

# ENERGY EFFICIENCY

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**Design and Technology scheme of work**

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**Key stage:** 4

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**Duration:** 3 weeks (approximately 7.5 hours)

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**Project overview:** Design a prototype for a more energy efficient electric kettle.

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# OVERVIEW

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## ABOUT THE SCHEMES OF WORK

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The new GCSE for Design and Technology (D&T) was introduced in 2017. It has shifted the focus of the subject towards problem solving in different contexts while remaining relevant for students. It allows D&T to simultaneously engage students' creativity and imagination, whilst grounding their learning in mathematics and physics.

Students will learn how to take risks, be resourceful, innovative and enterprising. This scheme of work has been designed to support you in delivering project-based, engaging and relevant D&T lessons that are mapped to the national curriculum. The aim is to introduce your students to design engineering and teach them the skills they need to become an engineer.

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## LEARNING OBJECTIVES

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### Objectives

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Understand how to use real design techniques to solve real problems.

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Analyse and apply iterative design processes.

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Identify and master the technical skills needed to produce design solutions.

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Produce a functioning prototype that could solve a relevant problem.

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## ABOUT THE SCHOOLS PROJECT

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# The UK faces an annual shortfall of 59,000 graduate engineers and technicians

Engineering UK, 2018

Students' closest experience of engineering in secondary education is through D&T. Too often the subject is taught through limited and irrelevant project work. This approach neither promotes student engagement in the subject, nor reflects the exciting reality of an engineering career.

The James Dyson Foundation believes that a D&T curriculum based on iterative design, problem-led and project-based learning is more relevant and engaging to students. As a result, students enjoy D&T more, their perception of engineering improves and more students choose to study D&T and pursue engineering as a career.

Between 2012 and 2018, we worked with five schools in Bath to test this hypothesis. We helped these schools to develop their D&T labs and worked closely with them to develop schemes of work that reflect our beliefs.

Thank you to the teachers and students at Writhlington School, Ralph Allen School, Wellsway School, Hayesfield School and Chew Valley School, who helped to develop the content for this scheme of work.

### As a result of our intervention:

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32% of students chose to study D&T at GCSE in 2017, against a national figure of 18%.

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Over the course of the project, student uptake of D&T at GCSE increased by 37%, whilst the national uptake has decreased by more than a half.

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7% of students across all the schools opted to study D&T at A Level in 2017, against a national figure of 1.7%.

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Over the course of the project, there was a 156% increase in the number of students who would like to pursue a career in engineering.

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Between 2012 and 2018, there was a 300% increase in the number of girls who would like to be an engineer.

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# TEACHER RESOURCES

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## TEACHER'S NOTES

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### Context

We are challenging students to solve one of the pressing environmental needs of today. To improve the energy efficiency of home appliances. Although the energy used each time an electric kettle is boiled may seem small, the cumulative effect is large. 97% of UK homes have a kettle, and they are often used at similar times of day, in the morning before breakfast. This produces peaks in energy demand.

The task for students is to think and act like design engineers, and to come up with novel solutions when the most obvious ideas don't work. Although potentially complex, this project is on a human scale and within the experience of most students.

### Autonomy

Please note that this project is designed to have open-ended outcomes. It does not set out to define products or systems which might make good designs. Rather, it puts emphasis on the students identifying and developing good designs.

The variety of possible solutions enables students to retain a degree of autonomy over their design and decision-making. This may mean that some students create prototypes that do not achieve great functionality. It is important to recognise this as a normal and useful function of the design process.

### Scenarios

The project includes one given scenario within the scope of the EU Ecodesign Directive 2009. The directive aims to reduce the energy consumption of household appliances, and one of its key methods has been to set caps on the power inputs of domestic appliances.

The scenario assumes that the directive imposes an upper limit on the power input of electric kettles. Students examine the effects of this restriction in terms of energy reduction. Kettle elements are more or less 100% efficient, so reducing the power simply extends the time. This scenario should prompt the design challenge: 'what should we try next?'

