SMART MATERIALS
THERMOCHROMIC PIGMENTS
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Introduction

About the project
This project has been carefully designed by teachers for teachers. It is designed as an introduction to thermochromic pigments (heat changing colours). It is not intended as a full scheme of work although you may wish to incorporate it into one but as a small design and make task which could be completed within a couple of lessons. It would also be an ideal task for “Technology/Enterprise day” or the like or even as a project for your next CPD!

This booklet is intended as an aid to teachers in their planning and contains a wealth of information to help you along with a few worksheets and levellers you could use during your lessons.

Thermochromic mugs are a common ‘giveaway’ by companies wishing to keep the name of their business on your lips and this project helps to take away the mystery of its workings whilst introducing the technology of smart materials into a graphics project.

Suggested Design Brief if necessary
A leading manufacturer is planning to launch a new hot drink range which are fruit based and would like to have a thermochromic mug to give away in their introductory package. They insist that the mug is to be white but the logo you design will need to reflect the product and be heat changing.

Access FM
Possytronics uses Access FM to encourage the design process in their full schemes of work projects and would recommend its use here if you intend to run this as a scheme of work rather than a small design & make project.

A=aesthetics – Appearance; use of colour, lettering, images & style.
C=cost - Value for money; expensive or cheap to make?
C=client - The customer. How well does the product suit the client it is aimed at?
E=environment - Is the product environmentally friendly? Is it recyclable or refillable?
S=safety - Is the product safe to use? Are there any sharp edges or loose parts?
S=size - Is the product a good size?
F=function - Job. How well does the product do its job?
M=materials - Is the product made out of suitable materials?
Smart Materials and Smart Pigments

Smart Materials – ‘Smart materials’ and systems sense and respond to their environment and have applications in areas as diverse as health, defence and packaging. They sense and respond to the environment around them in a predictable and useful manner. For example: ‘photochromic’ materials used in reactive spectacle lenses become darker in response to increased light.

Smart pigments - Smart pigments are thermochromic materials which change colour at a specific temperature. Strip thermometers are now available for children and babies rather than the old glass, mercury filled thermometers in which each segment is set to change colour at a particular temperature. The pigments in the kit change colour at 27ºC and are suitable for designs which are trying to get across a temperature warning for example a hot drink, safe food storage temperature, a warning regarding the sun’s temperature for skin safety, etc.

Students will also be familiar with colour changing properties of mugs which change colour with a hot drink in them or kettles which change colour dependent on how close they are to the boil, etc.

This is done by the thermochromic pigment being added to inks for printing onto the ceramics of the mug or by mixing them with the plastic of the kettle so that as the temperature changes the colour of the plastic or ink changes too. A mood ring is also an excellent example of this.

Most thermochromic materials are based on liquid crystal technology. The crystals re-orientate at specific temperatures which then produce an apparent change of colour. The liquid crystals in inks and paints are very often micro-encapsulated in a suspension. The ones in the kit are made up into a liquid paste which is compatible with any acrylic media and are available in 4 colours; orange, blue, magenta, green plus black.
The pigments supplied come with a set of acrylic paints, the primary colours plus black and white. These can be added to provide an abundance of other colours but prior to using in the classroom it may be wise to do some testing for yourself and then give the students a list of colours and how to make them based on the acrylic paints you have available. Below is a table of some of the combinations possible but you will find more dependent on your resources and knowledge and understanding of colour. The primary colours of yellow, blue and red will mix all the secondary colours of green, purple and orange. The black and white will help to provide further tones of all these colours.

