.00 – £9.99	5
£10.00 – £11.99	3
£12.00 – £13.99	3
£14.00 – £15.99	3
£16.00 – £17.99	0
£18.00 – £19.99	0
£20.00 – £21.99	1

EXPLORE

Students will learn how maths and statistics are used and communicated to audiences in real life.

Students will also find out about potential future careers within the field of STEM.



LESSON 4
USING MATHS AND STATISTICS IN REAL LIFE

THE BIG IDEA

Students will have the opportunity to learn about solutions to the problems they have identified and investigate the importance of maths and statistics in future careers.

LEARNING OBJECTIVES

Could be able to start making decisions about their future career choices, including their upcoming GCSE options.

Should be able to identify the connections between the work they have been doing about air pollution and their chosen Explore visits.

Must be able to identify where maths and statistics are being used in the careers identified for each of the Explore visits.

RESOURCES

Resource 4.1: Exploring future career

EXPLORE

POSSIBLE SITES

All of the Explore options give students the opportunity to look at how maths and statistics are used in real life and investigate STEM career choices. Whichever visit is chosen, Resource 4.1 Exploring future careers (page 38) should be completed as it is also helpful for the Connect lesson.

National Citizen Science surveys with OPAL

OPAL runs surveys across the UK to find out more about the environment, including the quality of the air. Participating in such a survey and being part of exciting, cutting edge research shows a clear link to the work students have been doing during the Discover lessons and gives them insight into the work of a research scientist. The link below gives information about participating in one of these surveys.

www.opalexplorenature.org/surveys

Natural History Museum

Citizen Science projects

020 7942 5555

Citizen Science projects give students the chance to be involved with cutting edge research by collecting data for the Natural Museum's scientists. This Explore session shows students a very clear link between the work they have been doing in the Discover lessons and its relevance to real life. It also opens their eyes to the career of a research scientist.

To get information about participating in Citizen Science projects in the local area, please use the link below:

www.nhm.ac.uk/take-part/citizen-science.html

The Crystal

One Siemens Brothers Way, E16 1GB

0207 055 6400
education@thecrystal.org

The Crystal is a sustainable cities initiative by Siemens. Home to the world's largest exhibition on the future of cities, the Crystal uses its unique interactive approach to inform about urban planning and sustainable living. This encourages students to challenge and change the way they think about cities. Educational visits can be personalised, so that students can explore areas of particular interest to them. The Crystal provides information and activity sheets for students which can be used before a visit, materials to use as they explore the exhibition and project sheets to continue learning in the classroom. It also provides an introduction and description of the exhibits and curriculum links for each of the zones. The zones which are most closely related to air pollution are Creating Cities, Smart Energy, Clean and Green and Future Life zones. However, this could also be a good opportunity to make cross-curricular links and explore other areas as well.

www.thecrystal.org

The Science Museum

Exhibition Rd, SW7 2DD

020 7942 4777
edbookings@sciencemuseum.ac.uk

The Mathematics Gallery

This exhibition brings mathematics to life by exploring how mathematicians, their tools and ideas have shaped the modern world. The stories told span 400 years of human ingenuity and the objects range from handheld mathematical instruments to an experimental design for an aircraft. This would complement a visit to the Engineer your Future exhibition.

www.sciencemuseum.org.uk/visitmuseum/new_galleries/mathematics_gallery.aspx

Engineer your Future

Also to be found at the Science Museum, Engineer your Future is an interactive exhibition that aims to inspire and engage students aged 11–15 with careers in engineering. It encourages students to use skills that engineers use in their everyday roles and discover the wide variety of options open to them with a background in engineering. Students will have the opportunity to design a space rover, build and test systems, discover how engineers improve existing items and find out about engineers who work in unusual locations. There is a strong link to the topics of their Discover lessons as engineers are directly involved in designing vehicles and improving their efficiency.There are supporting materials available for teachers to download and more information can be found at the link below:

www.sciencemuseum.org.uk/educators/plan_and_book_a_visit/things_to_do/galleries/engineer_your_future.aspx

EXHIBITION ROAD
© Olivia Woodhouse

EXPLORE

RESOURCE 4.1: EXPLORING FUTURE CAREERS

Which careers have you identified during your visit?
Where are maths and statistics applied in the careers you have identified during your visit?
What are the connections between your work on air pollution and your visit?

NAME

CLASS

WHERE DID YOU VISIT?