### Learning management

This is an open-ended design project. Students are encouraged to think in new ways about new solutions, so the design outcomes will vary. It can be a classroom management challenge in the sense that there are many possible design improvements that can be made, and each will have its own skill and resource needs. However, the learning and teaching activities for week 2 list the most likely design investigations that students will follow.

Without constraining students' imaginations, it is usually worth testing the external surfaces of a kettle as it boils to consider the conductivity of various materials, and to observe the speed of reaction of a traditional thermostat. These and other simple observations, such as the amount of steam that escapes during operation, can be useful design pointers for students.

Using electric kettles involves risk. Teachers are strongly advised to pay particular attention to risk assessment in accordance with their school policies and to take advice where necessary.

### Design iteration

While students should aim to create a high-quality final prototype, our goal is for them to practice a non-linear and iterative design process. This ensures that students make improved versions of their designs within the project's time allocation, and allows them to demonstrate skills in analysis, judgement and synthesis, while simultaneously developing their technical skills. Students should understand that they need to master technical skills in order to realise good design solutions. The outcomes of students' work may be products or systems, but they will be prototypes and not finished products.

## TEACHER'S NOTES CONTINUED

### Mapping

For convenience, this project has been mapped to the OCR J310 GCSE Design and Technology specification. Please note that this mapping is indicative only. You and your students will use a range of techniques and materials according to the needs of their design ideas, and some content may be covered in more depth than others. You can use your professional judgement as to what masterclasses and other teaching is needed to ensure students can demonstrate their design and technical skills.

### JDF project backbone

This scheme of work has been created in line with the format that is applied to all James Dyson Foundation project work. This format is outlined below.

#### Phase one: Conception

Introduction to the contextual area and identification of problems, issues and user needs

#### Phase two: Development

Research into evidence and sources  
Analysis of risks, scale, impact and affected people  
Compilation of the design brief, project plan and evaluation criteria  
Compilation of individual sketches and drawings

#### Phase three: Realisation

Early prototyping of possible solutions  
Evaluation and iteration  
Taught masterclasses to achieve technical skills  
Completion of iterated and developed prototypes

#### Phase four: Explanation

Presented explanation of the prototype and design process  
Portfolio



## TOP TIPS FROM TEACHERS

Our resources have been created with the help of our champion teachers in our five Bath schools. Below are some of their hints and tips for running a James Dyson Foundation project.

Shift the focus to the design process, as opposed to assessment and producing a finished product.

If possible, arrange for students to present their work to an external visitor. This allows the students to take ownership over their project.

Teach technical knowledge through practical activities – this way students are more likely to retain this knowledge.

Remember these key words when planning lessons: Risk, failure, autonomy, iteration and prototyping

Teach failure as a technical term, not a criticism or opinion.

Create a habit of constantly documenting students' work.

Test, test, test – fail, fail, fail.

Avoid linear processes.  
Avoid fixation.

Be brave!

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# SCHEME OF WORK

## OVERVIEW

### Project overview

This project is aimed at Key Stage 4 students. It encourages students to combine what they learn in technology, science and maths and apply it to a real problem. It is also suitable for students doing Design and Technology or Science in Year 12.

The project explores the contextual theme of securing the future. Energy efficiency and sustainability are urgent national and global issues. 97% of homes have an electric kettle, so the issue is within the experience of virtually all students, and they are likely to have high awareness of the environmental risks and effects of energy use in the developed world.

The EU Ecodesign Directive of 2009 has led to the reduction in power consumption of some household appliances. Further plans are being considered to cap the energy input of electric kettles. At one time, it was suggested that the cap might be similar to that on vacuum cleaners – 1600 watts. Many of the kettles around at the moment consume up to 3000 watts.

The energy used by electric kettles is a particular issue for the UK. The nation drinks a staggering 165 million cups of tea and a further 70 million cups of coffee each year. Electric kettles use up 4489 gigawatt hours of energy nationally. This represents 34% of all the energy used in cooking.

The problem is that, electric kettles are already very efficient. They work by placing a resistance across positive and negative wires at mains voltage. The heat generated goes directly into the water. If the energy input is reduced, the kettle simply takes longer to boil. Testing this concept provides a valuable lesson for students: that a great deal of design effort initially results in little or no progress. The project works best if students experiment with the effects of reducing power input and draw these conclusions first, before being challenged to go further and come up with some really inventive and innovative designs to improve efficiency in new ways.

