

Unit 9A(ii) Selecting materials

Focus: resistant materials

About the unit

The main aim of this unit is for pupils to apply their understanding of the properties of materials when designing.

In this unit, pupils tackle a design and make assignment (DMA) on the theme 'Fold it up'. They identify a need for a folding structure, selecting the materials they will use according to their characteristics, and matching them to appropriate making processes. The optimum use of materials should reconcile a number of criteria, including the working characteristics, production processes, environmental and social issues, costs and aesthetics.

Pupils gain the knowledge, skills and understanding they need to carry out the DMA successfully through product evaluation activities and focused practical tasks. They:

- understand that the properties of materials, *eg strength, durability*, influence what they select for a design
- select materials and match them to appropriate making processes
- learn how to use heat treatment and other processes to change the working properties of materials
- learn about the diversity of one product, *eg tool racks*, and the influence of lifestyle
- consider minimising environmental damage, use materials sympathetically, and find out about the importance of reuse and recycling issues
- conduct fair test procedures using qualitative and quantitative measures
- learn about the uses of modern materials, *eg composites*
- consider different structural designs to withstand greater loads
- redesign products to distribute the forces of tension, compression and shear more evenly throughout a product

Where the unit fits in

This is one of three resistant materials units that focus on understanding materials: one in year 7 on using and understanding materials; one in year 8 on exploring materials in greater depth; and this one in year 9 on critically selecting materials. These units ensure progression in understanding about materials.

This is part of a series of three units in year 9 on selecting materials; there are equivalent units, with similar learning outcomes, on food and textiles. Together these units are expected to take 10–15 hours. It is important that the department plans as a team so that pupils are able to draw on knowledge, skills and understanding from across the units to reinforce their learning and avoid unnecessary repetition.

Some of the optional activities are also suitable for later in year 9.

If you choose not to teach this unit, then plan to include the essential activities identified by the symbol ■ as part of another unit.

■ essential activities

○ optional activities

Expectations

At the end of this unit

most pupils will: understand the physical and chemical properties and the working characteristics of a range of common and modern materials; classify materials and components according to their properties and working characteristics, using a range of sources of information; take account of the characteristics and properties of materials when deciding how and when to use them; reconcile those decisions, taking account of aesthetics, time and cost; combine, process and finish materials and components to create more useful properties and particular aesthetic effects; select tools and equipment to shape and form materials safely and accurately, and to finish them appropriately; understand whether resources have been used appropriately, and the impact of resources beyond the purpose for which they were designed (including their global and environmental impact and whether they are sustainable)

some pupils will not have made so much progress and will: consider aesthetic characteristics as they design, exploring the use of materials and describing their attributes; understand how the working characteristics of materials affect the way they are used; combine and mix materials to create useful properties; measure, mark out, cut, shape and form a range of materials safely and with some accuracy; carry out appropriate tests before putting any improvements into practice; recognise that the quality of a product depends on how well it is made and how well it meets its intended purpose, *eg how well a product meets social, economic and environmental considerations*

some pupils will have progressed further and will: use a range of industrial applications when working with common materials and processes, where appropriate; cut, shape and form materials to specified tolerances; combine processes or materials to create more useful properties, and know how the ability to change materials is exploited in industry; take account of a wider range of issues, *eg product maintenance, safety, the degree of accuracy required in production*; devise tests to check the quality of their work at critical points; know how to ensure that their products are of a suitable quality for intended users, *eg how well a product meets moral, cultural and environmental considerations*, and suggest modifications that would improve their product's performance, if necessary

Prior learning

It is helpful if pupils have:

- applied their understanding of the properties of materials
- considered more complex finishing processes, including their potential environmental impact and health hazards
- used thermoforming processes
- identified methods of using the structural properties of metals when reinforcing and strengthening frames

Pupils should have gained the above knowledge, skills and understanding in year 8, through unit 8A(ii) ‘Exploring materials (resistant materials)’, or similar projects.

