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OCR
Oxford Cambridge and RSA

GCSE (9–1)
Delivery Guide

MATHEMATICS

J560
For first teaching in 2015

Statistics

Version 2

www.ocr.org.uk/maths

Introduction

GCSE (9–1) *MATHEMATICS*

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk

Curriculum content

GCSE (9–1) content Ref.	Subject content	Initial learning for this qualification will enable learners to…	Foundation tier learners should also be able to…	Higher tier learners should additionally be able to…	DfE Ref.
OCR 12	**Statistics**				
12.01	**Sampling**				
12.01a	Populations and samples		Define the population in a study, and understand the difference between population and sample. Infer properties of populations or distributions from a sample. Understand what is meant by simple random sampling, and bias in sampling.		S1
12.02	**Interpreting and representing data**				
12.02a	Categorical and numerical data	Interpret and construct charts appropriate to the data type; including frequency tables, bar charts, pie charts and pictograms for categorical data, vertical line charts for ungrouped discrete numerical data. Interpret multiple and composite bar charts.	Design tables to classify data. Interpret and construct line graphs for time series data, and identify trends (e.g. seasonal variations).		S2
12.02b	Grouped data			Interpret and construct diagrams for grouped data as appropriate, i.e. cumulative frequency graphs and histograms (with either equal or unequal class intervals).	S3 S4

Curriculum content

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12.03	**Analysing data**				
12.03a	Summary statistics	Calculate the mean, mode, median and range for ungrouped data. Find the modal class, and calculate estimates of the range, mean and median for grouped data, and understand why they are estimates. Describe a population using statistics. Make simple comparisons. Compare data sets using 'like for like' summary values. Understand the advantages and disadvantages of summary values.		Calculate estimates of mean, median, mode, range, quartiles and interquartile range from graphical representation of grouped data. Draw and interpret box plots. Use the median and interquartile range to compare distributions.	S4, S5
12.03b	Misrepresenting data	Recognise graphical misrepresentation through incorrect scales, labels, etc.			S4
12.03c	Bivariate data	Plot and interpret scatter diagrams for bivariate data. Recognise correlation.	Interpret correlation within the context of the variables, and appreciate the distinction between correlation and causation. Draw a line of best fit by eye, and use it to make predictions. Interpolate and extrapolate from data, and be aware of the limitations of these techniques.		S6
12.03d	Outliers	Identify an outlier in simple cases.	Appreciate there may be errors in data from values (outliers) that do not 'fit'. Recognise outliers on a scatter graph.		S4

Thinking conceptually

Current students are learning statistics at a time when vast quantities of data are readily available and presented to us. Studying statistics provides an opportunity for students to develop both the analytical skills and the critical skills needed to consider and evaluate inferences about data, which are frequently presented by both the media and the internet as factual.

Statistics can be thought of as descriptive and inferential. With descriptive statistics, students use graphical representation and find summary measures to convey information about the available data. With inferential statistics, students use samples of data, which will be subject to random variation, in order to learn about the population from which the sample of data is thought to represent, and then to make deductions and draw conclusions.

The three broad areas of statistics content (sampling, interpreting and representing data, and analysing data) provide a structure to teach statistics. Students' learning and understanding will benefit through always engaging with all three areas as part of an investigative cycle when interrogating samples of data.

Whilst sophisticated sampling techniques are not included in the content, it is important for students to understand the distinction between a population and a sample and also to understand how sampling bias and variability between samples may affect summary measures and subsequent inferences.

Numerical data on its own does not provide a sense of the inferences that can be made. Representing data graphically is an effective tool to reveal potential trends and allows easier comparisons between data sets. Grouped data sometimes causes students difficulties, for example plotting frequency instead of cumulative frequency and when calculating frequency density.

A common misconception when analysing data is to pick any values to make comparisons rather than comparing 'like for like' measures, such as two mean values. To address the assessment objectives for mathematics, teaching should focus on enabling students to make deductions within the context of the data. For example, when investigating correlations, students should be able to explain any correlation in terms of the variables and at the same time never assuming correlation implies causation.

It is strongly suggested that where possible, teachers provide current examples to emphasise the importance of statistical reasoning. Examples could include analysing graphs presented in the media; making decisions on the efficacy of 'beneficial' food products; using time series data to make long term predictions. Links to other areas of the school curriculum will be enhanced through using examples from other subjects, in particular science, geography, psychology and economics.

Thinking contextually

Activities

A major advantage of teaching statistics is the real life context within which the application exists.