<table>
<thead>
<tr>
<th>PIGMENT</th>
<th>YELLOW ACRYLIC</th>
<th>BLUE ACRYLIC</th>
<th>RED ACRYLIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>COLD</td>
<td>HOT</td>
<td>COLD</td>
</tr>
<tr>
<td>ORANGE</td>
<td>orange</td>
<td>yellow</td>
<td>brown</td>
</tr>
<tr>
<td>BLUE</td>
<td>green</td>
<td>yellow</td>
<td>blue</td>
</tr>
<tr>
<td>BLACK</td>
<td>black</td>
<td>yellow</td>
<td>black</td>
</tr>
<tr>
<td>MAGENTA</td>
<td>red/orange</td>
<td>yellow</td>
<td>purple</td>
</tr>
<tr>
<td>GREEN</td>
<td>yellow/green</td>
<td>yellow</td>
<td>blue/green</td>
</tr>
</tbody>
</table>

The above table works in a similar fashion to a times table square; therefore if you choose your primary colour (i.e. Yellow, Blue or Red) and its temperature column (i.e. cold or hot); then choose your pigment colour from the left hand column (i.e. Orange, Blue, Black, Magenta, or Green); move down from the temperature column and across from the pigment row and you will discover the colour your mixed pigment/ acrylic will be when cold. i.e.

By moving over one more column, it will tell you what colour it will appear when hot, in this case yellow.

If you paint the pigment on without mixing it with an acrylic it will be its own colour when cold and dry, when hot it will almost disappear.

The rule is that mixing the colours with the pigments is like mixing any other colours and paints but that when they become warm the pigment will disappear leaving behind the colour you mixed it with.

The amount of pigment required is trial and error and the syringes are only 5ml but a little goes a long way. They are very concentrated.
They can be used just like acrylic paint now; stencilled; stippled; screen printed; pad printing or roller. Water can be added to thin the mixture down and mixing periodically helps to stop any separating. The pictures below show the above example visually (blue plus yellow equals green; when hot goes back to just yellow. Blue pigment on its own when hot will disappear.

As with all chemicals normal precautions should be taken when using. Handle in accordance with good industrial hygiene and safety practice – e.g., use in a well ventilated area and wear disposable gloves.
In order to ensure everyone does understand how to mix colours – this is a good basic exercise to get all to do.

Name ______________________

Understanding colour

Task one

Paint a colour wheel using only the 3 primary colours – Red, Blue & Yellow.
Sample designs

[Images of six sample designs: a starfish, a seahorse, a flower, a leaf, an apple, and bunches of grapes.]
This task is fine to do on paper along with the task 2. The paints work just the same on paper but it is cheaper than testing on mugs!

Name ______________________
Testing out your logo
Now paint your design into the box below as it will appear when cold.

Now paint with the smart paints in the right hand box, as you want your design to appear when hot. Remember you can mix another acrylic paint with the smart paint to obtain the colour you want but that will affect the colour when warm too!
Name ______________________

Word Creator – using the letters in the circle, create as many words as you can. You must use the centre letter in every word you create. All the letters make up one 12 letter word related to this design and make task.
Name ______________________

Evaluation

The evaluation of your design is very important and judges how successful you have been in your project.

Answer the following questions in full sentences where appropriate.

1. Did you use your time effectively during this project?

2. Are you happy with the appearance of the design? Would you make any changes?

3. Is the size of your design the most appropriate? Should it be smaller or larger?

4. How would you grade the quality of your design and making on a range of 1-4 where 1 is poor and 4 is excellent?

5. Now get 4 members of the class to grade your work in a similar way. Add all the marks together, including your own and then divide the total by 5. This gives you the average mark. What was your average mark for your project?

6. What changes would you make to your design to improve your average? Think about the comments your classmates will have made when grading your project.
Storyboard – The making process

The items you need to start: paper towel, low tack tape, acrylic paint, pigment, dry wipe pen, brush, palette, water and the mug.

Use the low tack tape around the rim of the mug and press down well. This protects the rim so it can still be used after varnishing.

Draw your design on the mug with the dry wipe pen. Alternative: use carbon paper & trace design over the top or use a china graph pencil.

Use a small amount of acrylic paint and an even smaller amount of the pigment to make the colour you want when cold. Mix well.

