Science and Technology Teaching Notes

for ages 7-11
with Cross Curricular links

These notes accompany the PaperWorks Pack 2 whiteboard presentation:
http://www.paper.org.uk/paperworks/presentation2/
and are free to use within the classroom.

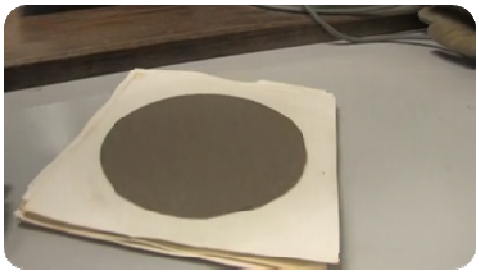
TEACHING NOTES

Introduction

Welcome!

PaperWorks Pack 2 is an interactive, themed educational resource designed to show pupils the impact of paper on society.

Aimed at 7-11 year olds, Pack 2 explores the science and technology behind paper production and how the processes have changed over time.



Through imagery, video and an interactive game, pupils start to understand the paper production process through simple technical descriptions. They will discover the history of paper and how it has evolved, highlighting paper's dynamic nature. Pupils can also make their own paper in a hands-on activity.

This pack contains:

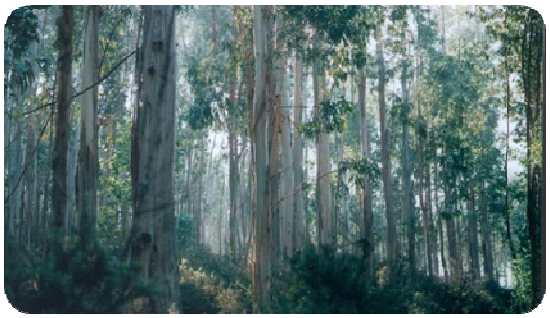
- Background information on paper production and the importance of paper.
- Ideas for a themed week (page 10).
- Six Science and Technology lesson ideas (pages 11-13) with curriculum links.
- Lesson ideas for Literacy, Maths, Geography, History, Art and Computing (pages 14-15) with curriculum links.
- Supporting notes for the Whiteboard Presentation and online worksheets.

You will need:

- A computer.
- An audio system.
- An Interactive Whiteboard to gain full value from this resource.

Paper: The Facts

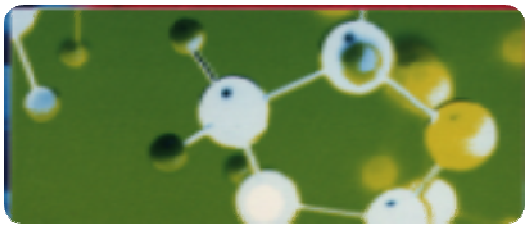
- Of the fibres used to make paper in the UK, over 70% comes from recovered paper recycled by households and businesses. The rest comes mainly from virgin wood fibre from trees grown in sustainably sourced forests. Pulp is a mixture of fibres and water.
- Used paper sent for recycling is recovered and reused to make new paper. This paper is called "Recovered Paper" or "The Urban Forest".
- Paper fibres can only be recycled around 4-7 times as they increasingly degrade in the recycling process, and eventually lose their papermaking qualities. Degraded fibres are replaced with new, virgin fibres, often from recovered paper that has not previously been recycled.



- Without virgin fibres from new trees, the paper cycle can neither begin nor continue.
- Coniferous and deciduous trees are used in papermaking and they contribute different qualities to the end product.
- Almost any used papers can be recycled, including newspapers, cardboard, packaging, stationery, 'direct mail', magazines, catalogues, greeting cards and wrapping paper. It is important that these papers are kept separate from other household waste as papers contaminated with food waste or broken glass, for example, cannot easily be recycled.
- Every year, more than 10 million tonnes of paper and board are consumed in the UK.
- In 2011, 8.0 million tonnes of used paper and board was collected for recycling.
- In promoting the UK's paper recycling industry, jobs can be created in collection schemes, sorting plants, recycled paper mills and the design, marketing, advertising and distribution of recycled paper products.
- Modern papermaking is surprisingly cost-effective and environmentally friendly. What's more, the UK paper industry is the largest recycler in Europe and is the UK's most successful recycler.