### Curriculum mapping

This project has been mapped to the OCR J310 GCSE Design and Technology specification.

#### The specification identifies eight topic areas:

Identifying requirements

Learning from existing products and practice

Implications of wider issues

Design thinking and communication

Material considerations

Technical understanding

Manufacturing processes and techniques

Viability of design solutions

The scheme of work uses numbering that corresponds to the specification (e.g. 1.1, 1.2) to highlight which design and technical principles are being covered.

The iterative element of this scheme of work corresponds to the 'Iterative Design Challenge' marking criteria in the specification, covering strands 1 to 5.

## OVERVIEW CONTINUED

Success criteria		
All	Most	Some
Explore context around energy issues and home appliances, and identify some problems and opportunities for further work.	Explore context and offer some detailed points and a breadth of problems and opportunities for further enquiry.	Evaluate how different people experience problems and frustrations in their living and working spaces and how this affects a design.
Investigate and analyse existing products and identify some relevant features.	Investigate and analyse existing products and identify the most relevant features and attributes in relation to their own designs.	Investigate and analyse all the key attributes and features of existing products and show how they could influence their designs.
Act as part of a team.	Make an effective contribution to a team and understand the needs of other team members.	Understand roles and strengths in working as a team. Make a key contribution to achieving outcomes in a given time frame, taking into account the needs of all team members.
Identify a range of materials used in the construction of electric kettles.	Identify and describe the properties of materials used in electric kettles and show the main effects they have on energy performance.	Understand and describe a full range of properties of materials used in electric kettles, describe all the main effects they have on energy performance, and suggest alternatives.
Provide some evidence of how design ideas show innovation throughout the design process.	Understand how ideas can improve through iteration and show clear evidence of innovation throughout the design process.	Use consistent design iteration to show clear and comprehensive progression from earlier developments and all of the identified opportunities.
Evaluate a series of design ideas using a set of evaluation questions.	Evaluate a series of design ideas using a range of evaluative tests and reach conclusions for further development.	Use a range of appropriate evaluative techniques to provide evidence and priorities for further development.
Use taught technical skills required to carry out project tasks, but not always appropriately to the materials or systems being used.	Select and apply the technical skills required to complete the project. Demonstrate an awareness of when additional skills are required. Techniques are usually appropriate to the materials and systems being used.	Explain how technical skills have been used to enhance functions and outcomes. Skills are used effectively, consistently and appropriately for the materials and systems being used.
Produce a final prototype that is generally functional.	Produce a final prototype that is made with enough precision to demonstrate key functional aspects.	Produce a final prototype that is made with accuracy and precision. Functions are appropriately demonstrated and show the use of a range of appropriate techniques.
Make a contribution to a presentation.	Make a relevant contribution to a presentation that effectively explains the project process and outcomes.	Make a relevant contribution to a presentation that effectively explains, analyses and justifies the project process and outcomes.

## WEEK 1: CONCEPTION

### Overview

Students engage with the concept of how individual activities can have large-scale effects. They experiment with energy use, examine ways it might be constrained, and carry out a range of tests to measure and analyse outcomes.

### Resources

Domestic electric kettle rated 3Kw

Domestic electric travel kettle rated 1Kw

[Electric kettle test methodology \(page 26\)](#)

[Risk assessment \(page 26\)](#)

### Useful references

Tea-time Britain video:

[www.bbc.co.uk/britainfromabove](http://www.bbc.co.uk/britainfromabove)

Ecodesign Directive 2009 summary:

[ec.europa.eu/growth/industry/sustainability](http://ec.europa.eu/growth/industry/sustainability)

D.M. Murray, J. Liao, L. Stankovic, V. Stankovic, 'Understanding usage patterns of electric kettle and energy saving potential,' in Applied Energy, Volume 171, 1 June 2016, Pages 231-242:

[sciencedirect.com/science](http://sciencedirect.com/science)