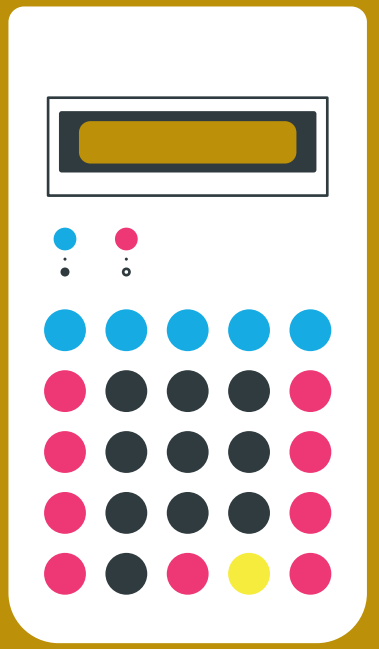
EXPLORE

RESOURCE 4.1: EXPLORING FUTURE CAREERS CONTINUED

Of the careers you have explored, which interests you the most and why?
Which GCSE options would you need to take for the career you have chosen above?
Additional notes:

CONNECT

In this session students will create a presentation to communicate the steps being taken to improve London air quality and the roles of the different professionals who are making this change happen. They will apply their learning about statistical techniques, air pollution and careers to the task.



LESSON 5
LOOKING FORWARD TO IMPROVED AIR QUALITY IN THE FUTURE

BIG IDEA

In this session, students will establish what is being done to improve air quality and the careers and jobs involved in making this happen.

You could ask a member of the Royal Statistical Society to come in and speak to the students about statistics and careers statistics – see External Links.

LEARNING OBJECTIVES

Could be able to explain what the current options for improving air quality are, contrasting their effectiveness and the improvements they are able to bring about, showing where the links with other government policies lie.

Should be able to give at least three different examples of what is being done to improve air quality and the corresponding roles of people working in the field, including any links to maths and statistics.

Must be able give at least one example of what is being done to improve the air quality in London and explain the different roles people who are working within this field have, including any links to maths and statistics.

RESOURCES

Resource 5.1: Biography of Bruno Beloff

YOU WILL ALSO NEED

- Access to computers
- Notes from previous Discover lessons
- Notes from the Explore lesson

EXTERNAL LINKS

tfl.gov.uk/cdn/static/cms/documents/improving-the-health-of-londoners-transport-action-plan.pdf

cleanerairforlondon.org.uk/about-us/what-mayor-doing

rss.org.uk/RSS/Get_involved/Promote_statistical_careers/RSS/Get_involved/Promote_statistical_careers.aspx?hkey=d3ba64c6-e711-4337-9f6e-a25c1c7d60a0

LESSON 5: LOOKING FORWARD TO IMPROVED AIR QUALITY IN THE FUTURE

SETTING THE SCENE

As air pollution is a significant problem in London, there are a number of agencies and organisations who are working to improve air quality in a number of different ways. TfL are looking to reduce the impact from transport in a number of ways, from introducing an ultra-low emissions zone, to introducing cleaner buses and encouraging walking and cycling. Local authorities are required to review air quality in their area and if improvements are necessary they have to designate specific air quality management areas where they work towards specific targets.

BUSES AND TRAMS IN CROYDON TOWN CENTRE, 2009
John Chase © Museum of London

LESSON 5: LOOKING FORWARD TO IMPROVED AIR QUALITY IN THE FUTURE

ACTIVITIES

MAIN 1

Working in small groups choose a strategy to improve air quality. There are a number of online sources of information that could be used or alternatively draw on one of the exhibitions you have seen. Research how this strategy will improve air quality and find out the jobs done by people involved in implementing such a strategy, looking particularly at how maths and statistics are used within these jobs. NO_2 limit is the one that exceeds EU limits, so it may be worth particularly looking at this pollutant.

As a group, present your findings to the rest of the class.

More capable students can be asked to do their own research and report with minimal guidance, whereas those who struggle could be provided with a structured set of questions that need to be answered

Plenary

Students decide which of the careers presented they are most interested in and be prepared to explain why this is the case.

Homework ideas

Choose one of the careers and write down what GCSEs you would need to do to get into this field, which A-level or vocational qualifications you would need to pick after GCSE and whether a degree is necessary to do this job.

Pick a topic which will lead to an improvement in air quality – for example renewable energy – and write a report about how this works and how it could lead to an improvement in air quality. Also research jobs connected to this area for improvement

Other suggestions

This could also link to work they may be doing in PHSE to pick their GCSE options

It may also be worth inviting the school's careers adviser or an external careers adviser to this session, not only to help with the session, but to introduce students to the idea that these services are available to them.

Additionally, as this lesson is looking to their employment options in the future, they could prepare a CV as part of a cross-curricular link.

