

Improving Processes: Paper Cups Challenge Teacher Notes

Materials Required:

- Square Paper (NB: If you don't have square paper, you can make square paper out of A4 by cutting off the bottom few inches.) - *Please be kind to the environment and recycle afterwards!*
- Pens or pencils to design
- Certificates (optional): To add a fun and competitive element, consider awarding the winning group with our ready-to-print certificates. You can prepare the Young Person in OR award certificates for winners and participation certificates for all students.

Preparation Required:

Students will be required to get into groups of 4 or 8.

- If desired, pre-arranged groups of 4 or 8 can be organised beforehand.

Session duration guide:

- For Year 8 – 10: allow 45 – 60 minutes.

FACTORIES

Presentation Slide 2

3 minutes

Most factories take in raw materials and convert them into products that are purchased by their customers. This sounds simple, but in most cases the process is very complicated.

Raw materials can come from all over the world and have to be ordered in just the right amounts ahead of time. Think of a paint factory – it makes paints in countless colours, different types like undercoat, primer, gloss, and more and each in various sizes of tins!

When customers place orders, they might want a lot of a few colours or just a little of many colours. This means the factory has to juggle a lot of different requests.

So, factories have to figure out the best way to make all these products using what they already have. They can't just buy new machines or hire more people whenever they want because that costs money and affects their profit. So, they have to be really smart about how they use their resources, including their staff.

Efficiency

Presentation Slide 3

3 minutes

This means the factory has to be efficient, which means it has to work in a way that gets the right results with little wasted effort.

In order to do this, factories will look at improving their processes, so they will look to improve the usefulness, the timeliness and the quality (so how good something is).

This idea of improving processes is a technique that falls under "operational research". Operational research is used to identify areas that need improving and to make those processes better. A key technique to figure out how to improve processes and make things more efficient, is to use simulation.

Simulation means modelling a process. So businesses might simulate a process, identify what needs to be improved and make suggestions on how to improve this, and then simulate the process again using these changes. Using simulation to try out

new changes means that you are making more informed decisions and are less likely to fail since you are trying out changes ahead of time.

So an example of this will be what we are doing in this workshop where students will run the process of making paper cups. We will then consider where you can make improvements and make changes based on what you have found to produce more cups.

PAPER CUPS CHALLENGE

Presentation Slides 4 to 14

15 minutes

Student worksheet – Question 1 - What did you notice?

Give students 1min organise students into teams of 8 - the team sizes can be changed depending on size of group but should be in multiples of 4.

Tell the class that they will be helping their chosen animal in the animal race by making paper cups. Ask the class to decide what animal they will be representing. Get each person to make a paper cup following the instructions on their sheet or on the board. You can also make a paper cup with the students so they can follow along (slides 5 – 13).

Slide 14 –Get them to think about how long it took them and why. Had they made paper cups before? Did the folding part take longer than the other parts? Did they draw a very complicated pattern or design?

Get them to fill out *Question 1 - What did you notice?* On the student worksheet

PAPER CUPS CHALLENGE – TRIAL 1

Presentation Slides 15 to 17

10 minutes

Student Worksheet - Question 2 & 3 - How many paper cups did you make in 2 minutes?

Slide 15 - Give them a minute to organise their team structure. They will also need to decide who will act as a spokesperson from their group.

Slide 16 - The aim is for each team to make as many of the same paper cups as possible in 2 minutes. For each sub task ensure there is an equal number of people (e.g., two for folding / two for shaping / two for moulding / two for designing).

Students will be working an assembly line format so those in the folding stage will be folding as many papers as possible and handing them over to the students in the shaping stage. The students in the shaping stage will be shaping the papers they received from the students in the folding stage and handing them over to the students in the moulding stage etc.

Highlight that the students should be drawing the animal the same size and on the same part of the cup to ensure fairness and quality control.

Once the students are ready, start the 2-minute timer on the slide.

Slide 17 – Get the students to fill out *Question 2 – How many paper cups was your team able to make in 2 minutes?* On the student worksheet.

Get the students to fill out the table in *Question 3* of the student workshop. Students need to record the number of cups made at each stage in the table and the number that passed the entire process at the end.

PAPER CUPS CHALLENGE – DATA COLLECTION

Presentation Slide 18 - 22

6 minutes

Student Worksheet – Question 4 – Fill in the table.

Slide 18 – Now the whole team will work together to make as many cups as possible in each stage. For example, all 8 team members will first work together to fold as many paper cups as possible in one and then record in the table in *Question 4* of the student worksheet how many each student made. This will be repeated across each stage.