Paper Production

The papermaking process starts with plant material, usually trees, and changes it into the common everyday product we know as paper. The woody part of the tree, within the bark, is made up of tiny strands of cellulose (fibres) held together by a natural glue called lignin. The first part of the process is to separate the fibres into a pulp, a concentrated mixture of fibres in water, which is then remixed to form the paper.



Of the fibres used to make paper in the UK, over 70% comes from recovered paper recycled by households and businesses.

Having been recovered from recycle bins, the waste paper is taken to the paper mill where it is pulped (by mixing water and sodium silicate together) and turned into stock. It is then sent through cleaners and spun to remove excess water and debris and whitened before being washed and drained. To start to look like paper, the stock is finally heated and dried through rollers before being spun as paper on a reel. The paper is then converted into everyday products such as, newspapers, books, tissues and cardboard boxes/packaging.

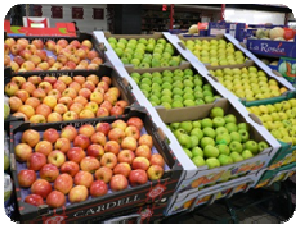
Paper fibres can only be recycled around 4-7 times as they increasingly degrade in the recycling process, and eventually lose their papermaking qualities. Degraded fibres are replaced with new, virgin fibres, often from recovered paper that has not previously been recycled.

Without virgin fibres, from new trees, the paper cycle can neither begin nor continue.

To use virgin wood fibres, bark from the tree is removed and then the wood is chipped. The fibres in each wood chipping are then separated and washed before being turned into pulp like in the process above.

TEACHING NOTES

The Importance of Paper



It's difficult to imagine a world without paper. We use paper for writing, reading, packaging and absorbing liquids. Everything from nappies to birthday cards use paper.

Cardboard is used for protective packaging and to help make transporting goods easier. It also informs us of the details of the products inside the packaging so we can make purchasing decisions.

Artists and designers use paper because of its presentation qualities. It's cheap, convenient to use and environmentally friendly.

Protecting with cardboard
Prevents insects feeding on fruit and vegetables
Makes transporting goods easier
Prevents goods being damaged
Provides information on the product
Reduces food and product waste

Celebrating with paper
Celebration cards
Present wrapping
Tissue paper
Present boxes
Parcel bags

Whilst we have a digital version for just about anything now, we still use millions of tonnes of paper.

Paper is here to stay and pupils should be aware of its importance in their lives. Would it be easy to live without it?

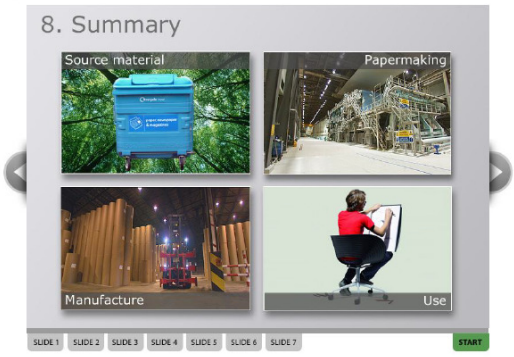
Presentation Notes

Below, you'll find an image of each slide found in the main whiteboard presentation and its accompanying notes.