### Planning

Learning objectives	Teaching and learning activities
<p>Demonstrate awareness of national energy supply issues. Categorise energy use.</p>	<p>Students watch <b>Tea-time Britain video</b>, including the 'EastEnders' effect of 1.75 million kettles switching on.</p> <p>Students/teacher discuss video and the sensitivity of energy supplies to sudden demand.</p> <p>Students individually research the annual energy consumption of electric kettles in UK (4489 gigawatt hours – 34% of total cooking energy used in the home).</p> <p>Students also investigate UK tea/coffee consumption.</p>
<p>Understand supranational energy conservation initiatives. Understand the relationship between large-scale environmental issues and family-scale actions.</p>	<p>Introduce the project challenge: <b>To design and create a more energy-efficient electric kettle.</b></p> <p>Students consider the urgency of improving energy efficiency in the home. They review the relevant EU Directive for improving the environmental performance of appliances:</p> <p><b>Ecodesign Directive 2009.</b></p> <p>This directive sets targets to achieve by 2020. Consideration has been given to capping the maximum input power of many appliances, including kettles.</p> <p>Students examine a scenario where the maximum input power of electric kettles must be capped at 1.0 kilowatt.</p> <p>Their first task is to experiment with the proposition that power is to be cut from today's typical 3 kilowatts to the new level of 1 kilowatt.</p>

# WEEK 1: CONCEPTION CONTINUED

<p>Experiment with and investigate causes and effects of using different power inputs.</p> <p>Appraise results of tests and draw conclusions.</p>	<p>This can be tested in two ways: through practical work, or by mathematical modelling. It is recommended that students try both the practical test method and the mathematical test method.</p> <p><b>Note:</b> Refer to <b>Electric kettle test methodology</b> (page 26) and <b>Risk assessment</b> (page 26)</p> <p>Students compare their results. Using both test methods, the results should be the same: The 1Kw kettle will take three times as long to boil as the 3Kw kettle.</p> <p>Students reflect on the design implications – that a reduction in power input produces no efficiency gains.</p>
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## Curriculum mapping

Design skills	Technical skills	Assessment of iteration
<p><b>1.1. Explore a context:</b></p> <ul style="list-style-type: none"> <li>a. Considerations for exploring a context should include:                             <ul style="list-style-type: none"> <li>i. Where and how a product is used.</li> <li>ii. Identifying user and wider stakeholder requirements.</li> </ul> </li> </ul> <p><b>2.1. Opportunities and constraints:</b></p> <ul style="list-style-type: none"> <li>a. Initial critique of existing designs, systems and products.</li> <li>vi. Impact on the environment.</li> </ul> <p><b>3.3. Influences on the processes of designing and making:</b></p> <ul style="list-style-type: none"> <li>a. Environmental, social and economic influences.</li> <li>vi. Impact on the environment.</li> </ul> <p><b>4.1. Communication of design solutions:</b></p> <ul style="list-style-type: none"> <li>a. Use of graphic techniques including: mathematical modelling</li> <li>– Domestic electric kettle rated 3Kw</li> </ul>	<p><b>1.1. Sources of energy and power:</b></p> <ul style="list-style-type: none"> <li>a. How energy is stored and transferred.</li> </ul>	<p><b>Strand 1:</b></p> <p>Investigations of the context.</p>

## WEEK 2: DEVELOPMENT

### Overview

Students sort into groups and consider what to do when a design development fails to produce positive outcomes. They consider looking at a problem in new ways and then conduct systematic analysis to categorise key features that may influence their new designs. They evaluate what they discover and use this to decide on a range of possible design iterations.

