

## **Algorithms: MAZE CRAZE**

### **Teacher Notes**

#### **Materials Required**

Each student/pair of students will need:

- Pen and paper
- Coloured pencils
- Dice
- Maze Grid (provided)

#### **Preparation Required:**

- None

#### **Supporting Resources Available**

The following resources support this session and are free to download from [www.LearnAboutOR.co.uk](http://www.LearnAboutOR.co.uk) :

- PPT, Maze Grid, etc.

#### **Session Duration Guide**

- For Year 10-11 / Average ability groups: Allow 45-60 minutes
- For Year 12-13 / High ability groups: Allow 45 minutes

**STARTER****Slide 2**

(approximately 5-10 minutes)

Ask students if they can think of any games which involve a maze (e.g. pacman).

As an introduction to numerical mazes (i.e. mazes with some maths involved!), click on the link to show an example of this type of maze. Read the instructions through with the class and then spend approximately 5 minutes allowing the students to play 5 levels of this game. In order to involve everyone during this task, ask a different student to come up to the front of the class each time and complete a level. The student at the front of the class is allowed to receive help from the rest of the class on the level.

Ask students how they think this maze and others like this one were created? Tell them that mazes are not generally created through trial and error – Maths is involved! State that mazes are created using different algorithms. Inform students that an algorithm is a process or set of rules which are to be followed in order to complete calculations or problem-solving operations.

**“Depth-First Search Algorithm” and “Example”****Slides 3 to 5**

(approximately 5 minutes)

Tell students that this is an example of a simple algorithm used for creating mazes. Briefly take the students through the example step by step to give them an introductory idea of how mazes are created using algorithms.

**“Binary Tree Algorithm” and “Example”****Slides 6 to 7**

Introduce the binary tree algorithm to the students. Take them through the example step by step. Tell them to pay close attention to this algorithm as they will have to apply it later on!

Inform students that for the last step of the example (i.e. before the final picture of the maze), the only possible option would be to create a passageway travelling north because the algorithm states that a solid line must be kept around the edges of the grid).

**“Making the Maze Numerical” and “Example”****Slides 8 to 10**

(approximately 5-10 minutes)

Explain to students how we are going to make our maze mathematical, using the slide. Take them through the example step by step in order to help them understand the steps which are involved.

**"Your Task (Part 1)"****Slide 11**

(approximately 10-15 minutes)

Introduce the task to the students. Ask students to firstly sort themselves into pairs. Distribute a grid (attached) and one die between each pair. Tell each of the pairs to use the grid and work together to create a maze, using the binary tree algorithm which they have just learnt. They should decide whether or not a cell should lead north or west by rolling their die: if they get an even number, they should go north; if they get an odd number, they should go west.

They should colour/shade in each "cell" once they have dealt with them to help prevent them from making any mistakes. On this draft copy, they should, for now, put a dash through the "walls" (i.e. the lines between any two cells) which they plan to discard. Once they have completed their draft copy, they should then each, individually, create a neat copy of their maze, discarding the appropriate walls. (They could put a piece of paper over the draft copy and trace over the lines, if easier.)

Every student should now have an individual copy of their maze.

**"Your Task (Part 2)"****Slide 12**

(approximately 20-25 minutes: 15 minutes of maze creation; 5-10 minutes of finding a solution to another student's maze)

Students must now individually add in the start points, end points and appropriate numbers to their mazes. (This will result in no two mazes being exactly the same, due to the differing numbers.)

They must then find the solution to their maze and write this up on a separate piece of paper.

Once students have finished their maze, encourage them to decorate it how they wish and perhaps come up with some sort of story to accompany their maze. Suggest ways they could make their maze unique: for example, they may choose to add in different symbols to their maze which could have different commands, or obstacles which force the user to travel around that particular cell.

Ask students to then swap their maze with another student close to them (but not the student who they were paired with earlier). Every student should now attempt the other person's maze and try to find the optimal solution.

Students should swap their mazes back after and check to see if their solution is correct!

**"Relation to Real Life"****Slide 13**

(approximately 5 minutes)

Introduce firstly the idea of Operational Research to students. Inform students that this whole process relates to the discipline of Operational Research. Operational Research involves applying often advanced and analytical methods to real life problems, in order to help make better decisions.

Ask students if they can then think of any real life examples of where algorithms are/could be used in real life before then showing them the examples on the slide.

State that the travelling salesman problem is another topic which relates to Operational Research. Inform students that the travelling salesman problem involves visiting a certain amount of places in the shortest amount of time possible. The numerical mazes they have created today therefore relate to this idea due to the fact that they have had to make decisions to find the shortest possible route from the start point to the end point, whilst making a total of exactly 20. Ask students if they can think of any real life examples of where this concept is used, before giving the ideas given on the slide. This will encourage them to think about the idea in more detail first.

**"Evaluation"****Slide 14**

(approximately 5 minutes)

Ask the students to now think about and write down answers to the questions given on the slide individually.

If time, discuss with students some of the answers they have come up with.

**OPERATIONAL RESEARCH****Presentation Slide 15****2 minutes**

Ask the students if they have heard of operational research. Often not many people have. (Text appears on click/moving forward).

The answer on the slide can also be stated as "OR involves using maths to solve problems or make better decisions". It is a little unspecific as an answer – that's because OR is useful in many real-world situations!

OR is used today by many businesses – shops, airlines, architects, hospitals, local government and central government.

There are some in depth examples of OR on the following slides. Feel free to include your own.