Slide 1	**Paper is made from…**
	Here you'll find images of the two main sources of the fibres used to make paper – wood and recycled paper. Explain the role of wood fibres and how they need to be separated out to make paper. Highlight the concept of recycled paper and mention how most paper items can be recycled. However, stress that the fibres can only be reused to make new paper up to 7 times before they break apart. Fresh fibres are added to replace the broken fibres to strengthen the paper. Of the fibres used to make paper in the UK, over 70% comes from recovered paper recycled by households and businesses. The rest comes mainly from virgin wood fibre from trees grown in sustainably managed forests. Water is a staple raw material that is mixed with the fibres from wood or recycled paper to make the pulp used to make paper. *You might like to ask pupils to recap on what recycled paper is and how we can ensure there's always lots of it (by recycling).*

Slide 2  	**Paper, Science and Society** This slide shows the main ways paper has changed society. From being discovered in China in 105AD by T'sai Lun to the invention of The Gutenberg Press in 1440, paper products such as books, started to become more accessible by being produced on a large scale. Inform pupils that the printing press allowed knowledge and ideas to be passed amongst society. *Allow pupils to investigate how The Gutenberg Press might have influenced society. What impact did printing paper on a large scale have on society?* *Discuss how this might have impacted communication, education and media at that time.*
Slide 3  	**Paper Uses** Paper is used in so many products we see day-to-day. From packaging, writing paper, books and tissues, the list is endless. *Ask pupils to think of two uses of paper that you haven't already discussed as a class.*
Slide 4  	**Paper Uses – Did you know?** Teabags are made from paper, and so are disposable coffee cups. Packaging protects fragile products and foods, so substantially reducing food waste. Designers are always finding novel uses for paper like this vacuum cleaner. *Can pupils think of other uses?*

Slide 5  	**The Paper Trail** In this short video clip Paul Freeman, Operations Director of Smurfit Kappa SSK, takes students on a tour of the Birmingham paper mill. The mill takes recycled paper and board, mixes it with water to make a pulp. The water is then removed by draining, squeezing and drying to leave a fine mat. That mat is what we call paper. The paper produced at this mill is used to make cardboard boxes and packaging. These boxes protect and transport food and retail goods. Once the box or packaging is used it enters the recycling chain again and eventually turns up at this mill, or another, to make more paper. During the video students will see the papermaking process including: ♻ Recycling ♻ Pulping ♻ Drying ♻ Rolling
Slide 6  	**The Paper Game** Here is an unfinished diagram of the papermaking loop. Ask pupils to drag each post-it note to the correct place in the papermaking loop. We've done the first one to help you. Once all the icons are in the correct place, drag its simple description over to match it. *Correct sequence:* ♻ ***Use**: Paper has many uses, from newsprint to tissue and cardboard.* ♻ ***Fibre**: Paper is made from fibres from recycled paper and/or wood.* ♻ ***Pulp**: Water is mixed with the fibres to make pulp.* ♻ ***Squeeze**: water is squeezed out of the fibrous mat to make paper.* ♻ ***Dry**: The paper is dried and finished.* ♻ ***Roll**: Big rolls of paper are converted into many useful products.*

Slide 7  	**Mixing, Sieving and Separating** Here is Dr. Kate Fiddy, a scientist at a paper mill. Her work includes testing the properties of paper produced at the mill. In this video she will demonstrate the papermaking process in the laboratory. She starts by tearing up the paper for testing into small pieces and mixes it with water to turn it into a pulp, just like the papermaking process. She pours the pulp into a long cylinder, onto a sieve-like wire, stirs the pulp and drains the water out through the bottom. This separates the water from the paper pulp. Once most of the water has drained away, blotting paper is placed on the paper sheet, the water squeezed out and is left to dry. Finally, the sheets are pressed by using heavy metal discs secured into a large press and laid out to dry. When it is completely dry, it can then be tested.
Slide 8  	**Summary** Of the fibres used to make paper in the UK, over 70% comes from recovered paper recycled by households and businesses. The rest comes mainly from virgin wood fibre from trees grown in sustainably managed forests. Without virgin fibres, from new trees, the paper cycle can neither begin nor continue. If we recycle our used paper, it will be transported to the paper mill, pulped, squeezed, dried and rolled and made into various paper products. *You may wish to explore the images first by asking pupils what is happening in each picture and then clarify using the script above.*

Using PaperWorks in the Classroom

PaperWorks offers a themed approach. The video-led presentations and interactive activities will help you inspire pupils by showing them:

- How paper is made and its journey to consumers
- What its properties are
- How it has impacted society

PaperWorks can also be used within a themed week, by combining the ideas offered in packs 1 and 2.