### Resources

Scrap electric kettles (sourced from recycling centres, small electrical retailers, parents/carers)

### Useful references

How stuff works – your kettle:

<https://www.originenergy.com.au/blog/lifestyle/how-stuff-works-your-kettle.html>

### Planning

Learning objectives	Teaching and learning activities
<p>Understand how design can be stimulated by lack of initial success. Propose ideas, persuade others of their merits and use discussion as a positive design tool.</p>	<p>Students divided into groups of 3–4. Groups consider the nature of design in the light of the ‘failure’ of the preceding design exercise to produce an efficient solution.</p> <p>Each group has 30 minutes to suggest three ways to improve efficiency which do not involve reducing input wattage. Students should be encouraged to think as laterally as possible, drawing on ideas from outside the immediate context of home appliances.</p> <p>Groups share their ideas in a 15-minute feedback session.</p> <p>The seminar session lays the groundwork for generating new thinking.</p>
<p>Systematically analyse key features of existing designs and learn how to question existing technologies.</p>	<p>To provide a context for their ideas, student groups should be given a collection of redundant or scrap electric kettles to conduct a simple product analysis session.</p> <p><b>They need to consider:</b></p> <ul style="list-style-type: none"> <li>– Function</li> <li>– Shape and form</li> <li>– Materials and components</li> <li>– User needs</li> <li>– Unique features</li> </ul> <p>Students make notes of their analysis in relation to energy efficiency.</p>

## WEEK 2: DEVELOPMENT CONTINUED

<p>Use tests and observations to make judgements and design decisions.</p>	<p>Groups use their product analysis to revise and refine their original three ideas.</p> <p>They need to prioritise the key features of an electric kettle that affect efficiency and decide on at least one feature that they will work to improve.</p> <p>Each group will produce notes and design sketches to illustrate their proposed innovations.</p> <p><b>Note:</b> Although students should be free to produce their own ideas, teachers can anticipate that the following features may be relevant and plan accordingly:</p> <ul style="list-style-type: none"> <li>– Insulation</li> <li>– Materials used</li> <li>– Latent heat of turning water into steam</li> <li>– Steam produced and vented off</li> <li>– Radiation from surfaces</li> <li>– Effectiveness of bimetallic thermostat</li> <li>– Noise</li> <li>– Volume of water heated</li> <li>– Timing of use ('EastEnders' effect)</li> </ul>
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### Curriculum mapping

Design skills	Technical skills	Assessment of iteration
<p><b>2.1. Opportunities and constraints:</b></p> <p>a. Initial critique of existing designs, systems and products.</p> <p><b>3.3. Influences on the processes of designing and making:</b></p> <p>a. Environmental, social and economic influences.</p> <p>iv. Global sustainable development.</p> <p><b>4.1. Communication of design solutions:</b></p> <p>a. Use of graphic techniques including:</p> <ul style="list-style-type: none"> <li>– 2D/3D sketching.</li> <li>– Sketch modelling.</li> <li>– Exploded drawings</li> </ul> <p><b>4.2. Information and thinking when problem solving:</b></p> <p>a. Awareness of different design approaches including:</p> <p>ii. Systems thinking.</p>	<p><b>5.1. Categories of design materials.</b></p> <p><b>5.2. Select appropriate materials:</b></p> <p>a. Characteristic properties of materials.</p>	<p><b>Strand 1:</b></p> <p>Investigations of existing products and design practices.</p> <p>Exploration of materials and possible technical requirements.</p> <p><b>Strand 2:</b></p> <p>Generation of initial ideas.</p> <p>Design developments.</p> <p>Critical thinking.</p> <p><b>Strand 5:</b></p> <p>Ongoing evaluation to manage design progression.</p>



## WEEK 3: REALISATION AND DEVELOPMENT

### Overview

Students use their evaluations to refine their design thinking into one improved idea to turn into a prototype. Due to the relative unknown nature of their design outcomes, students have to identify and negotiate getting any additional skills and resources they need to construct their prototypes. During the prototype making, students evaluate and iterate through at least one further cycle of improvement before presenting their final outcomes for discussion and feedback.