Language for learning

Through the activities in this unit, pupils will be able to understand, use and spell correctly words relating to:

- materials, *eg composite, component materials, laminate, layer, shape memory alloy, thermoreactive, reuse, recycle, tension, compression, shear*

Speaking and listening – through the activities pupils could:

- ask different sorts of questions to extend thinking and refine ideas, *eg Does that imply that...? Does that mean...? Would we need to...?*
- discuss and evaluate conflicting evidence to arrive at a considered viewpoint

Reading – through the activities pupils could:

- recognise the author’s standpoint and how it affects the meaning

Writing – through the activities pupils could:

- organise content into complete text with the relationships between points/paragraphs clearly signalled, *eg therefore, nevertheless*
- structure paragraphs to develop points, by using evidence/additional facts
- write closely-argued text where precise links and connections are made within sentences

Resources

Resources include:

- a case study of a new material and technology
- modern materials for practical investigations, *eg shape memory alloy, composites*
- examples of a composite and a laminate
- useful websites, *eg www.destech.mit.edu; www.materialise.com; www.tep.org.uk*

Future learning

Pupils could go on to further work in year 9 in which they apply their understanding of materials when designing and making. This unit also acts as a foundation for key stage 4. Pupils will learn that to achieve the optimum use of materials they need to take greater account of the relationship between material, form and the intended manufacturing processes.

In key stage 4, pupils will learn:

- 1e) to match materials and components with tools, equipment and processes, taking account of critical dimensions and tolerances when deciding how to manufacture the product
- 2b) to use a range of industrial applications when working with familiar materials and processes
- 4a) how materials are cut, shaped and formed to specified tolerances
- 4b) how materials can be combined and processed to create more useful properties, and how these changed materials are used in industry
- 4c) how materials are prepared for manufacture and how pre-manufactured standard components are used
- 4d) about a variety of finishing processes, and why they are important for aesthetic and functional reasons
- 4e) that to achieve the optimum use of materials and components, they need to take into account the relationships between material, form and intended manufacturing processes

(Extracts from the D&T key stage 4 programme of study)

Out-of-school activities and homework

Pupils could:

- carry out a life-cycle analysis of a product to explore the impact on the natural environment of the extraction, production and disposal of the materials used, *eg plastics*
- collect recyclable materials and develop a design idea for an interesting product that could be made from the materials
- find out what is meant by ‘composites’, ‘laminates’, and ‘smart materials’ and find examples of each
- consider how a range of products is made, used and disposed of, and identify their impact on users, other people and the environment

Links with other subjects

- Science: learning about the extraction and use of fossil fuels for the production of some modern materials links with learning about different sources of energy (unit 7I ‘Energy resources’). There are also links with unit 7K ‘Forces and their effects’ in the focused practical tasks, and with unit 9K ‘Speeding up’.
- Mathematics: when investigating the effects of loads on test structures, pupils use number and algebra, breaking down complex calculations, using alternative approaches to get results and selecting techniques for calculating forces.
- Sustainable development: considering how a product affects the environment and discussing the ethical use of materials will underpin learning in the citizenship programme of study. Pupils will be taught about the world as a global community and the economic and environmental implications of this. They will be taught to think about moral, social and cultural issues by analysing information, and to justify orally and in writing their personal opinion about such issues.

Learning objectives

Pupils should learn:

Possible teaching activities**Learning outcomes**

Pupils:

Points to note**DESIGN AND MAKE ASSIGNMENT (DMA)**

- to design and make a product in which the optimum use of materials reconciles a number of criteria, including the working characteristics, production processes, environmental and social issues, costs and aesthetics, by applying the knowledge, skills and understanding they developed during the product evaluation activities and focused practical tasks

Set the pupils a DMA in which they:

- select materials according to their characteristics and match them to appropriate making processes
- evaluate the materials chosen by using fair test procedures with qualitative and quantitative measures
- explore the uses of modern materials, and use them sympathetically

The DMA should also give the pupils an opportunity to discuss how we are all responsible for the wellbeing of others.

Example

This example DMA has been written so it can be copied and given directly to pupils. Further details and contexts can be added, as appropriate.

Fold it up

There are lots of situations in which you might use temporary structures – in the workshop, on the beach, by the river, in a tent or caravan, in the garden, or after an accident. Identify a need and then design and make a useful structure to fulfil that need. Your structure should fold up or be easy to take apart, so that it doesn't take up too much space. Think carefully about suitable materials, bearing in mind whether your structure will be used indoors or outside.