Here's an example of how a school could offer a PaperWorks themed week:

Day/Week	Topics
1	**MAKING A PAPER BAG** Explore various paper materials and processes used in Art to make a fashionable paper shopping bag
2	**THE HISTORY OF PAPER** Practice interviewing techniques and research skills to recognise the biggest change in the use of paper
3	**A DAY IN THE LIFE OF PAPER** Pupils will develop their creative writing skills by imagining themselves as a £5 note!
4	**PAPER FRACTIONS** Explore the concept of fractions through paper folding
5	**MAKING PAPER** Pupils will design a papermaking science experiment to determine how to make the best paper
6	**PAPER RECYCLING COMPETITON** A school or class competition to decide who is the best recycler

Science and Technology Themes

1. Making paper: Pulping, mixing and separating paper fibres

While most paper is made in a paper mill, it used to be made by hand similar to the technique below.

Remind pupils of the papermaking process and show the video of how they can make their own handcrafted paper. Discuss the ways the paper-production process has changed. You can use slide 2 in the Online Presentation to help you.

You'll need:

- Paper ripped up into small pieces
- A 500ml jug of water
- A 125ml cup
- 5-10 beakers of the same size (1 per test)
- A flat sieve
- A relatively deep rectangle cake tin *(approx 40cm x 20cm x 15cm deep)*

1. Rip up the paper into small pieces and put into one of the beakers
2. Fill the 125ml cup with water from the jug and pour into the beaker
3. Use a potato masher or a blender until the paper is wet and sludgy
4. Pour the pulp mixture over the sieve letting the water drain off underneath into the empty cake tin
5. Use a sponge to squeeze out the water and leave to dry overnight

You may wish to ask pupils to repeat the experiment, keeping quantities the same but changing one of the following variables to ensure fair testing:

- The paper type
- Use both a blender and liquidizer
- Use both hot and cold water

What equipment, process and measurements make the strongest paper?

2. Paper properties quiz

Paper is extremely versatile. It can be effective in many day-to-day tasks as it is often treated to serve many uses.

Discuss the meaning of these various material properties:

- Transparent
- Opaque
- Strong
- Flexible
- Hard
- Magnetic
- Insulating

Show pupils an array of different paper types. Ask them to research each property and predict which properties each piece of paper has. Some examples of paper types and their properties, are found below:

- Transparent (tracing paper)
- Opaque (school paper)
- Strong (a paper mâché object)
- Flexible (school paper)
- Hard (thick cardboard)
- Magnetic (some photo paper)
- Insulating (any paper object)

Once pupils have recorded their findings, discuss reasons why each paper type has that property. Ask children to use **Worksheet 1** to record their predictions.

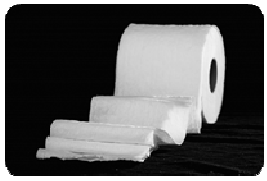
3. The paperclip test

Paper is so versatile, some can absorb water and sink and others can exude water and float.

Show pupils a range of paper types that can demonstrate floating, absorption and sinking (e.g. tracing paper, kitchen roll, printer paper and photo paper).

Ask pupils to make predictions on the amount of paperclips each paper will hold before it starts to absorb the water and sink. They can use **Worksheet 2** to record their answers.






4. The paper car challenge

While paper can be soft and able to tear, it can also be strong and durable. It is also an excellent versatile material when creating an entirely new product.

Challenge pupils to plan and design a paper car using paper objects they can find at home. They should design the car so it is strong and can be moved using a fan. Pupils can also be assessed on the amount of paper objects it is made out of.