### Resources

3D printing/CAD facilities

Arduino/Micro:bit

DS18B20 temperature sensor

Details of Vektra 1506 ecokettle

Details of XVEQIN electronic kettle

Clarke IRT 1 Infrared thermometer

[Design engineering and iteration \(page 21\)](#)

[Top tips from Dyson engineers:  
Giving presentations \(page 23\)](#)

[Top tips from Dyson engineers:  
Providing peer feedback \(page 24\)](#)

### Planning

Learning objectives	Teaching and learning activities
Identify, quantify and agree initial and on-going resource requirements.	<p>The task for each group now is to make a prototype of their new energy efficient kettle design, using their notes, sketches and analysis.</p> <p>Each student group should have identified one design innovation they want to attempt.</p> <p>Groups must consider the resources that they will need to make their prototypes and negotiate these with teachers in good time.</p> <p>Experience has shown that students often find it useful to 3D print new kettle designs and to attempt electronic controls for their kettles.</p>
Recognise skills abilities, skills gaps and skills needs.	<p><b>Masterclasses</b></p> <p>It is assumed that students have a basic understanding of conduction, convection, radiation and electrical resistance.</p> <p>Depending on need, masterclasses in these, CAD, 3D print and Arduino/Micro:bit coding might be required.</p>

## WEEK 3: REALISATION AND DEVELOPMENT CONTINUED

<p>Review and consider design decisions.</p> <p>Understand how improved developments are informed by evaluation of previous iterations.</p> <p>Apply appropriate criteria to produce functionality (or simulations) in prototypes.</p>	<p>Students will require at least one opportunity to check, test and assess their prototypes during the realisation phase, so that they can demonstrate how design iteration has taken place.</p> <p>Refer students to <b>Design engineering and iteration</b> (page 21) to help them understand the importance of iteration to improve their designs.</p> <p>The prototype for each group should demonstrate the functions which will make their kettle more energy efficient.</p> <p>In the time available, it may not be possible for the prototypes to actually function under power, but they should clearly show how they would function in use.</p>
<p>Explain and justify the design thinking behind the prototype and how it meets the design brief.</p>	<p>Each group should present their prototype design in a plenary session, explaining the design objectives, the energy efficiency expected to be gained, and the outstanding failures and successes of their design journey.</p> <p>Refer to <b>Top tips from Dyson engineers: Giving presentations</b> (page 23) and <b>Top tips from Dyson engineers: Providing peer feedback</b> (page 24).</p>

### Curriculum mapping

Design skills	Technical skills	Assessment of iteration
<p><b>4.1. Communication of design solutions:</b></p> <p>a. Use of graphic techniques including:</p> <ul style="list-style-type: none"> <li>– Sketch modelling.</li> <li>– Exploded drawings.</li> </ul> <p><b>4.2. Information and thinking when problem solving:</b></p> <p>b. Collaboration to gain specialist knowledge.</p>	<p><b>3.1. Impact of new and emerging technologies when developing design solutions:</b></p> <p>a. Exploration of impacts on:</p> <ul style="list-style-type: none"> <li>i. Industry and enterprise, such as the circular economy.</li> <li>iii. The environment.</li> <li>iv. Sustainability.</li> </ul> <p><b>5.1. Categories of design materials.</b></p> <p>f. Awareness of developments in:</p> <ul style="list-style-type: none"> <li>i. Modern and smart materials.</li> <li>ii. Composite materials.</li> </ul> <p><b>5.2. Selecting appropriate materials:</b></p> <p>b. Physical and working properties.</p> <p>c. Factors influencing:</p> <ul style="list-style-type: none"> <li>i. Required functionality of the design solution.</li> <li>iii. Environmental considerations.</li> </ul>	<p><b>Strand 2:</b></p> <p>Development of final design solution(s).</p> <p>Critical thinking.</p> <p><b>Strand 3:</b></p> <p>Quality of design developments.</p> <p>Quality of final design solution(s).</p> <p><b>Strand 4:</b></p> <p>Quality of planning for making the final prototype(s).</p> <p>Quality of final prototype(s).</p> <p>Use of specialist techniques and processes.</p> <p>Use of specialist tools and equipment.</p> <p><b>Strand 5:</b></p> <p>Ongoing evaluation to manage design progression.</p> <p>Feasibility of the final prototype(s).</p>

