

Be a Paper Engineer

This booklet will help you to design and make your own paper products, like pop-up cards, envelopes and gift boxes. There are four stages involved.



Stage 1
Looking at examples
pages 2–11



Stage 2
Exploring techniques
pages 12–14



Stage 3
Making your own original
pages 15–25



Stage 4
Going into production
pages 26–32

Stage 1 Looking at examples



In this stage, you will work in a small group.

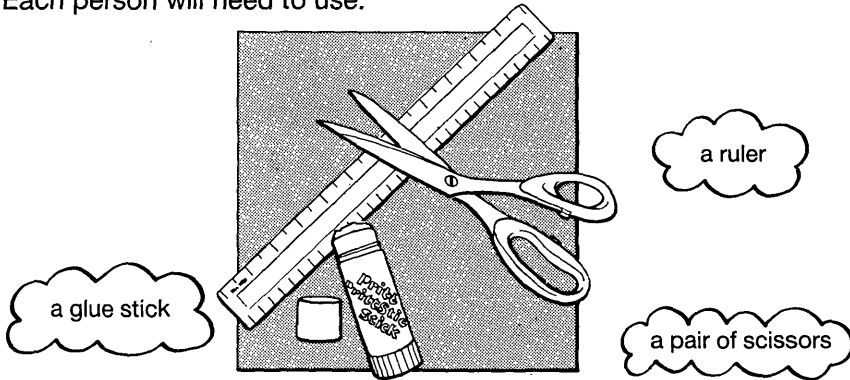
To get you started, each person will make a Cat pop-up card and a Birthday envelope to keep it in.

Your group will then work together to make a collection of cards, boxes and envelopes. You will compare all these items and see how they work.

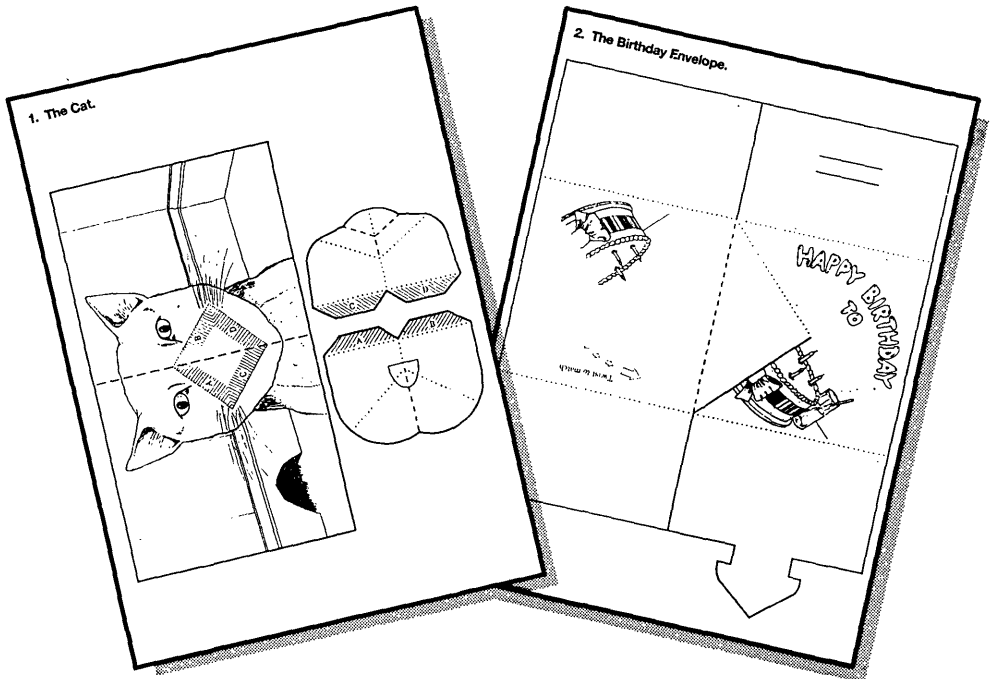
Finally, you will be asked to look for other examples of paper engineering at home or in the shops. These should give you some more good ideas.

Making the Cat card and the Birthday envelope

Each person will need to use:

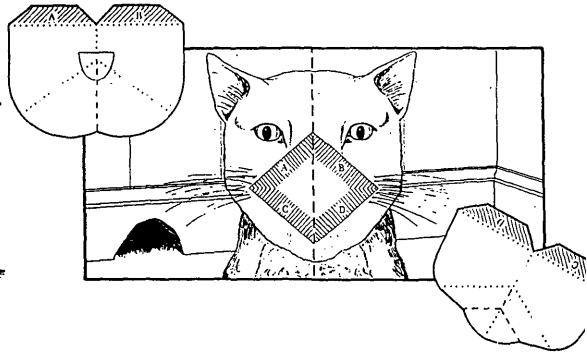
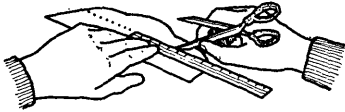


Each person will also need a copy of the Cat sheet and the Birthday envelope sheet.



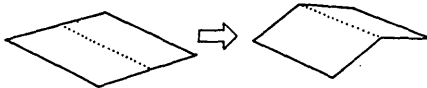
The Cat card

- Cut out the three pieces along the thick lines only.
- Score the dotted lines, and -----.

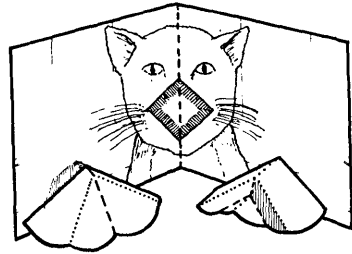
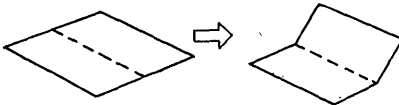


- Fold along the dotted lines.

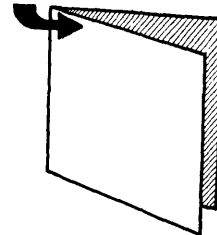
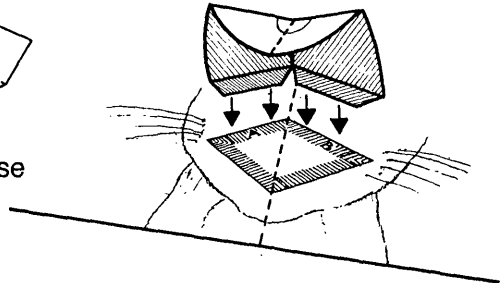
'hill' fold



'valley' fold

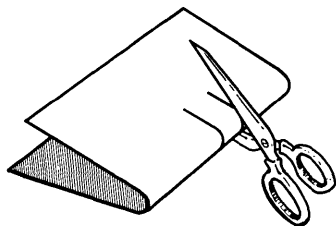


- Match up the tabs on the nose to A and B on the base.
- Glue where it is shaded and stick the tabs to the base.
- Do the same with C and D.
- Close the card along the centre fold.
- Open and close the card to check that it works properly.