It is suggested that:

- real data is used
- the context is accessible in order to avoid confusion
- the context interests the students
- the results and inferences are not obvious in order to maintain interest.

Additionally:

- sometimes it is okay to amend the data to be given, in order to avoid confusion before students are ready for the challenge of dealing with raw data or contradictory results. However, raw data is beneficial; it provides challenges and introduces the need for students to make judgement calls. It is important for students to realise data is rarely pristine; data could be incomplete and people do give silly answers or make mistakes when data is collected, such as using the current year for the year of their birth for instance
- inconclusive results are still valid to use in the classroom – they happen in real life
- using a variety of contexts is better than one long project – this enables students to understand what inferences are specific to the context and what is general to most contexts.

[12.03a] Averages and Range Jigsaw

This activity works best in pairs or groups of 3. It addresses misconceptions and provides practice of statistical concepts.

Cut out the 24 triangular jigsaw pieces for each group (Learner Resource 1).

The group task is to match sides to create a hexagon from the triangular pieces.

Use matching pairs to further consolidate concepts, for example:

- $\sum = 42$ $n = 3$ range 2 matches mean 14 - ask students what are the possible numbers
- $n = 5$ median 2 matches mean 2 - ask students how many possible sets of numbers they can find.

This leads to using the NRICH activity **M, M and M**, available at http://nrich.maths.org/6267. This activity challenges students to find sets of numbers giving rise to the same summary data.

Further jigsaws can be created yourself using freely available Tarsia software, www.mmlsoft.com/index.php/products/tarsia

[12.03a, 12.03c] Exploring a queuing problem

This is a whole class simulation activity.

A retailer has more than one service point for customers. Should the retailer require customers to individually choose and queue at one of the service points or all queue in a single line? A simulation is used to find possible waiting times. Data is gathered by students in a human simulation.

Cut out the set of 28 cards for the whole class simulation (Learner Resource 2). It is suggested that these are used with 3 service points. The actual simulation should take approximately 10 minutes.

For a more detailed explanation see the accompanying 'Teacher Resource 2: Exploring a queuing problem'.

The data generated is used to find means, medians, modal values, ranges (and quartiles for Higher tier). It is also used to plot scatter graphs (and box plots for Higher tier).

Thinking contextually

[12.02a, 12.03a] What's the Weather Like? (NRICH)

http://nrich.maths.org/10470/index

This activity involves using secondary data from Shawbury, Eastbourne and Nairn weather stations. The data sets are ideally suited to making comparisons over time or between different places. It is recommended that spreadsheets are used. It may also be a good task to undertake collaboratively with science or geography.