## **OR IN DETAIL - SUPERMARKETS**

### **Presentation Slide 16**

#### **2 minutes**

Supermarkets use teams of OR professionals to solve problems and make decisions, such as understanding consumer buying patterns, deciding how many staff they should allocate to a shift and calculating the optimal quantity and delivery times of their products.

Supermarket loyalty cards, like a Tesco's Clubcard, are a great example of OR in action. Loyalty cards let supermarkets track what their customers are buying, creating huge amounts of data for operational researchers to work with. They can use statistics to search for patterns in the data, attempting to predict how customers will behave in the future.

For example, the data might show that people buy lots of milk on a Saturday, in which case the supermarket would know to stock up on Friday evening. It might also show that lots of people shop at certain times, or on a particular day, so the store managers would know to have more staff members working at that time.

Most supermarkets also incorporate weather forecasting data, obtained from weather stations near each of their stores to optimise this further by making sure they have extra BBQ food in towns that are expecting sunny weekends.

It's easy to see what a big impact OR has on making the right decisions for supermarkets – helping them keep customers happy and make profits!

## **OR IN DETAIL - AIRLINES**

### **Presentation Slide 17**

#### **2 minutes**

Operational researchers at places like British Airways are involved in a lot of decision-making.

When you book a holiday, OR has been used to decide where an airline will fly to and how much they charge you for your ticket, using customer buying patterns and forecasting to predict demand.

When you arrive at the airport, OR has been used to minimise queueing times, and simulations are used to model the flow of passengers through the terminal to ensure staff members and equipment are in the right places at the right time.

When you board the plane, OR has helped choose a boarding strategy and ensure your plane leaves on time. OR is even used to forecast how many passengers are likely to cancel their holiday!

Just like supermarkets, airlines rely heavily on OR to make better, more informed decisions that result in better outcomes for their business.

## **OR IN DETAIL - HEALTHCARE**

### **Presentation Slide 18**

#### **2 minutes**

Some hospitals have dedicated OR teams to help with resource allocation – especially if they have multiple specialities. The OR staff allocate patients, equipment and surgical teams to operating theatres based on the urgency and specific requirements of each patient – some operations need specialist equipment and others do not and it's not very efficient to have a 'general' patient in a 'specialist' surgery.

The OR team have to set a schedule, which is made complicated by the fact that how long an operation takes can be hard to predict and an emergency patient might need immediate attention and throw off the rest of the rota!

OR researchers designed an algorithm to optimise kidney transplant surgery – imagine somebody needs a kidney transplant and their family member is willing to be a donor, but is incompatible. The algorithm identifies patients in this situation and matches them up so they can swap donors, and both patients receive the kidney that they need.

The surgery has to take place simultaneously to prevent anybody from backing out at the last minute, so the algorithm also has to take into account the nearest hospital with enough resources (theatres and surgical teams) to carry out the transplant when matching patients.

## **WHEN IS OR USED?**

### **Presentation Slide 19**

#### **2 minutes**

Decision-making and problem-solving in business can be complicated and messy. It may not be clear what the main problem is, what the outcome of different actions may be or how well things are currently working, and there may be lots of different factors to consider.

For example, if things don't go well when businesses make big changes, they might upset customers, slow down production, or create a need for extra staff training. Any of these could have a negative impact on the business. OR can help to reduce the chances of this happening.

## **WHAT OR TECHNIQUES ARE USED?**

### **Presentation Slide 20**

#### **2 minutes**

Some commonly used OR techniques include:



Optimisation – making something more effective - depending on what variable is most important (manufacturing something quickly, or maximising profit?), optimisation will find the best use of limited resources.

Simulation – this modelling tool is fantastic when there are a lot of different ways to solve a problem as you can try lots of different solutions until you find the best one. It also allows something to be tested in a safe way, for example, organisations like the NHS have to be careful when making changes as lives could be at risk!

Forecasting – forecasting can be used to try and predict unknown factors, to help keep a business running smoothly. For example, estimating customer demand so companies know which goods to produce or forecasting the impact of rush hour traffic on a delivery route, so the driver can stay on schedule.

Also many more techniques – including algorithms!

## **WHERE CAN OR TAKE YOU?**

### **Presentation Slide 21**

#### **2 minutes**

So where can OR take you? Employers who recruit for O.R. analyst are large and varied, spanning across all different industries.

So this is a non-exhaustive list of businesses that use OR. These are not endorsed by the OR Society but are designed to show the variety of careers in OR.

As you can see from the slide, there are various organisations across so many industries that use OR. For example, the government is a big employer of OR analysts, with more than 25 government departments and agencies relying on OR analysts to help them find solutions to complex managements problems. Other organisations from other industries also rely on OR analysts like, EY, British Airways, IBM and the Royal Bank of Scotland just to name a few!

OR analysis will typically work with colleagues in areas such as economics, statistics, social research and science.

## **INTERESTED?**

### **Presentation Slide 22**

#### **2 minutes**

If you are interested in OR here are a few next steps. You can continue studying Maths at GCSE and A Level and then further on into university.

Not many universities offer OR degrees, although some offer maths and OR degrees or similar. OR is often a module in a maths or business studies degree and can be hard to find on its own.

STEM degrees (science, technology, engineering and maths) show a skill set and analytical way of thinking that is often beneficial to people working in OR and are a good alternative to an (often elusive) OR degree.

**FIND OUT MORE**

**Presentation Slide 23**

**2 minutes**

For more information on OR and how to get into OR, visit the OR Society website or twitter. Any questions?