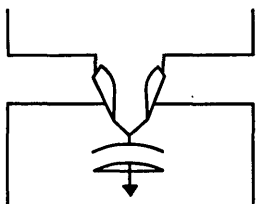
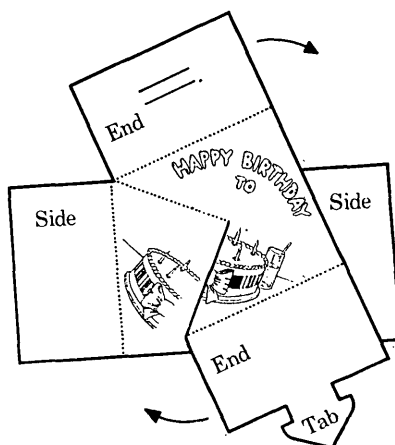
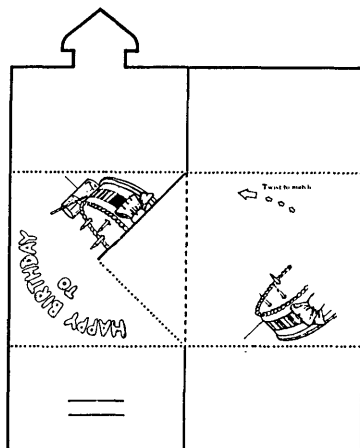


The Birthday envelope

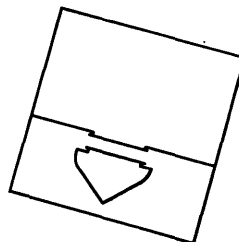
- Cut along the thick lines only.
- Cut the slots like this:



- Score along the dotted lines.
- Fold along them to give 5 hill folds and 1 valley fold.
- Twist and fold over to match up the two halves of the birthday cake.
- Fold the two sides over.
- Then fold over the two ends, pinching the tab so that it goes through the slots.



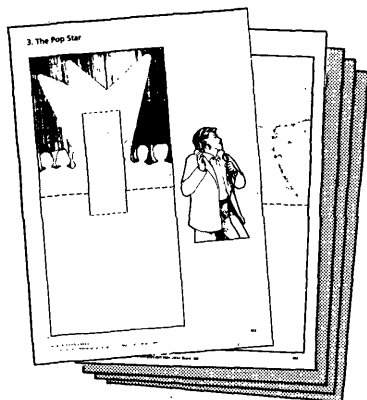
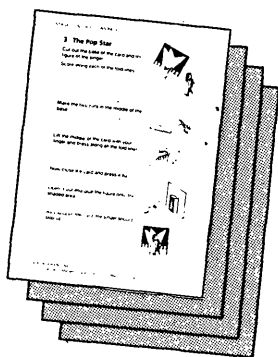
- Flatten out the tab to secure it.
- Undo the envelope again. Your 'Cat' card should just fit inside.



Making a collection of cards, boxes and envelopes

Your group will now need . . .

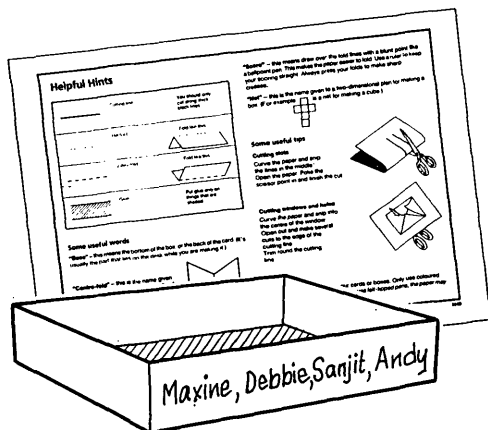
a set of 29 plans which may be cut out to make pop-up cards, boxes . . .



an Instructions pack which tells you how to make each item

a Helpful hints sheet

and a tray or box lid for storing your finished items.



Each person in your group should choose a different card, box or envelope to make, and find the matching instructions. Make the item you have chosen. When you've finished one item, choose another . . .

Looking at the things you have made

When you have made a large collection of items, try playing the following game in your group.

- Put all your cards, boxes and envelopes in the middle of your table.
- One person, the 'chooser', secretly writes down the name of one item.
- The other players try to find out which it is by asking questions in turn.

But . . .

- the 'chooser' can only answer 'Yes' or 'No',
- the questions must not mention pictures or designs, (so you *cannot* ask 'Has it got an animal on it?'),
- only *one* guess is allowed at the name of the secret item.

Here's how one game went . . .

Is it a card?

Yes!

Does it have a centre fold?

Yes!

Are all the fold lines parallel to each other?

No!

Do you need glue to make it?

Yes!

Does the picture pop up when the card is fully open?

Yes!



Which cards could it be?

Classifying the things you have made

Ask your teacher for a large copy of the Flowchart sheet and a counter.

This will help you to sort out (or classify) the things you have made.

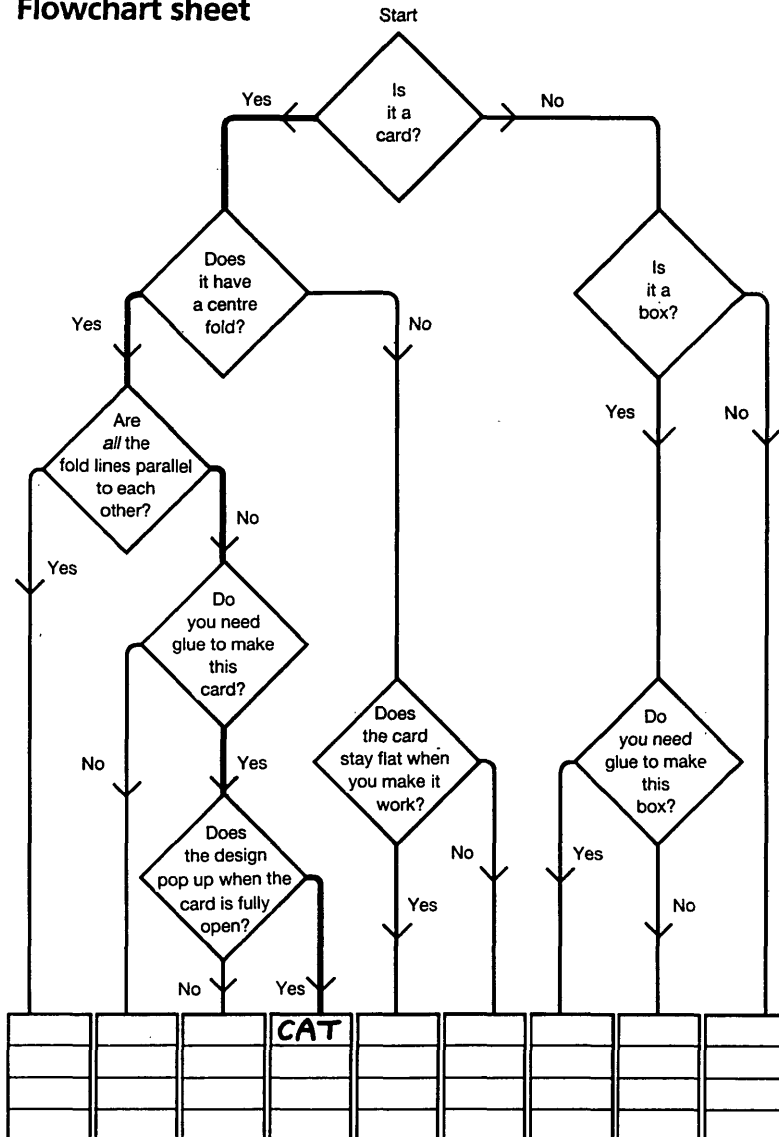
How to use the Flowchart sheet

- Choose a card, envelope or box that you have made.
- Now place a counter on the first question:
'Is it a card?'
- If the answer is 'Yes' then move your counter along the 'Yes' line to the next question.
If the answer is 'No' then follow the 'No' line.
- Now answer the next question . . . and so on.
- When your counter reaches the bottom of the page, write down the name of the card, envelope or box in an empty space.