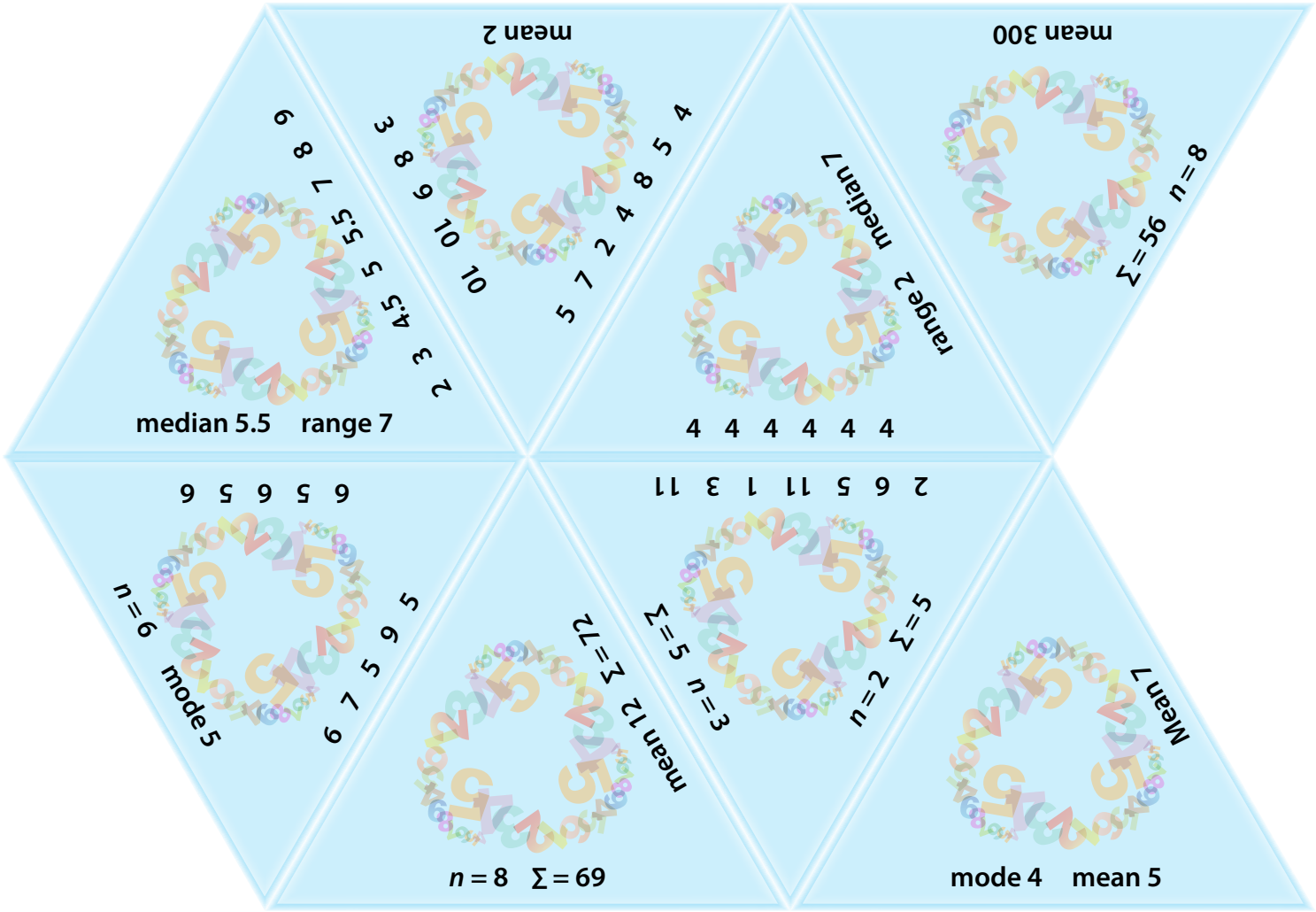
[12.03c] Olympic Records (NRICH)

http://nrich.maths.org/7489

This activity gives students the opportunity to make sense of graphical data and challenges them to apply their own knowledge about athletics to explain and interpret key features of the graphs.