- draw up a design specification and criteria that reflect users' needs
- combine ideas from a variety of sources
- refine a single idea from a range of ideas and draw up a manufacturing specification
- match and select materials, considering their fitness for purpose and environmental impact
- specify and justify the exact types and grades of materials, and give details of processing methods in the specification
- prioritise and reconcile decisions on materials, time and production
- use materials sympathetically
- evaluate their product against the original design criteria and assess how well the users' needs have been met
- write an account of the evaluation

Language for learning when writing evaluations

- Remind pupils that a written account of an evaluation could include:
 - an introductory paragraph that explains the assignment and the design issues
 - a paragraph for each design criterion
 - evidence of evaluation
 - a summary of success
 - a concluding paragraph that includes an overall evaluation, suggestions for future improvement, and a comment on what they have learnt during the DMA

Pupils should learn:

Pupils:

PRODUCT EVALUATION

Organise a range of activities that give pupils an opportunity to:

- learn about the diversity of a product
- consider possible recycling and disposal of the materials used
- explore the use of modern materials

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| <ul style="list-style-type: none"> ■ to explore the diversity of one product, <i>eg tool racks</i>, and the influence of lifestyle on new product development | <ul style="list-style-type: none"> ■ Ask the pupils to compare different examples of one product that are intended to meet similar needs. Ask them to identify how designing for the user and for manufacture can conflict with other design criteria, <i>eg the cost of materials</i>, and to suggest ways to minimise resulting problems. | <ul style="list-style-type: none"> ■ put together criteria and questions that they can use to evaluate products and suggest improvements ■ appreciate the conflicting demands faced by designers and product makers, and reach a practical outcome, <i>eg reconciling function and aesthetics with the cost of materials</i> |
| <ul style="list-style-type: none"> ■ the practical applications, working characteristics and uses of modern materials | <ul style="list-style-type: none"> ■ Organise some practical investigations that enable the pupils to explore the uses of modern materials, <i>eg to compare the characteristics and uses of composite materials such as glass-reinforced polyester with other materials.</i> | <ul style="list-style-type: none"> ■ describe the working characteristics of one type of modern material, <i>eg composites</i>, and suggest what it could be used for |

Language for learning when evaluating products

- Ask pupils to work in small groups to discuss a set of needs that products might be designed to meet. They could use a flip chart to list questions that users might want to ask about any product, then rephrase these into criteria. It would be helpful if the teacher gives an example of this process initially. Group presentations to the whole class will allow for further discussion and refinement of criteria.

■ essential activities

○ optional activities

Learning objectives

Pupils should learn:

- about the uses of modern materials, *eg composites, shape memory alloy (smartwire)*

Possible teaching activities

- Ask the pupils to explore how the development of new materials and technologies has allowed designers to achieve things that were not possible before, *eg we can now make materials with the properties that we want, and in the future we are likely to see materials made to measure for a huge range of applications*. Ask the pupils
 - *What areas of research should we focus on?*
 - *What products might be made?*
 - *Who will benefit?*

Case studies could be used to illustrate the discussion, *eg*

- *car manufacturers can improve the properties of existing materials by processing, and use new materials and components that are 'smart' (responsive), to produce a car that is cheaper, lighter, saves fuel, has better performance and is 90% recyclable*
- *trains, aircraft, racing cars can be made faster, safer and lighter by using carbon-fibre reinforced composites, advanced electronic materials, intelligent guided vehicles*
- *computers can be made easier to use with flexible polymer roll-up display screens, speech recognition, and materials to improve battery life and printing*
- *medical breakthroughs include biomedical implants, intelligent wound dressings, artificial tissues, personal health monitors*
- *houses can be improved with wall coverings that change on demand and intelligent appliances, such as a fridge that reorders food and suggests meals according to contents, a self-cleaning floor covering, smart glass to control light*

Learning outcomes

Pupils:

- know where new materials come from and what they might be used for, and express an opinion about why research on materials might be directed at particular types of products and needs

Points to note

■ essential activities

○ optional activities

Learning objectives

Pupils should learn:

- the importance of reusing and recycling when designing
- how to minimise environmental damage when selecting materials, *eg by disposing of plastics, cutting coolants*

Possible teaching activities

- Ask the pupils to consider the wider implications of choosing a particular way of meeting a need or solving a problem. They could think about whether meeting the need is worth the resources required, and whether the proposed solution has other consequences that should be taken into account, *eg environmentally damaging by-products from the manufacturing process, difficulty in the safe disposal of manufacturing by-products*. Ask the pupils to discuss as a class
 - *What happens to the product after use?*
 - *How long will it last?*
 - *What factors might limit or lengthen its lifespan?*
 - *How easily can it be recycled?*
 - *Who will pay the cost of recycling?*
 - *What materials have been used and why?*
 - *Where do the materials come from?*
 - *Are the resources likely to run out?*
 - *Is there a problem with side effects, eg waste disposal and pollution?*
- Divide the pupils into groups and give each group a product. Ask them to brainstorm the possible benefits, resources, costs and other consequences, and to come to a group view of the balance of factors. Ask them to report back as a group on their particular example.