The page opposite shows the route taken by the counter when the Cat card was chosen.

Now make up your own Flowchart sheet, using your own questions.

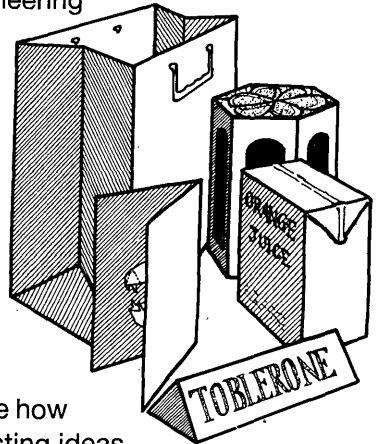
Flowchart sheet



Looking at other examples

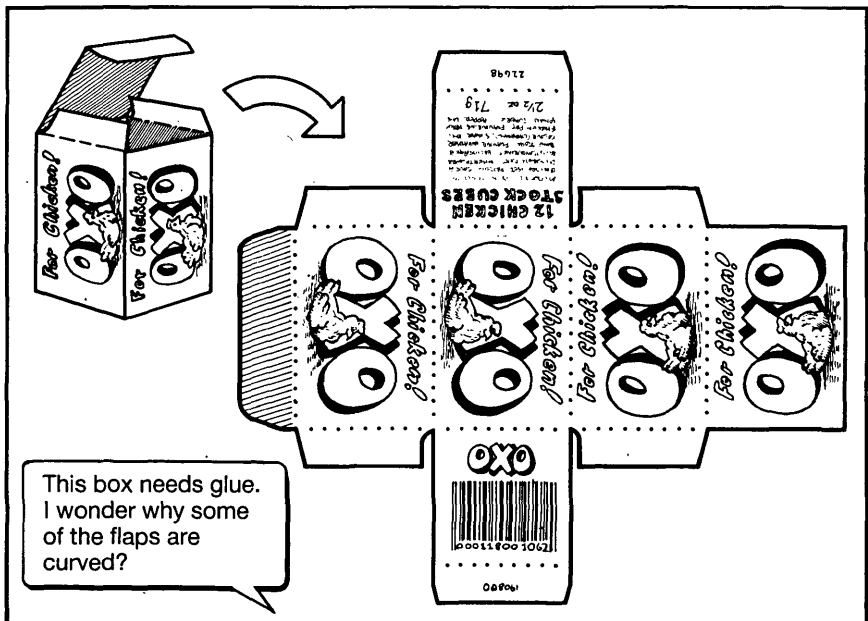
Search for other examples of paper engineering in shops or at home, like

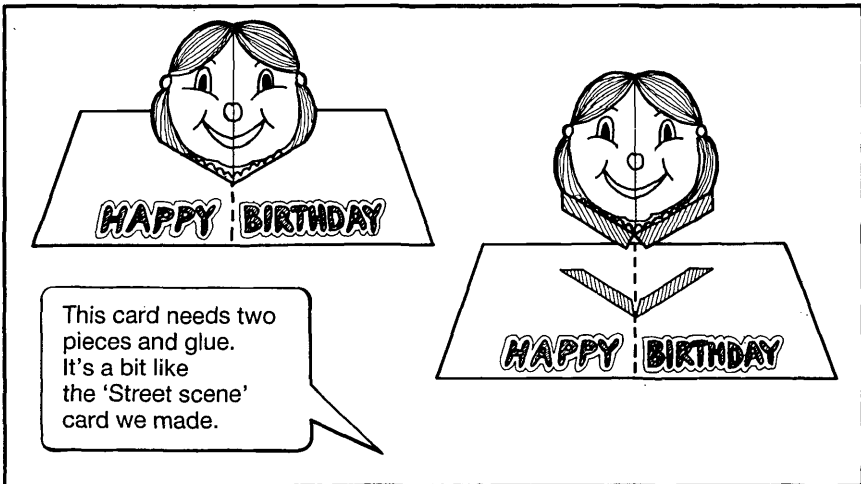
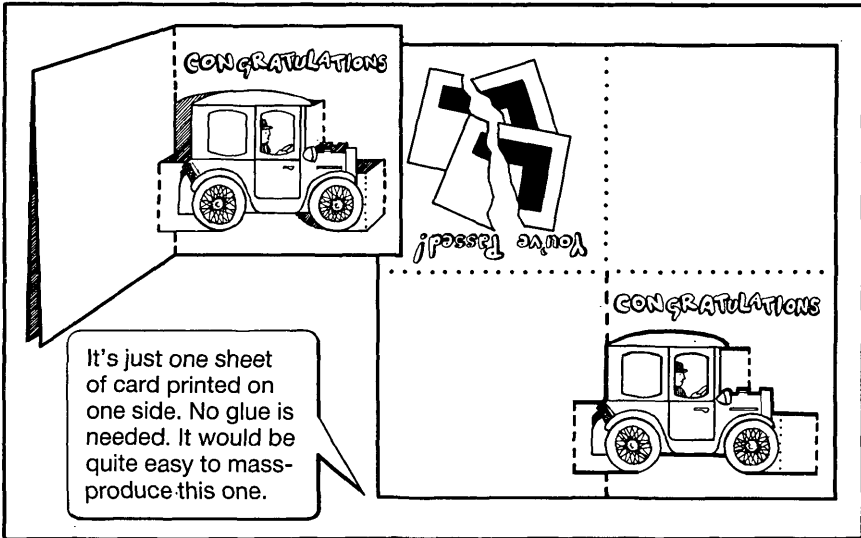
- pop-up books or cards
- carrier bags
- Easter egg boxes
- boxes for scent bottles
- paper lampshades
- ... and so on.



Bring some to school.

If you can, carefully take them apart to see how they are made. Keep a note of any interesting ideas ...





Perhaps you will be able to use some of the ideas when you design your own items, later on.

Stage 2 Exploring techniques



In this stage you will work mostly on your own using some of the Exploring techniques sheets.

You will try some

- **investigations**, which ask you to explore what happens when you fold, cut or stick things in different ways,
- **challenges**, which show you pictures of finished articles that you can try to make.

You will also

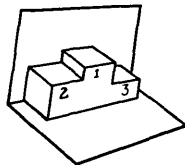
- **keep a record** of everything you discover for use later on, when you come to design your own item.
(Page 14 describes how to do this in more detail.)