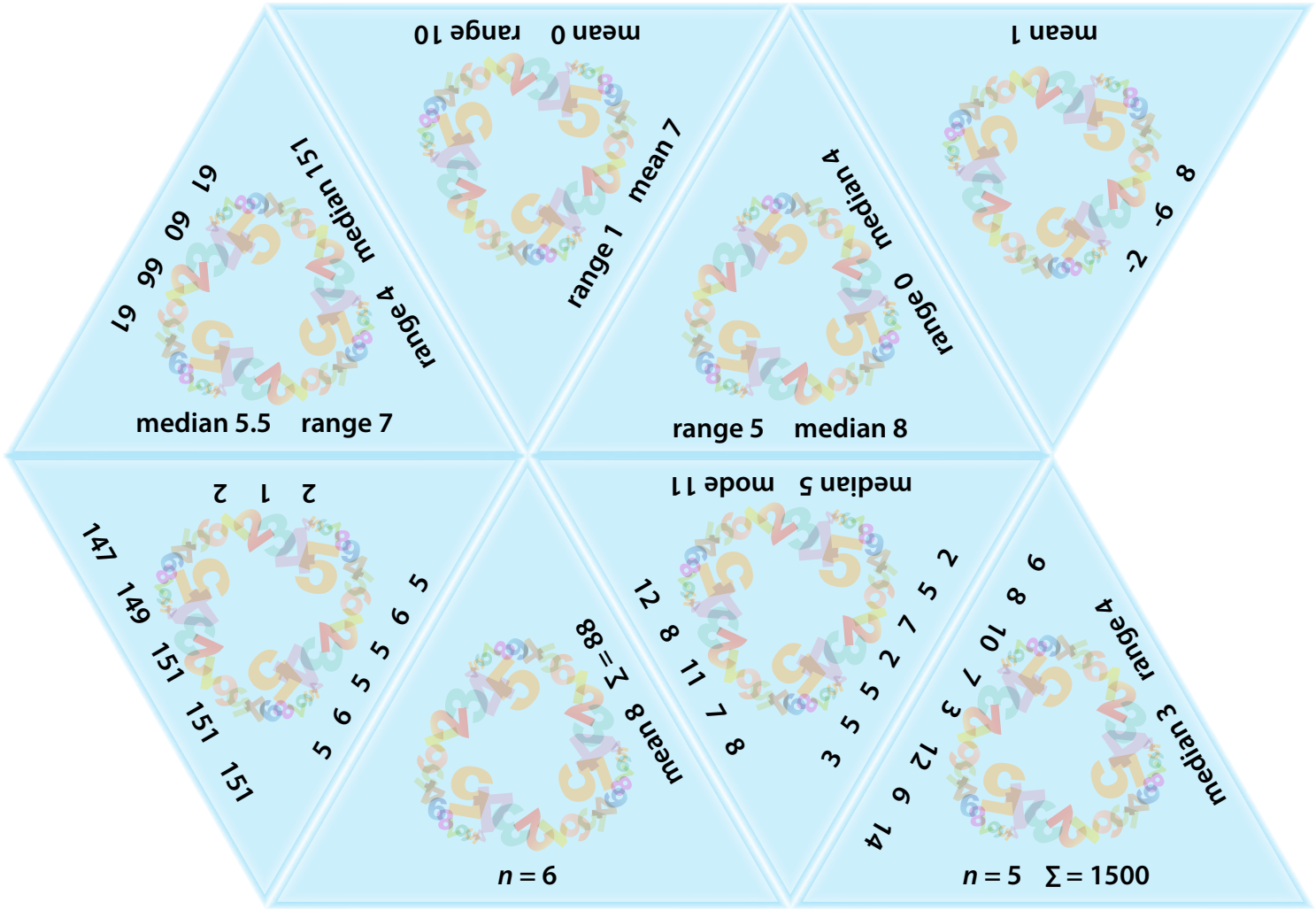
Learner resource 1

Averages and range jigsaw



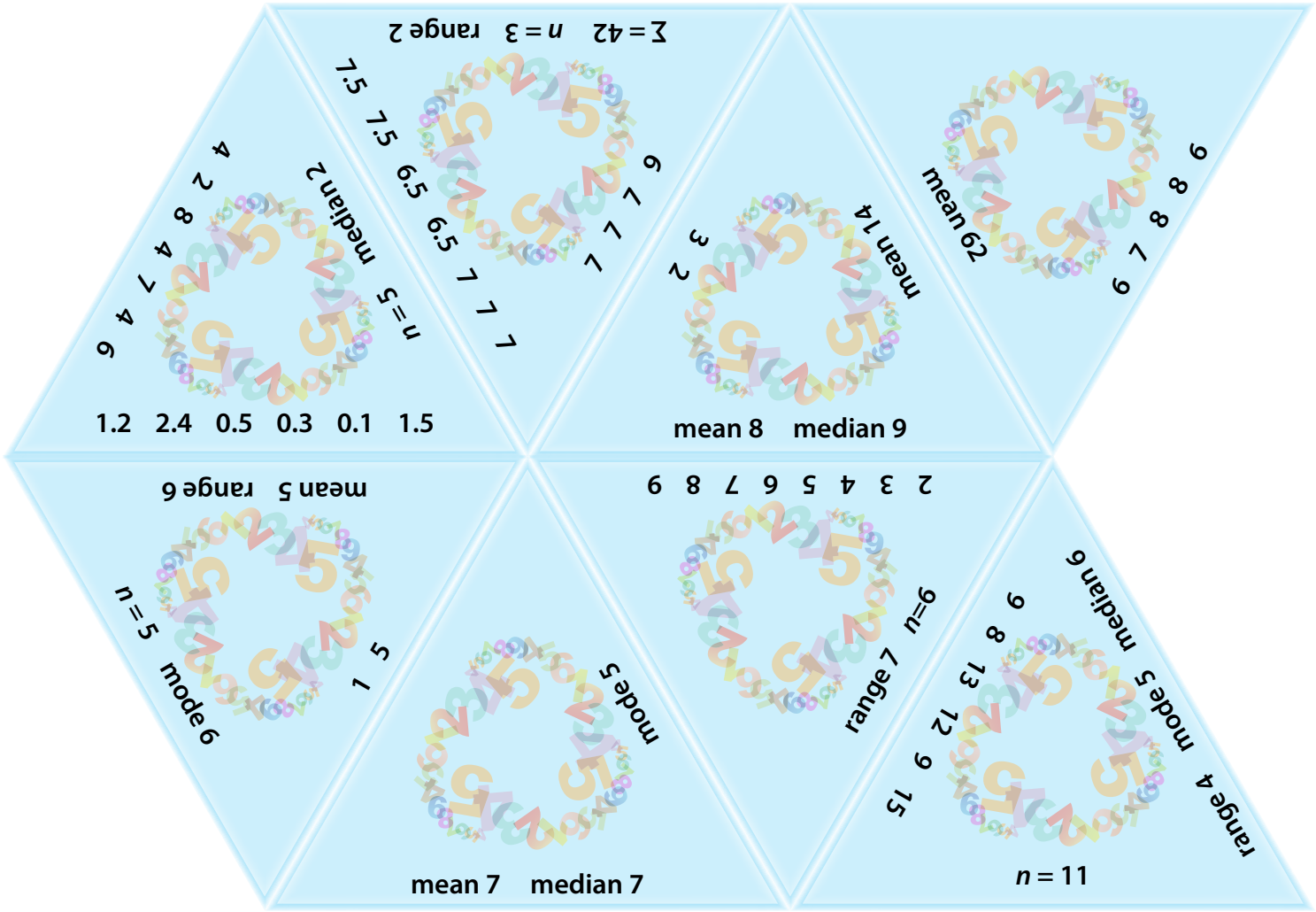
Learner resource 1

Averages and range jigsaw



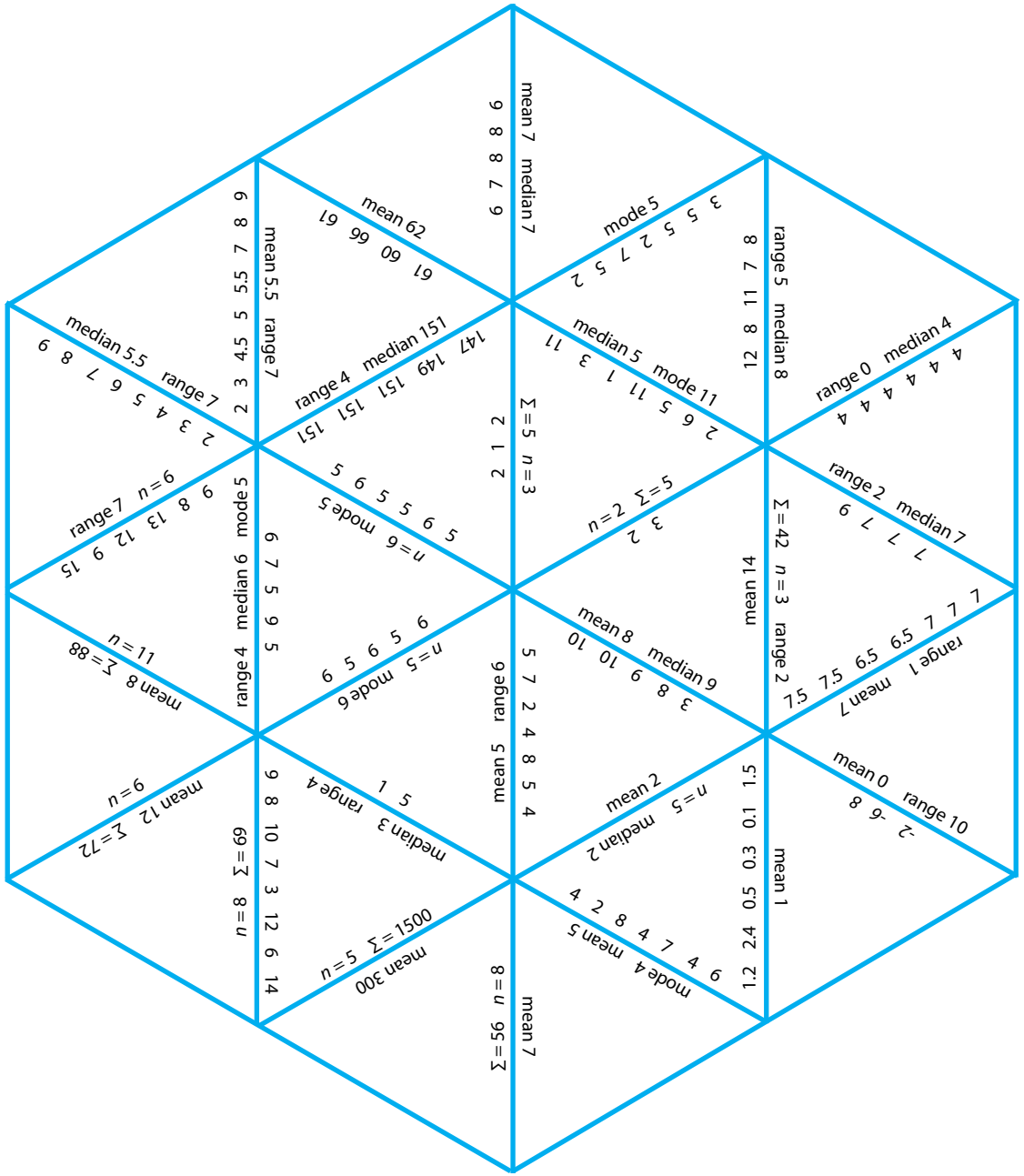
Learner resource 1

Averages and range jigsaw



Teacher resource 1

Averages and range jigsaw solution



Learner resource 2

Wait time cards

Arrival time: 10:13 Transaction time: 9 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:17 Transaction time: 6 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:21 Transaction time: 3 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:14 Transaction time: 7 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:18 Transaction time: 7 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:07 Transaction time: 9 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:16 Transaction time: 5 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:20 Transaction time: 3 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:14 Transaction time: 3 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:04 Transaction time: 5 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:10 Transaction time: 8 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:09 Transaction time: 9 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:19 Transaction time: 4 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:12 Transaction time: 6 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Learner resource 2

Wait time cards