Explain that they will use the mini fan for 3 seconds to move the car then they'll record how far it has travelled.

5. Making a friendship puzzle

Paper and cardboard are often used to make many consumer goods like board games. Here, pupils can make their own game using only one piece of paper.

- Start with a large piece of paper *(A3 or A2 possible)*
- Fold all corners of the square into the middle so you can see 4 triangles
- Turn the paper over
- Do the same to this side: fold all the corners into the middle, can you see 4 smaller triangles with little ones inside?
- Turn the paper over again so you can see 4 squares
- Put your first finger under one square and thumb under the one next to it and pinch them together. Do the same with the other hand and the other squares left. Pinch them together so all fingers and thumbs meet Number each square on the top of the puzzle
- Write a kind word about your friend under each number
- Ask them to pick a number that they can see. Open the flap and read out their friendship word!

SEAL curriculum link: *This lesson can also be used as part of the SEAL curriculum in making and sustaining friendships.*

6. A paper bag

Paper can be colourful, thick, durable and shiny. Paper is so versatile that it has been used as a staple product in wedding dresses and there are even cardboard shoes on the market!

Ask pupils to design a fashionable paper shopping bag using paper as the main material. You may wish to give them other materials to use as decoration e.g. buttons, transfers, sequins, pipe cleaners etc.

Other Subject Ideas

Literacy

- Pupils can practice their speaking and listening skills through interviewing older members of their family on what they feel the biggest change in paper has been. They can use the information to write a newspaper report or an informal letter. Photocopy **Worksheet 3** as a template for their newspaper report.
- Ask pupils to imagine they are; a £5 note, an envelope, toilet paper or a newspaper and to write a creative story on a typical day as that object. Ask them to think about describing how they look and feel and how useful or useless they are. You may wish to ask them to avoid mentioning what object they are in the story and the class can guess what object they are.

Maths

- As an introduction lesson to fractions, you can demonstrate the concept of 'equal parts' using a large sheet of paper, folded as many times as needed. Once pupils have grasped the concept, you may wish to ask them to fold their paper in halves, quarters or eighths and shade in the fraction you choose. As an extension activity, use **Worksheet 4** found on the PaperWorks website (answers on page 16).
- Ask pupils a variety of questions based on paper (e.g. who prefers one birthday card or ten birthday emails, would they prefer to read a story from a book or a kindle?). Show these results on a graph and discuss the findings.

Geography/PSHE

- Explore how humans can improve the environment by recycling paper. Discuss the best places for recycling bins in the school and why. Use the internet to find out which country recycles the most paper. Use **Worksheet 5** to write a recycling fact-file of that country.

TEACHING NOTES

History

- Use the internet to find out more about the history of paper. Explore the technological changes that have occurred recently and whether they reduce the need for paper. Use the internet to visit historical websites and research other sources of paper years ago.

Art and Design

- Show pupils the work of the paper sculptor Jeff Nishinaka, and explore how paper can be cut, stuck and shaped to create various stand-up designs. Provide pupils with a theme (e.g. summer) and ask them to create their own paper sculptures based on that theme.

Computing

- Pupils use a computer programme to design a celebration card for someone in their family. Once designed, they can print it out and give it to their family member in an envelope. Discuss how they felt about making the card and how the person might have felt receiving it.

Worksheet 4 Answers

Extension Activity for 10-11 year olds: Fractions, Ratios and Percentages

Q1 – 480 litres (96/100 x 500)

Q2 – 20 litres (500-480)

Q3 - 75% (3/4 x 100)

Q4 - 15kgs (30/100 x 50)

Credits

The CPI wishes to thank the following for their invaluable contribution to these resources:

- Smurfit Kappa SSK
  www.smurfitkappa-paperuk.com

- Sue Faux of Faux Arts
  12, High Street, Pewsey, Wiltshire SN9 5AQ

- Jeff Nishinaka, paper artist
  http://www.jeffnishinaka.com/

- Helen Snell, paper artist
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