Investigations Try these . . .



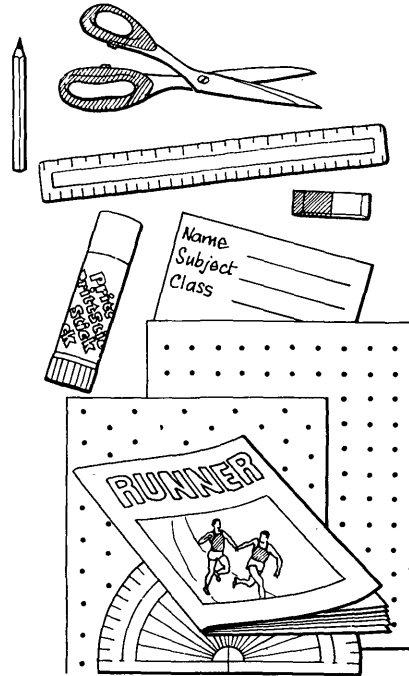
Make up your own examples as well

Challenges Try to make this winners' podium



You will need

- some Exploring techniques sheets,
- a pair of scissors,
- a glue stick,
- a pencil, ruler and rubber,
- lots of paper or card,
- an exercise book or folder to record what you find out.



You may also need

- some old magazines – for extra pictures,
- some squared or isometric dotty paper,
- a protractor – to measure fold angles.

There are seven different 'techniques' to explore:

- cards with parallel folds
- cards with parallel 'stick-ons'
- cards with angled folds
- cards with angled 'stick-ons'
- cards with slides or pivots
- boxes
- cubes

Choose one technique to work on.

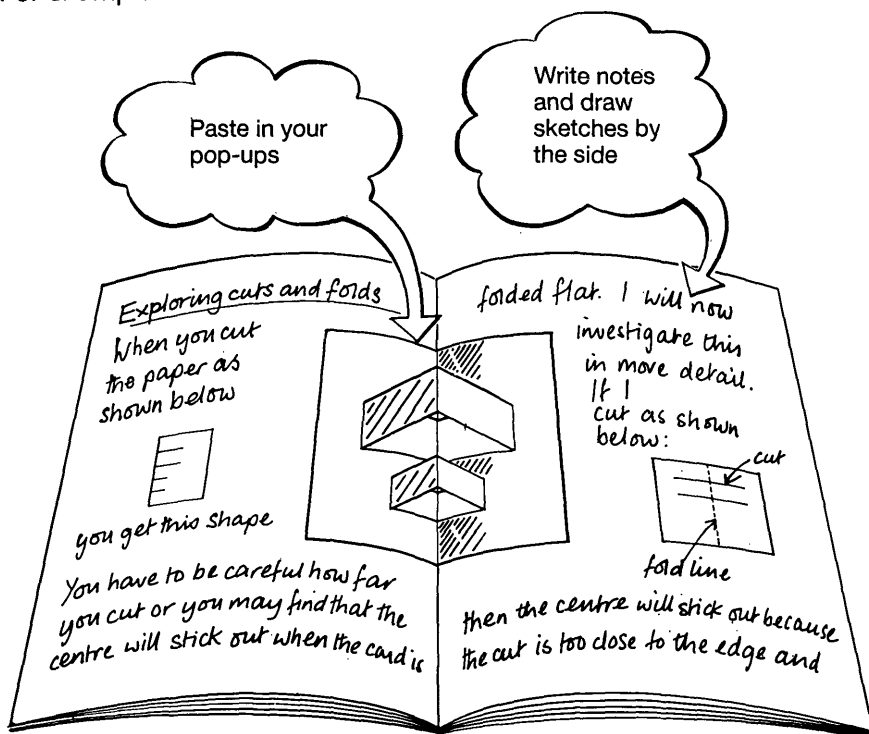
You do not have to try everything on the sheets.

You should aim to explore at least three of the seven 'techniques'.

Keeping a record

Record all you do in an exercise book or in a folder. This will help you to remember what you've found out.

For example:



Keep everything you make – even the things that go wrong.

Make a note of

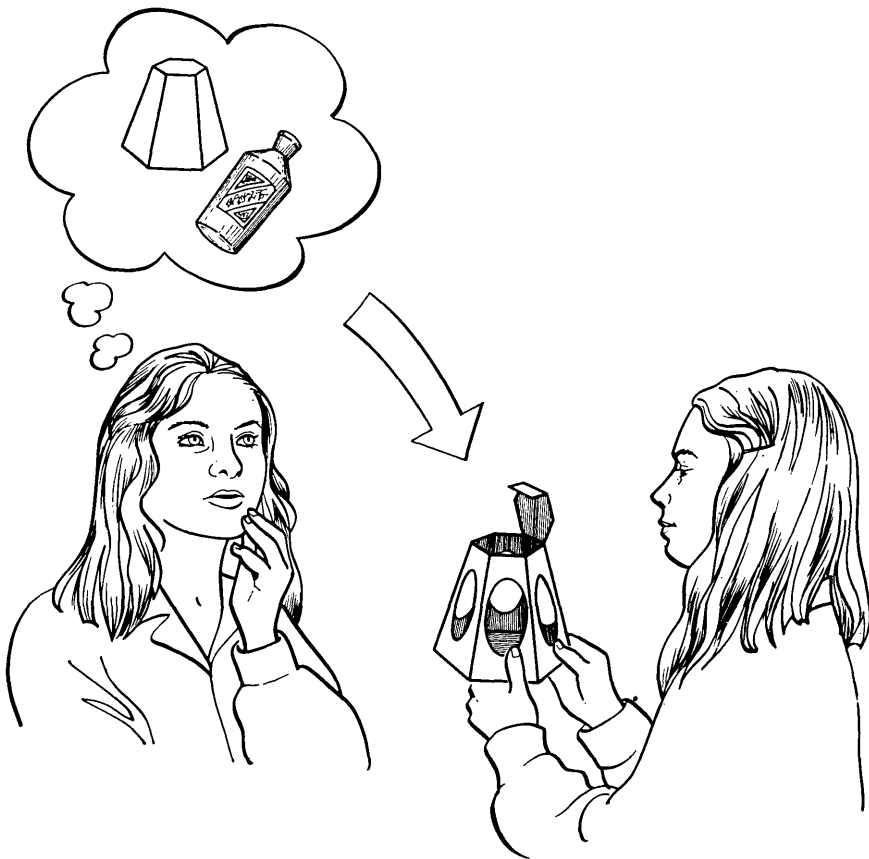
- what you tried to do,
- what happened,
- what you learnt.

You'll need all this information for Stage 3.

Remember

You can learn a lot from failures, so include these as well.

Stage 3 Making your own original



In this stage you will

- brainstorm to find a good idea for a pop-up card, box etc, of your own,
- make a rough version of your own idea in paper,
- make a 'best' version of your idea in card.

Brainstorming

You will each need a Brainstorming sheet.

In your group, write down some original ideas for pop-up cards, boxes etc, which *you* could make.