Learning outcomes

Pupils:

- discuss a range of resource issues when designing, *eg what happens to a product after it has outgrown its usefulness?* and use materials sympathetically

Points to note**Language for learning when reviewing texts**

- Ask pupils to discuss objectivity and bias in texts, *eg the author's standpoint and its effect on meaning*. They could review information from a production company and a consumer group on a contentious issue, *eg the use of non-renewable energy sources*.

- how technological advances and the use of local and global resources change the materials available for products

- Discuss with the pupils why the materials used for products today, *eg plastic*, are different from those used when their grandparents were young. Ask the pupils to consider *Why will the materials used to make products in the future be different from those we use today?*

- describe how the materials used in one product have changed over time and predict how materials may change in the near future, *eg the materials used for tool racks*

- what is meant by 'composites' and 'laminates', common examples of these and their properties

- Discuss with the pupils what is meant by 'composites' (where different materials are used together to make a new combined material, *eg glass-reinforced polyester*). Explain that these have different properties from their constituent materials, usually combining the properties of each. Together they are often better than any of the component materials on their own. Explain to the pupils that products made of layers are called 'laminates', and ask them to find some products made from composites and laminates (they should include both resistant materials and textiles). Ask them to explain what properties the component materials provide and why they have been used.

- describe a 'composite' and a 'laminated', and give two examples of composite and laminated materials

■ essential activities

○ optional activities

Pupils should learn:

Pupils:

FOCUSED PRACTICAL TASKS (FPTs)

These practical tasks should focus on the knowledge, skills and understanding outlined in 'About the unit'. They should give pupils an opportunity to practise any new skills they will need during the DMA, *eg when considering different structural designs*.

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| <ul style="list-style-type: none"> ■ to consider different structural designs to withstand greater loads ■ to redesign products to distribute the forces of tension, compression and shear more evenly throughout the product ■ how to carry out fair test procedures using qualitative and quantitative measures and how to use appropriate vocabulary when they are testing, <i>eg durability, elasticity</i> | <ul style="list-style-type: none"> ■ Ask the pupils to compare the structures used in a range of products, <i>eg folding structures such as tents and chairs</i>, and to identify criteria for choosing different structures for different purposes. They should investigate the effects of loads on test structures of different kinds, varying the materials used, and testing samples of materials to compare their flexibility or their relative strength under load. They should also test different shaped sections of materials to compare their weight, torsional rigidity, flexional rigidity and strength under load. | <ul style="list-style-type: none"> ■ describe different structural designs to withstand loads ■ explain how products can be designed to distribute the forces of tension, compression and shear ■ carry out simple fair tests and use appropriate vocabulary, <i>eg durability, elasticity</i> |
| <ul style="list-style-type: none"> ■ that working properties can be altered by heat treatment and by combining materials ■ how to use the working characteristics of different materials and components when designing products | <ul style="list-style-type: none"> ■ Ask the pupils to experiment with different combinations of materials for different purposes, <i>eg to laminate wood with plastic to give it a hard-wearing surface</i>. | <ul style="list-style-type: none"> ■ alter the working properties of materials by combining and processing them, <i>eg laminating</i> |
| <ul style="list-style-type: none"> ■ to use their knowledge of the properties of materials, <i>eg strength and durability</i>, to influence what they select for a design ■ to test materials against a specification before going into production, <i>eg to check raw materials for flaws, faults or degradation</i> | <ul style="list-style-type: none"> ■ Discuss with the pupils how to select materials for their working properties, functional characteristics, aesthetic quality, cost, and appropriate processes. Discuss how selecting materials often involves reconciling conflicting demands, <i>eg strength versus overall weight of a product</i>. Discuss methods of testing those materials, <i>eg making a scale model or using computer software to undertake testing of materials</i>. | <ul style="list-style-type: none"> ■ consider conflicting demands when selecting materials, <i>eg to choose the material within a price range that best meets the function and aesthetic qualities required</i> |

■ essential activities

○ optional activities