The Royal Statistical Society also offers a series of lessons that could be downloaded and adapted for KS3 (they are currently more relevant for KS4). The link for this is in the External Links section at the top of this lesson.

LESSON 5: LOOKING FORWARD TO IMPROVED AIR QUALITY IN THE FUTURE

RESOURCE 5.1: BIOGRAPHY OF BRUNO BELOFF

Bruno Beloff,
lead developer for AirSensa

What's your role at Deliver Change?

I'm the Lead Developer on the AirSensa air quality monitoring project. The project involves lots of different technologies – some in the AirSensa devices themselves, others on web servers and in the networks. We say it's the iTunes of air quality - a collection of different devices and services that were designed to work together.

The AirSensa devices are small computers in their own right. My main task over the last year has been to write the software for those devices - it measures lots of air quality aspects, and uploads this data over the network. Most of the rest of my time is spent discussing electronics designs and database systems with specialist design engineers.

We are a very small team, so my work tends to change frequently – it depends what needs to be done. I love that way of working.

What's your background? How did you get here?

I originally went to university to study computer science and maths, but I became fascinated by the idea of studying a subject where no one knows the answer, so I ended up moving to the arts faculty, and eventually got a degree in linguistics

As a new graduate, I worked for a commercial computer science laboratory, designing computer chips. After five years, I left all that to do a postgraduate diploma in photojournalism, and ended up working in Bosnia, during the war there, for several years.

If you can write your life story after the events have happened, you can always make it make sense. The reality, I think, is that whatever I learned along the way has come in useful. The logic of computing is good for journalism. The communication skills of the newspaper world are very good for engineers.

What are the challenges the project presents?

Two very different sorts of challenges…

At a technical level, we are trying to make pollution monitoring devices that are very accurate, but not very expensive. Back to iTunes – designing a music player is easy. Designing a music player that is both cheap and sounds really good, that's very hard. So we design things, then let the chemists and the environmental scientists test them. They say "You can do better than that!" So we do. Alan Turing, the founder of computer science, once said "Don't tell me when I'm right, tell me when I'm wrong." Good advice for life.

LESSON 5: LOOKING FORWARD TO IMPROVED AIR QUALITY IN THE FUTURE

RESOURCE 5.1: BIOGRAPHY OF BRUNO BELOFF CONTINUED

At a business level, our organisation is driven by technology, but is not run by technologists. This is a common problem in the UK (less so in many other countries). One solution is communication – technologists need to be able to explain the needs of the technology and its development to people with a very different background. You can be the best programmer in the world, but in the end it's people that count.

What is your work day like?

I usually work from home, two minutes from the beach. The rest of the time I am on trains to meetings with scientists and engineers around the country. I like jobs where the workload is variable and slightly unpredictable. This is one of those.

What gives you most enjoyment in your work?

I get most enjoyment from finding good solutions to logical problems – the sort of problems that electronics and software always generates. What's a good solution? It's not about making things work, but about making them work well, efficiently, reliably; solutions that other people can understand and use.

The other big thing is meeting people who are cleverer than me, or have skills I don't have. A good job is one that gives you that.

What next?

It's good not to know for sure. That's a very positive aspect of the AirSensa project – in essence, we have spent a lot of time away from the rest of the world, developing this technology; now we are rejoining the world. I think the AirSensa project will become very, very different when people start to engage with it, and examine its data.

LINKS TO OTHER LONDON CURRICULUM SUBJECTS

The health STEM theme

This unit is one of a set of three exploring the science and maths behind health in the city.

SCIENCE – BIOLOGY

Healthy London living
Drawing on a number of leading London medical and science centres, sporting events and venues, this unit introduces the topics of nutrition and digestion, health and the skeletal and muscular systems.

SCIENCE – CHEMISTRY

Healthy London water
explores the chemistry that helps meet the challenge of providing London with water that is fit to drink.

CREDITS

The GLA would like to thank the following organisations for their contribution:

Our collaborators on the London Curriculum

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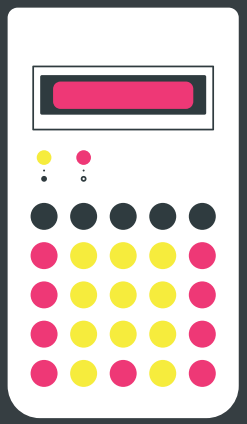

‘The idea of using London as a teaching resource has never been explored much before, so both students and teachers are excited about it’

Key stage 3 teacher

‘It makes me feel proud to be a Londoner’

Key stage 3 student