STAGE 3

Brainstorming Name Sanjit

Type of article (card, box, envelope...)	Theme	Special features	How it moves or works	Useful examples that we have already made
Pop-up card	Halloween party	Spooky castle	Castle stands up	'Cat' card
Pop-up firework box	Bonfire party	fireworks, food	Rocket shoots up	Rise and shine card
Card and envelope	Disco invitation	Record-shaped card	Pop star jumps	'Pop stars' card Disco invitation
Pop-up card	Moving house	House flies across card	Pull	'Frog' card
	Scent box		Lid opens and closes	

(Draw a sketch on the other side)

A pop-up castle and a scent box

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© Shell Centre for Mathematical Ed

I could make it for a Hallowe'en party.

It could be a spooky castle.

Let's look back at our Stage 2 work to get some more ideas . . .

You could pull a slide and make the drawbridge open – like on the Mole card!

Choosing an idea to work on

You may want to work together on an idea . . .

Let's make a pop-up storybook for children. We could each invent a different page, and then put it all together, at the end.



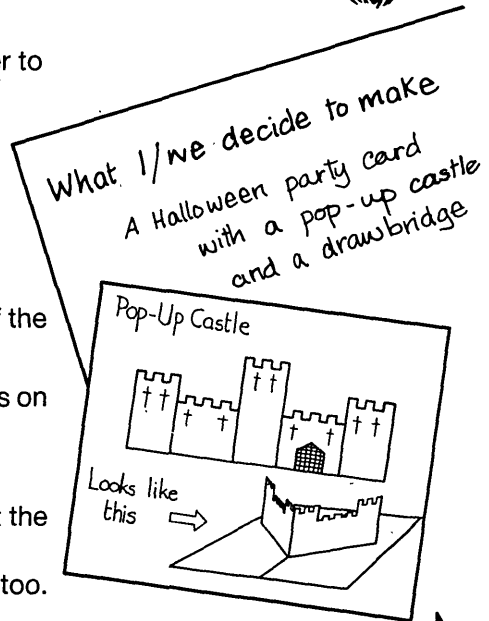
. . . or maybe you would prefer to work on your own.

Whichever you decide,

- choose what you want to make,
- describe it at the bottom of the Brainstorming sheet,
- draw sketches of your ideas on the back of the sheet.

If you are working in a group, decide how you will share out the work.

Write that down on the sheet too.



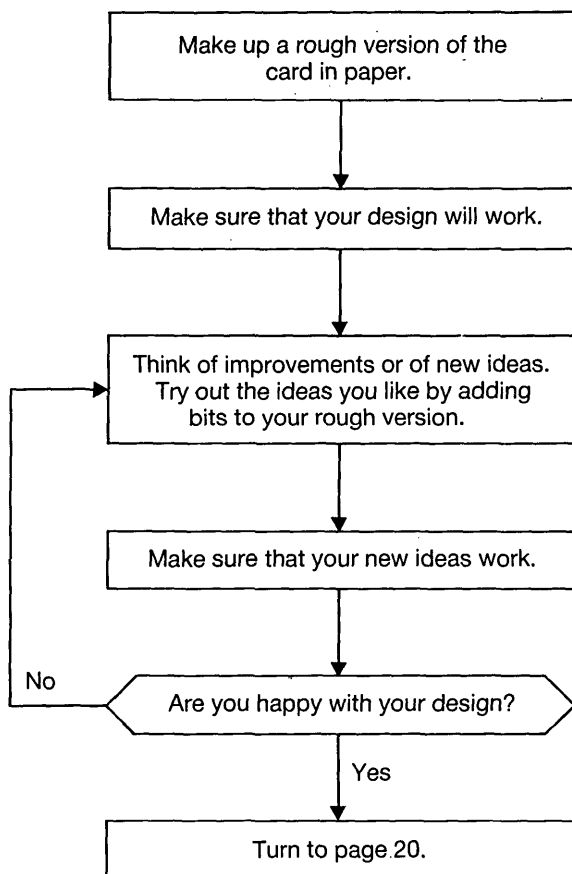
Are you making a box or envelope? If so, turn to page 22. Otherwise, turn over to page 18.

Developing your idea for a pop-up or moving card

Planning your design in rough

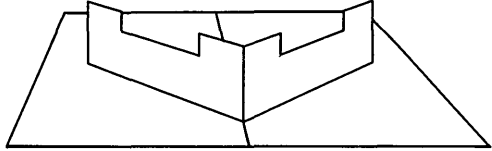
So, you have an idea for a card.

Here is one way to develop it.

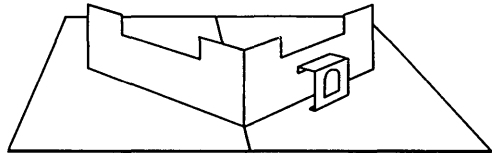


Here's how one girl developed her idea . . .

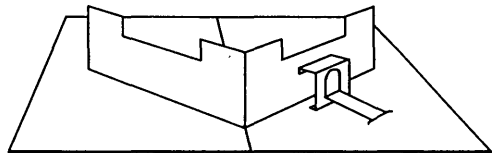
Let's try to make the basic castle shape. It works!



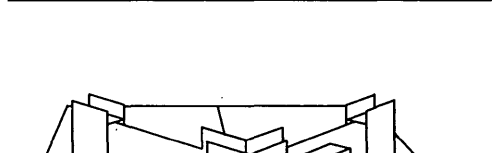
An idea! I could have a pop-up Dracula . . . no that's silly. A gate would be better, (using parallel folds) . . .



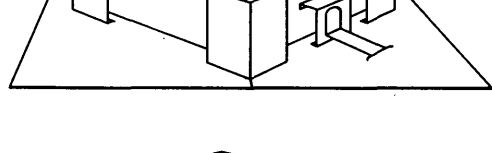
. . . and a sliding drawbridge! It works!



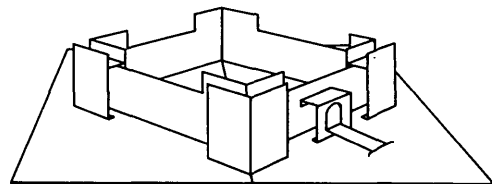
It still looks a bit boring. Let's think of some more ideas.



How about some towers attached to the front . . . like on the 'Rise and Shine' card . . .



. . . and a back? It works if I don't stick the back to the base.



I'm happy with it now.

Drawing an accurate plan

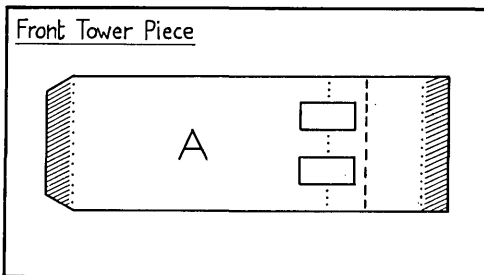
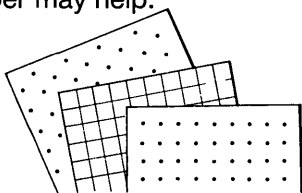
By now you should have a design with which you are happy.

You now need to spend time polishing it until you have a 'best' version.