## WEEK 3: REALISATION AND DEVELOPMENT CONTINUED

### Curriculum mapping

Design skills	Technical skills	Assessment of iteration
	<p><b>6.1. Structural integrity:</b></p> <ul style="list-style-type: none"> <li>a. Reinforcement to withstand stresses and forces.</li> </ul> <p><b>6.4. Electronics systems providing functionality:</b></p> <ul style="list-style-type: none"> <li>a. Response of sensors and control devices to:               <ul style="list-style-type: none"> <li>i. Sensors.</li> <li>ii. Switches.</li> </ul> </li> <li>b. Use of devices to produce outputs:               <ul style="list-style-type: none"> <li>ii. Sound.</li> </ul> </li> <li>c. Programmable components.</li> </ul> <p><b>7.1. Materials and processes to make iterative models:</b></p> <ul style="list-style-type: none"> <li>a. Early models to support iterative designing.</li> </ul> <p><b>7.3. Accuracy when making prototypes:</b></p> <ul style="list-style-type: none"> <li>a. Use of appropriate and accurate marking out methods including:               <ul style="list-style-type: none"> <li>iii. Working within tolerances.</li> </ul> </li> </ul> <p><b>7.4. Digital design tools:</b></p> <ul style="list-style-type: none"> <li>a. Use of 2D and 3D digital technology:               <ul style="list-style-type: none"> <li>– Rapid prototyping.</li> <li>– CAD/CAM.</li> </ul> </li> </ul>	

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# STUDENT WORKSHEETS

## DESIGN ENGINEERING AND ITERATION

Design engineers are problem-solvers. They research and develop ideas for new products, and think about how to improve existing products.

Everything around you has been designed, from the smart phone in your pocket to the pen in your hand. Design engineers work on lots of different products. Their day-to-day job is varied but centres around the design process. Tasks may include brainstorming, sketching, computer-aided design (CAD) or prototyping new ideas.

An important design process is iteration. This is the repetitive method of prototyping, testing, analysing and refining a product.

Consider Dyson's vacuum cleaner tools.

Dyson engineers noticed that the spinning action of the brush bar on Dyson's Carbon Fibre Turbine Head could cause hair or other long fibres to wrap around the bar, slowing it down or stopping it altogether.

Instead of ignoring this problem, Dyson engineers set out to design a solution. The design brief: Create a cleaner head that doesn't tangle hair or fibres.

Design engineers thought about the fact that rubbing hair in a circular motion creates a ball – easy to suck up and no tangles. With this theory in mind, they tested dozens of ways to simulate the circular motion. The result was two counter-rotating discs, each with sturdy bristles, enclosed in polycarbonate casing. The spinning discs ball the hair, then it is sucked straight into the vacuum cleaner bin. Hygienic – with no mess.

Iterative design processes result in better solutions and better technology.

### Repeat:

1. Explore
2. Create
3. Evaluate

Regular brush bar.  
Tangles.



Counter-rotating discs.  
No tangles.



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## MEET THE DYSON ENGINEERS

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### Laura Design Engineer at Dyson

I found engineering through a combined enjoyment of art and maths. While I loved both, I didn't want to spend my time solely doing one. Engineering is a great combination of the two, with the logic of maths but the creativity of art. I wasn't aware of engineering as a potential career option until I applied to the Arkwright Scholarship as a teenager. At this point, I realised how many different engineering specialities there were to choose from – some of them technical, but some much less so than I had originally thought. The wide range of possibilities available through engineering became clear, and I saw the potential to make a real difference to the world. Dyson gives me the opportunity to be creative, whilst still being backed up by the logic of maths and physics.



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### George Senior Design Engineer at Dyson

When I started secondary school, my Grandfather took me to Coventry Transport Museum and I saw Thrust SSC (the current holder of the World Land Speed Record and first to break the sound barrier). I was fascinated by its design and aerodynamics. I started researching engineering feats: The Shinkansen (Bullet) train, Concorde, International Space Station and more. I wanted to find out everything about them – how they work and what technologies they use. I can't think of any other profession that would give me the freedom to design and build multiple prototypes, to learn through failure and success, and to create iterative changes and see their effects first-hand. Engineers are always pushing the limits, finding new materials, technologies and methods to solve problems that are important to society. I wanted to be a part of that community, inspiring through STEM (and design!) and making a difference with my career.



