# **Queueing theory**

Use queuing theory to determine which queue to join at the checkout

**Potential GCSE content covered**

* Calculating the mean from a frequency table
* Finding median from a frequency table
* Comparing two sets of data using an average and measure of spread
* Finding the quartiles and the interquartile range (IQR)
* Statistical diagrams, including; bar charts, box and whisker plots, cumulative frequency
* Reasoning and problem solving
* Estimation and modelling

**In the classroom**

Allow the students some time to read the information on the first slide and think about the benefits and problems with each of the systems. Give them time to work on the problem before comparing their answers and reasons.

Encourage the students to think about how they can compare the two systems, what figures could they find/calculate. What diagrams would help to provide a picture of advantages and disadvantages of each system? (You may like to try a simulation).

Give the students some time to find/calculate their figures then ask them to present their case.

**Problem Solving**

With the first problem, the students will have to make some assumptions, for example each article will take an equal amount of time to scan, there will be a standard time to pay for the goods and move away. The students will need to estimate times for these before being able to do any calculations and draw conclusions.

On the second task, the students will find that the mean customer wait time is the same for both systems. This should encourage them to look at other factors such as the median, mode and range.

They will need to think about other measures of spread, such as the IQR, and make choices about which diagrams to use - bar charts, box and/or whisker plots.

**Discussion Points**

The first task provides many opportunities for discussion particularly around the assumptions the students have made.

This task provides an opportunity to discuss which average would be most appropriate. The mean time for system 1 is affected by longer wait times for a few (4) customers. Would the mode time be a better average as this is the most frequent experience, or is the median better? Ask the students to think about what both of these figures represent in this context. Possibly the maximum wait time would be a better measure of customer’s satisfaction with the system.

Discuss the range and IQR in the context of the question, which do they think is the better measure of spread in this context. Which diagrams were more helpful? Why?

**Extending the problem**

You could examine other situations involving queuing.

This website allow students to play with different traffic flow problems on a motorway <http://traffic-simulation.de/roadworks.html>

**Additional Materials**

A spreadsheet with the data included.

**Answers**

The answers to the first task will depend on the assumptions which the students have made, for the processing time per article and the delay time between customers for paying and moving.

The answers for the second task are given below:



|  |  |  |
| --- | --- | --- |
| Waiting times for 25 People | |  |
| Time (mins) | Frequency | F\*X |
| 0 | 4 | 0 |
| 1 | 5 | 5 |
| 2 | 5 | 10 |
| 3 | 3 | 9 |
| 4 | 4 | 16 |
| 8 | 2 | 16 |
| 10 | 2 | 20 |
|  | Mean = | 3.0 |
|  | Median= | 2 |
|  |  |  |
|  |  |  |
| Waiting times for 25 People | |  |
| Time (mins) | Frequency | F\*X |
| 0 | 3 | 0 |
| 1 | 2 | 2 |
| 2 | 3 | 6 |
| 3 | 9 | 27 |
| 4 | 3 | 12 |
| 5 | 3 | 15 |
| 6 | 2 | 12 |
|  | Mean = | 3.0 |
|  | Median= | 3 |

**A graph with red squares

Description automatically generated**

**Curriculum links**

|  |  |
| --- | --- |
| **England** | **Northern Ireland** |
| > N2. Apply the four operations, including formal written methods, to integers, decimals and simple fractions (proper and improper), and mixed numbers – all both positive and negative; understand and use place value (e.g. when working with very large or very small numbers, and when calculating with decimals)  > S4. Interpret, analyse and compare the distributions of data sets from univariate empirical distributions through: appropriate graphical representation involving discrete, continuous and grouped data, including box plots appropriate measures of central tendency (median, mean, mode and modal class) and spread (range, including consideration of outliers, quartiles and inter-quartile range) | > T1 T3(h) - Calculate median, mean, range and mode, and understand their uses  > T3(h) - Interpret and display information in a variety of ways, including box plots and stem and leaf diagrams |
| **Scotland** | **Wales** |
| > MNU 3-07a I can solve problems by carrying out calculations with a wide range of fractions, decimal fractions and percentages, using my answers to make comparisons and informed choices for real-life situations  > MTH 4-20b In order to compare numerical information in real-life contexts, I can find the mean, median, mode and range of sets of numbers, decide which type of average is most appropriate to use and discuss how using an alternative type of average could be misleading  > MTH 4-21a I can select appropriately from a wide range of tables, charts, diagrams and graphs when displaying discrete, continuous or grouped data, clearly communicating the significant features of the data | Using Data Skills  > Y10 - Construct and interpret graphs and diagrams (including pie charts) to represent discrete or continuous data, with the learner choosing the most appropriate representation, including frequency polygons and lines of best fit on scatter diagrams  > Calculate the upper quartile, lower quartile and interquartile range of a set of discrete data and use them to describe a data set  > Y11 - Use the interquartile range to compare distributions  > Compare sets of data and their distributions, using appropriate methods, including those that involve describing central tendency, dispersion, correlation |