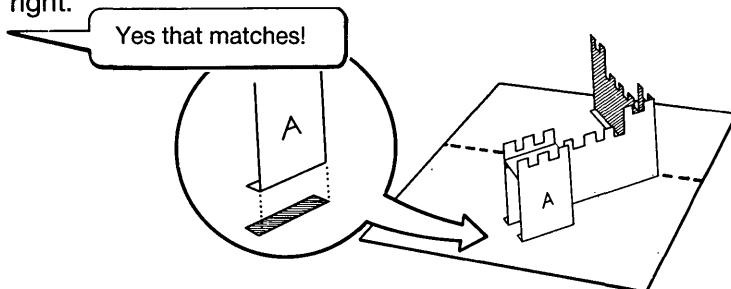
In pencil, draw each piece of your design accurately on paper.

You only need to draw each different piece *once*.

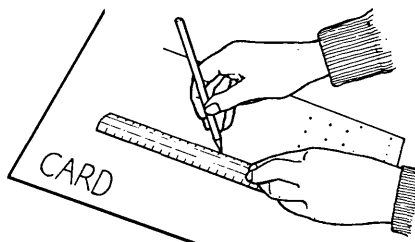
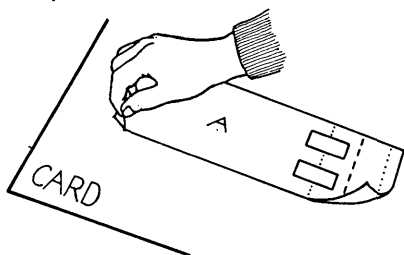
Squared or isometric dotted paper may help.



Cut out the pieces, and check that all your lines and angles are *exactly* right.



Transfer your design onto thin cardboard by pricking through the corners of each piece and drawing lines between the pinpricks with a pencil.



Try to plan the layout so that not much card is wasted.

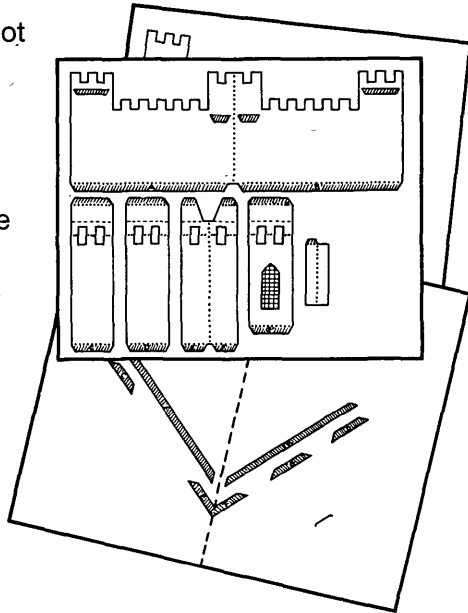
Mark in hill and valley folds.

Label tabs with letters.

Shade in places which must be glued. Add any other details.

This is now your 'copymaster.'

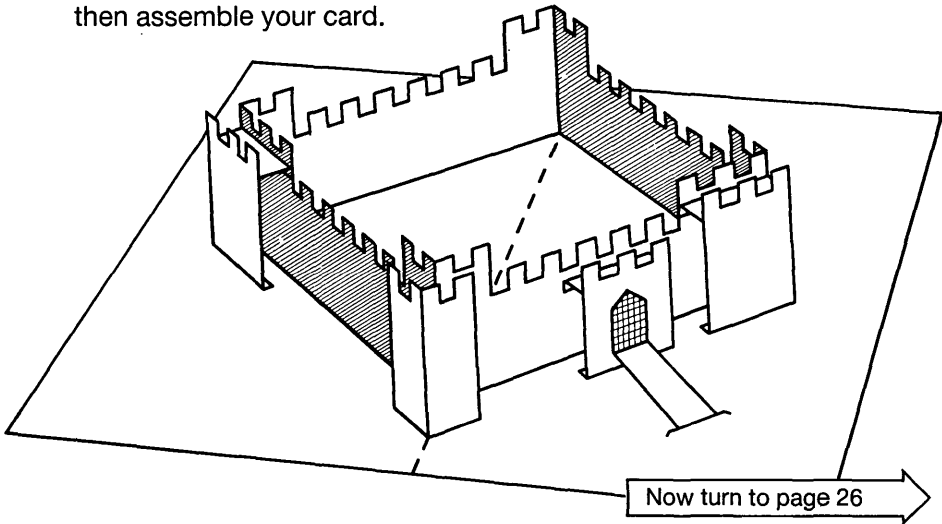
Keep it safe!



Making the finished product

Make one copy of your design on a fresh sheet of cardboard.
Cut the pieces out.

Check that the pieces will all fit together. Add colours, if you need to, then assemble your card.

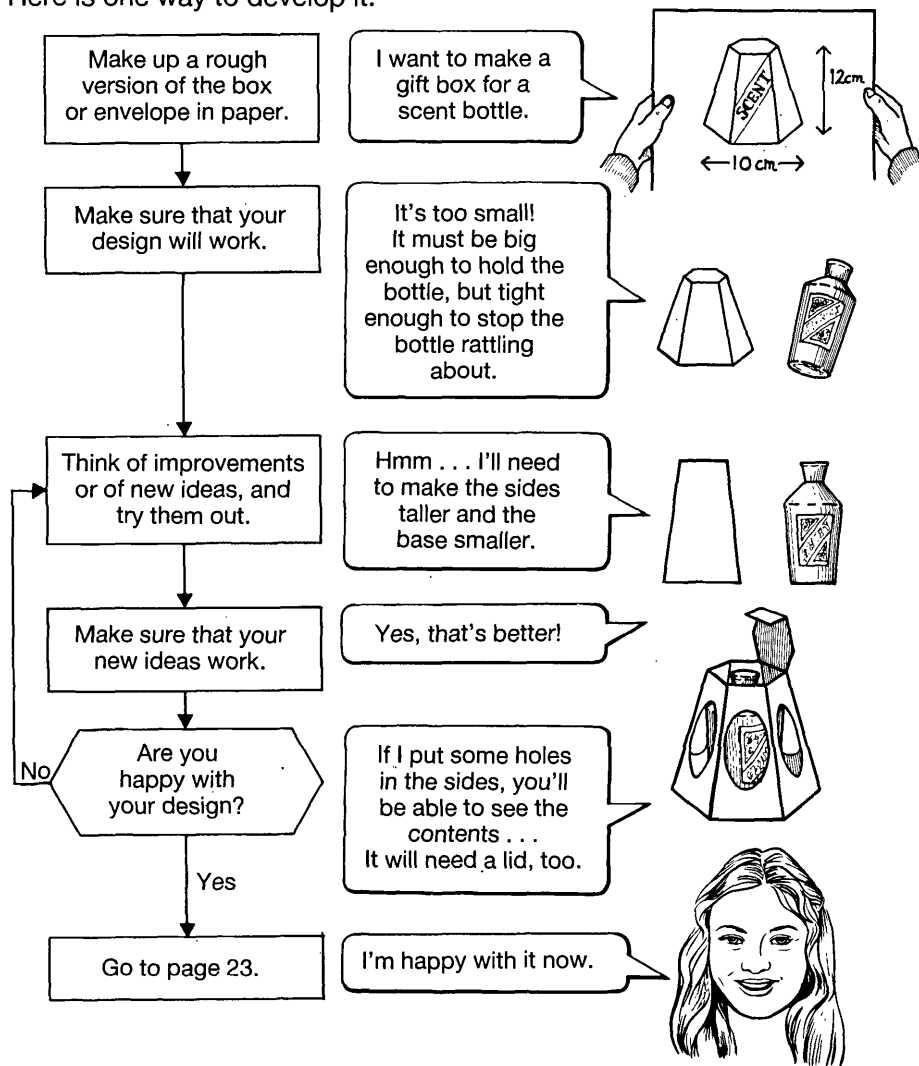


Now turn to page 26

Developing your idea for a box or envelope

Planning your design in rough

So you have an idea for a box or envelope.
Here is one way to develop it.