Arrival time: 10:08 Transaction time: 3 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:13 Transaction time: 4 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:22 Transaction time: 2 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:03 Transaction time: 8 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:06 Transaction time: 7 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:07 Transaction time: 10 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:24 Transaction time: 4 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:23 Transaction time: 5 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:16 Transaction time: 1 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:20 Transaction time: 2 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:25 Transaction time: 7 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:02 Transaction time: 9 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:21 Transaction time: 6 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Arrival time: 10:15 Transaction time: 10 minutes

Single queue wait time: ---------- mins

Multiple queue wait time: ---------- mins

Teacher resource 2

Exploring a queuing problem

Explain the scenario:

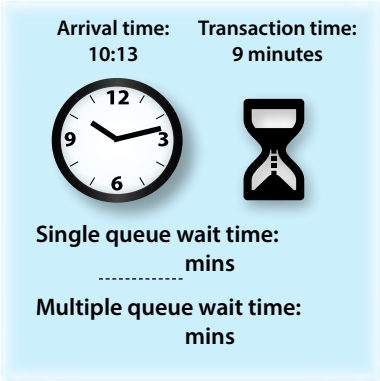
A retailer has more than one service point for customers open. Should the retailer require customers to individually choose and queue at one of the service points or just all queue in a single line? A simulation is used to find possible waiting times.

Discuss with the class:

- Places where people queue to use a service point (bank / shop / post office / toll booth / etc)
- Potential issues with the two types of queuing system
- What do they think may be best? Best for whom? Why?

Each student is issued with a card showing arrival time and transaction time. There is space on the card to write in wait times using each of the queuing systems.

For example:



- Arrival time 10:13 means they join the queue at 10:13.
- If they reach the service point at 10:20 the wait time is 7 minutes.
- Transaction time 9 minutes means they leave the service point at 10:29.

Teacher resource 2

Exploring a queuing problem

Run the simulation first with a single queue and then with multiple queues.

With multiple queues, allow students to switch lines.

Use chairs as service points.

The teacher calls out the times at minute intervals, adjust the cadence to give students time to complete the wait time. (You may need a trial run using a few students).

The data generated is used to find means, medians, modal values, ranges (and quartiles for Higher tier). It is also used to plot scatter graphs (and box plots for Higher tier).

Discuss with the class:

- Is it better to have a lower mean wait time or lower modal wait time?
- Would a single queue or a multiple queue system deal better with situations in which one or two people have long wait times (outliers) and everyone else had a very short wait time?
- What difference would it have made if you weren't allowed to change queues?
- Which queuing system is fairer? Why?
- Which queuing system would you choose? Justify your choice using the results.

The arrival times and transaction times are randomly generated. A further set of results will enable meaningful discussion of sampling and bias.

Produce a second set of cards and run the whole simulation again to find a second set of summary values and plot graphs.

Discuss with the class:

Are the results similar or different for the second simulation?

Which queuing system would you choose now? Why?

The small print

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