Further amounts of either colour can be added after a first mixing until you achieve the colour you wish.

You can see how little paint has been used to paint the starfish on the mug, the paint goes a long way. Then clean your brush with water.
Once dry, wipe the dry wipe pen off the mug, try not to rub over the paint too much or it may discolour your painting.

Fine detail can be added by use of glass relief outliner or permanent pen.

Now apply a fine coat of spray varnish, very fine! 3 thin coats are far better than 1 thick coat.

Alternative: Mask off the area around the design with low tack tape, press down well. Apply with a very soft brush glass painter’s varnish. Do not ‘work’ the varnish as it will lift the paint. Leave to dry. Peel off the tape. Note: varnishing in this way requires turps or white spirit to clean your brush.

Filling the cup with hot water helps the paint and varnish to dry quicker and the heat changing effect can be seen. If you have any ‘unneat’ edges from the varnishing, the use of petrol or white spirit on a cotton bud rubbed around the edges should neaten it up.
These pigments can also be used on textiles with the addition of an acrylic base paint and react in exactly the same way. Smart Bear is designed as an introduction to using patterns and is mainly machine sewing. He is designed to remind Mum to put the suntan cream on the little one as his painted patch on his tummy will disappear when the temperature reaches 27°. He is unique to Possytronics; as well as a beloved bear, he unfolds to become a changing mat on one side, a blanket on the other. His unique folding system allows him to be attached to the safety harness of a buggy and also to be used as a muff when the gloves have been forgotten! He comes complete with the pigments, the acrylic base, a CD with printable resources, PowerPoints for helping with certain lessons, fully typed up lesson plans and scheme of work plus a hard copy of the necessary research and the resources. Please contact Possytronics for further information and to order on 0191 519 1725 or 07961717787.

**Smart Mug Project**

<table>
<thead>
<tr>
<th>Code: SM40</th>
<th>Price £41.99</th>
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</thead>
<tbody>
<tr>
<td>Contents:</td>
<td></td>
</tr>
<tr>
<td>40 mugs</td>
<td></td>
</tr>
<tr>
<td>10 dry wipe whiteboard markers.</td>
<td></td>
</tr>
<tr>
<td>1 Masking tape</td>
<td></td>
</tr>
<tr>
<td>6 acrylic paints (brush+pencil)</td>
<td></td>
</tr>
<tr>
<td>5x5ml heat changing pigments Blue, black, magenta, green, orange.</td>
<td></td>
</tr>
<tr>
<td>400ml spray polyurethane varnish.</td>
<td></td>
</tr>
<tr>
<td>1 instruction booklet</td>
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**Acrylic Starter Set**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Contents:</td>
<td></td>
</tr>
<tr>
<td>6 Acrylic tubes</td>
<td></td>
</tr>
<tr>
<td>12ml Black, crimson red, lemon yellow, white, cerulean blue, Prussian blue</td>
<td></td>
</tr>
<tr>
<td>Pencil and Painting brush</td>
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**40 White mugs**

<table>
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<tr>
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<th>Price £12.99</th>
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<tbody>
<tr>
<td>Contents:</td>
<td></td>
</tr>
<tr>
<td>A set of 40 white mugs ready for decorating</td>
<td></td>
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**10 Black markers**

<table>
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<tr>
<th>Code: BM</th>
<th>Price £2.49</th>
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</thead>
<tbody>
<tr>
<td>Contents:</td>
<td></td>
</tr>
<tr>
<td>A set of 10 black whiteboard markers</td>
<td></td>
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**5 Pigments (heat changing)**

<table>
<thead>
<tr>
<th>Code: PIG</th>
<th>Price £15.00</th>
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</thead>
<tbody>
<tr>
<td>Contents:</td>
<td></td>
</tr>
<tr>
<td>5 x 5ml pigments blue, black, magenta, green, orange</td>
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