Drawing an accurate plan

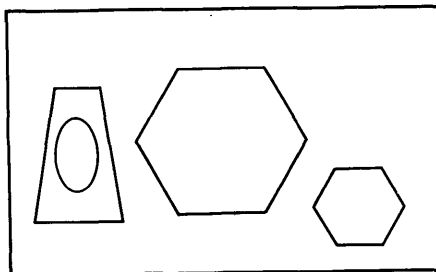
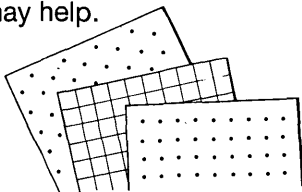
By now you should have a design you are happy with.

You now need to spend time polishing it until you have a 'best' version.

In pencil, draw each piece of your design *accurately*, on paper.

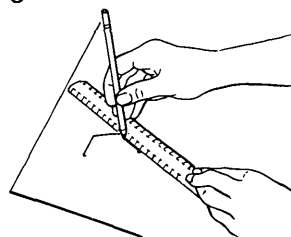
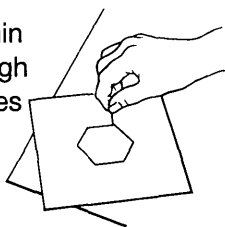
You only need to draw each different shape *once*.

Squared or isometric dotted paper may help.

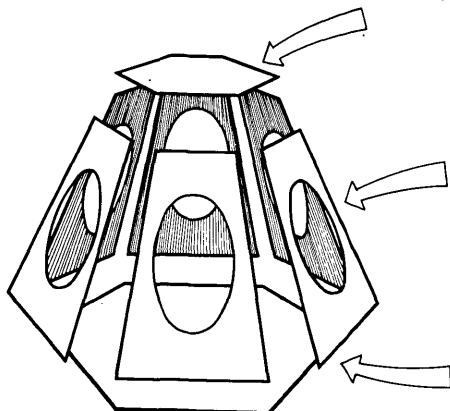


Check that all your lines and angles are *exactly* right.

Transfer your design onto thin cardboard by pricking through your design and drawing lines between the pinpricks.



Cut out the pieces and assemble your accurate version.



You will need to add tabs to join the pieces together.

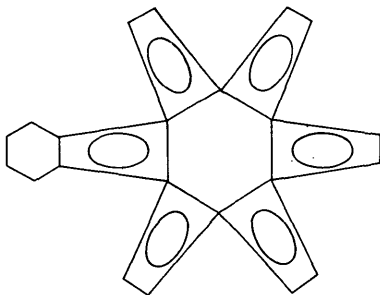
STAGE 3

The more tabs you use, the more difficult your box or envelope will be to make.

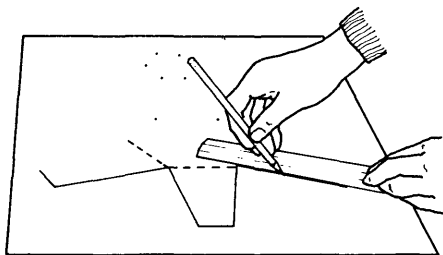
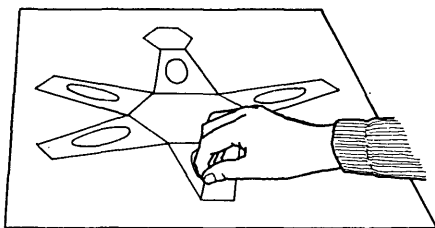
Try to make yours from a single piece of card or paper.

Here is one way to do this.

Cut along the folds of the tabs one by one, until the design can open out flat. This is called a *net*.



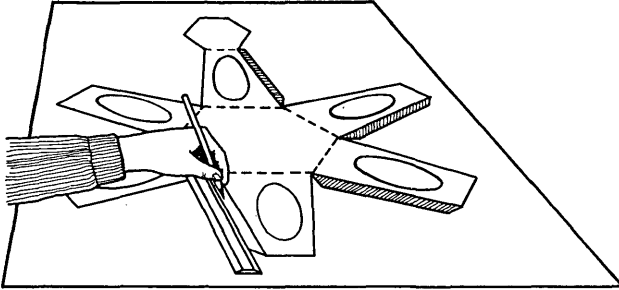
Now transfer your net onto a fresh sheet of thin card by pricking through with a pin and drawing lines between pin pricks.



Check that all the measurements are still correct.

Decide where you'll need tabs and draw them in.

(Don't make them too narrow or your box will fall apart!)



Mark in hill and valley folds.

Label tabs so that it is clear where they go.

Shade in places that must be glued.

Add decoration and any other details.

This is now your 'copymaster'. Keep it safe!

Making the finished product

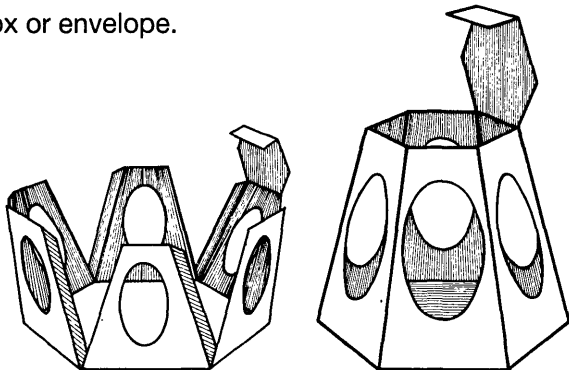
Make one copy of your design on a fresh sheet of thin cardboard.

Cut the design out.

Fold it up to check that it all fits together.

Add colour if you need to.

Now assemble your box or envelope.



Stage 4 - Going into production



In this stage, your aim is to produce a few complete kits, so that other people can make your paper product.

Each kit will contain

- a copy of your design
- a set of clear instructions for making your product.

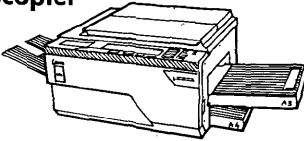
The stage is in 5 sections:

- Finding out about copying ("reprographics")
- Preparing your instructions
- Testing your instructions
- Putting your kits together
- Using your kits.

Finding out about reprographics

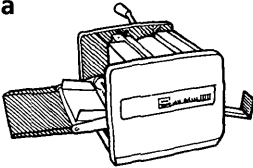
Your school probably has several different methods of printing copies from paper originals.