Slide 19 – All team members will work together to fold as many paper cups as possible in 30 seconds. Once the students are ready, start the one-minute timer on the slide. Give the students a time to record how many cups were folded by each student in the table in *Question 4* of the student worksheet.

Slide 20 – All team members will work together to shape as many paper cups as possible in 30 seconds. Once the students are ready, start the one-minute timer on the slide. Give the students time to record how many cups were shaped by each student in the table in *Question 4* of the student worksheet.

Slide 21 – All team members will work together to mould as many paper cups as possible in 30 seconds. Once the students are ready, start the one-minute timer on the slide. Give the students time to record how many cups were shaped by each student in the table in *Question 4* of the student worksheet.

Slide 22 – All team members will work together to design as many paper cups as possible in 30 seconds. Once the students are ready, start the one-minute timer on the slide.

Give the students time to record how many cups were shaped by each student in the table in *Question 4* of the student worksheet.

PAPER CUPS CHALLENGE – DATA COLLECTION

Presentation Slide 23 - 24

10 minutes

Question 5 - Fill in the table

Slide 23 - Get the students to fill out the table in *Question 5* on the student worksheet. Get the students to analyse the data and work out what the range and mean was for each stage. Students should have the information on their student worksheet on how to calculate the range and mean. Provide calculators if needed.

Slide 24 – info on how to calculate range and mean for each stage.

PAPER CUPS CHALLENGE – TRIAL 2

Presentation Slide 25 – 26

5 minutes

Question 6 and 7 – How many paper cups did you make / Fill in the tables.

Slide 25 - Get the students to discuss ways in which they could improve the process so they can produce more cups.

As you would expect, certain activities take longer than others. Based on the students' experience of the process (and the timing data if collected) ask the teams to re-distribute the number of people at each stage with the aim of making more cups and run the challenge again. When it comes to improve the process, a suggested solution would be: one person could do stage 1 and 2 (folding and shaping) for example, and two people could complete stage 3 or 4 (moulding and designing), whichever they feel takes the longest.

Once the students have redistributed the number of people at each stage, they will have another attempt at making as many paper cups as possible in 2 minutes using their new system. Once the students are ready, start the 2-minute timer on the slide.

Slide 26 - Get the students to record how many paper cups they were able to make in 2 minutes in this trial on *Question 6* of the student worksheet.

Have the students complete the table in *Question 7* of the student worksheet. Students need to record the number of cups made at each stage in the table and the number that passed the entire process at the end of Trial 2.

PAPER CUPS CHALLENGE – FEEDBACK

Presentation Slide 27 - 29

7 minutes

Question 8 - Fill in the table.

Slide 27 – Have the students complete the table in *Question 8* by calculating the mean of the total number of cups made between Trial 1 (*recorded in Question 2*) and Trial 2 (*recorded in Question 6*).

Slide 28 - Have the students complete the table in *Question 8* by calculating the percentage increase of number of cups between Trial 1 (*recorded in Question 2*) and Trial 2 (*recorded in Question 6*).

You can ask one group for their results and write an example to further explain how to do % change.

If some students get negative numbers explain that it means they were slower the second time around so had a percentage decrease

Slide 29 – Discuss which group has made the greatest number of paper cups in Trial 2. Discuss which groups has made the greatest improvement across Trial 1 and Trial 2. Who has the greatest percentage increase? Did the teams all make the same changes and what were their reasons for the changes?

Optional: Award the team with the greatest percentage increase with a prize.

OPERATIONAL RESEARCH

Presentation Slide 30

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.

IMPROVING PROCESSES - EXAMPLE

Presentation Slide 31

2 minutes

The workshop that we just did is an example of "improving processes" which is an OR technique. An example of this in practice is how we supported Crimestoppers using this OR technique.

Crimestoppers is a call centre where people call or fill out forms online to report information. They were getting busier and expected a 60% increase in calls and online forms. But they didn't want to hire more staff and they still wanted to answer 90% of calls within 20 seconds.

So, they looked at data about when the calls came in and how long it took to answer them. They used a computer programme to simulate different scenarios. This programmed helped them see what might happen if they changed things, like staff schedules or how the calls were handled.

They found that they could re-direct calls during busy times to different types of staff members. For example, if the regular call handlers were busy, calls could go to shift leaders, and if they were also busy, they could go to online staff.

With these changes, they were able to make their service better. They answered more calls on time and lost fewer calls.

So by using a computer programme and visual software, they were able to figure out the best way to manage their workload without hiring more people.

OR IN DETAIL - SUPERMARKETS

Presentation Slide 32

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 33

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 34

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 35

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 36

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 37

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 38

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 39

2 minutes

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