Photocopier



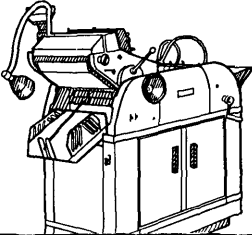
A bright light shines on an original, producing a picture of it on the copy paper.

Banda



You make an original with special coloured carbon sheets. The machine wets the original and prints copies on paper or card.

Offset litho



A trained operator makes a special printing 'Plate' – like your original but back-to-front. The plate rotates on a drum at high speed to make copies very quickly.

Find out about each method.

- Will it print in colour?
- Will it print on card?
- Will it print on coloured paper?

Your teacher will help you to decide on which method to use.

Check that your copymasters will produce good copies.
You may need to go over some lines with ink.

Preparing your instructions

People must be able to make your product without help from you, so your kit will probably need some instructions.

These will need to be as simple and clear as possible.

Here are some ideas which may help you to prepare them.

What instructions will you need?

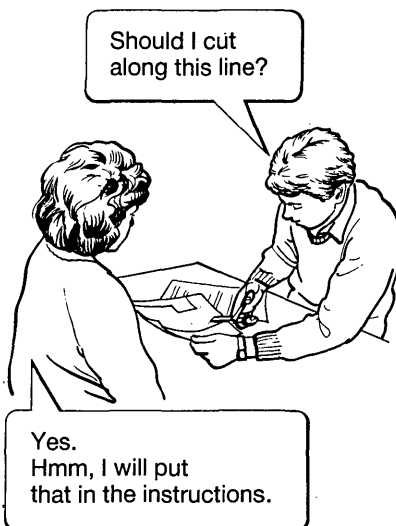
Give someone a copy made from your master.

Watch as they try to make your product.

Each time they go wrong or get stuck, explain what they should do.

Make notes of how you helped.

Use your notes to help you prepare your instructions.



How can you make your instructions clear?

You could include sketch diagrams, letters, arrows, numbers, colours, cartoons or photographs . . .

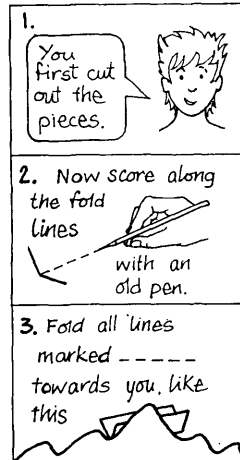


Using cartoons

You could make your instructions clearer with a cartoon strip.

If you can't draw, ask your teacher for the Cartoons for instructions sheet.

Cut out any cartoons you need from this sheet.



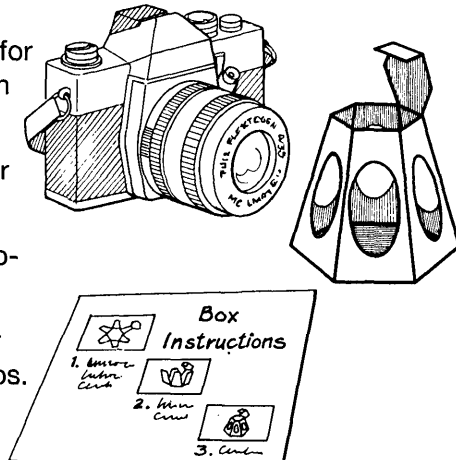
Using photographs

Borrow a camera with a film for prints. (A black and white film may be best.)

Take close-up photos of your product being assembled.

Use your photos to form step-by-step instructions.

Check that you can get clear photocopies from your photos. (If you can't, you could try tracing your photos.)



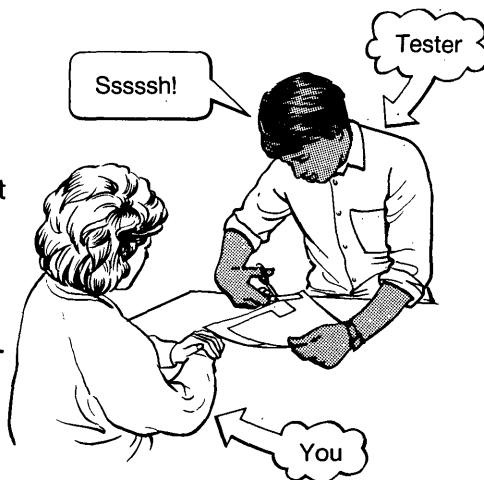
Testing your instructions

Make a copy from your master.
Find someone else who hasn't seen your product before.
This person will be your *tester*.

Watch as the tester makes
your product using your
instructions, but don't say
anything!

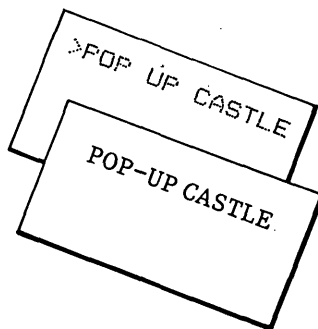
Check that your tester doesn't
need any help – apart from
your instructions.

Improve your instructions and
test them again if you need to.



When your instructions are 'perfect', make a 'best' copy of them.

Make the writing as clear and
as neat as possible.
Use a typewriter or computer
printer if you can.



Finally, stick on any cartoons or photos.

Putting your kits together

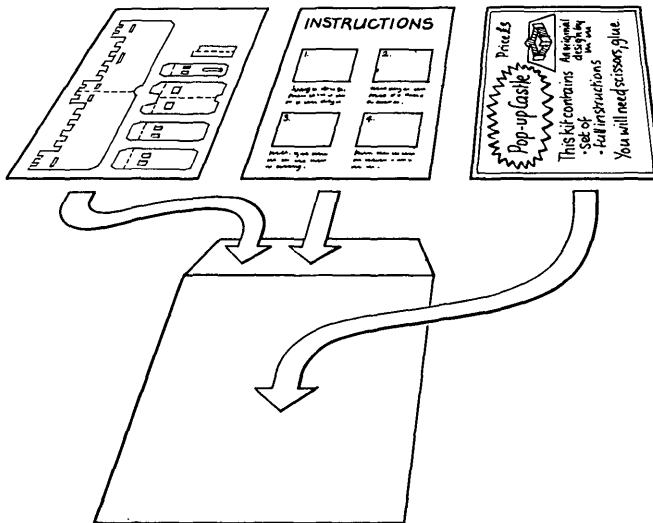
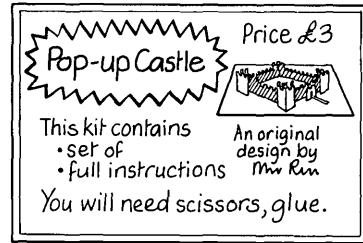
You will need large envelopes to put your kits in.

Design a master for a label to stick on your kit envelopes.

The label will need to show

- what the kit will make,
- what is in the kit,
- anything else that is needed.

Make copies of all your masters (designs, instructions, labels).



Put your kits together.

Using your kits

Think of ways in which you could *use* your final products.
Perhaps you could sell them in aid of some worthy cause . . .