## TOP TIPS FROM DYSON ENGINEERS

### Giving presentations

Laura, Design Engineer at Dyson

Being able to present your work is an incredibly valuable skill for engineers. It allows engineers to explain how their ideas have developed and how their prototype will function. This then prompts feedback from the stakeholder on the work done so far. This guide will help you to present your work successfully to your stakeholders.

Tip	Actions	Examples
Make your presentation attention-grabbing.	<p>Welcome your stakeholders with a thank you.</p> <p>State how you would like to deal with questions.</p> <p>Maintain eye contact and smile.</p>	<p>'Hello, welcome and thank you for joining us today!'</p> <p>'We would like you to ask questions at the end of the presentation.'</p>
Clearly state the purpose of your presentation.	<p>Summarise the aims of your presentation in one or two sentences.</p> <p>Your presentation must make sense to anyone who watches it.</p>	<p>'We're going to present our prototype...'</p> <p>'It solves the problem in this way...'</p>
Be concise.	<p>Follow a simple structure.</p> <p>Organise who is speaking and when.</p>	<p>'We chose this <b>design</b> because...'</p> <p>'We used these <b>techniques</b> to develop it...'</p> <p>'Our prototype <b>functions</b> in this way...'</p>
Be confident.	<p>Practice beforehand to ensure you are clear on what you want to say and can deliver it with confidence.</p> <p>Speak loudly and clearly.</p> <p>Believe in your design and prototype.</p> <p>If you are using PowerPoint, use pictures rather than words to make sure you are talking to your stakeholders, instead of reading your PowerPoint out loud.</p> <p>Keep on topic!</p> <p>Time yourself, practising your presentation to make sure you don't overrun.</p>	

## TOP TIPS FROM DYSON ENGINEERS

### Providing peer feedback

George, Senior Design Engineer

Giving and receiving feedback is incredibly valuable for engineers. Constructive criticism offers insight that the designer may not have considered and provides direction for future iterations. This guide will help you prepare your insights and suggestions so that they are well received and highly valuable to your design team.

Tip	How to...	Examples
Ask questions!	<p>Prepare as many questions as possible.</p> <p>Make sure to begin by praising the team for their efforts.</p> <p>If you are struggling, think about how you would do things differently.</p> <p>Ask what their next steps are.</p>	<p><b>Don't:</b> 'We don't think the prototype works very well.'</p> <p><b>Do:</b> 'Please could you explain to us how your prototype functions? Have you thought about another way it could function?'</p>
Put yourself in their shoes.	<p>Think about how and why they may have done things a certain way.</p>	<p><b>Don't:</b> 'You should have done it like...'</p> <p><b>Do:</b> 'Why did you choose to do...?'</p>
Prioritise your feedback.	<p>Focus on the most pressing issues first.</p> <p>Don't look to show up the designers. Instead, ask questions and offer solutions.</p>	<p><b>Don't:</b> 'What colour is the on/off button going to be in the final prototype?'</p> <p><b>Do:</b> 'The user said she can only carry up to twenty pounds at a time, so how can you make your design lighter?'</p>
Feedback should be informative and educational.	<p>Give specific examples and, when possible, context for what you like or dislike about a design and why.</p> <p>Use the word 'because'.</p>	<p><b>Don't:</b> 'I don't like this.'</p> <p><b>Do:</b> 'I don't think this will work because...'</p>
Don't focus on only the positive or the negative.	<p>Be sure your critique of the team's work is balanced and sensitive.</p>	<p><b>Don't:</b> 'This looks ugly' or 'this looks good.'</p> <p><b>Do:</b> 'I like the changes you made to the handlebars, but I think a different material might make the grip more comfortable and look better.'</p>
Provide constructive criticism.	<p>Don't use words like 'always,' 'never,' 'best,' 'worst,' etc.</p>	<p><b>Don't:</b> 'This feature will never work.'</p> <p><b>Do:</b> 'The Wi-Fi-activated alarm wouldn't work well, because it means you need to have access to Wi-Fi at home, which some people don't.'</p>



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# APPENDIX

## ELECTRIC KETTLE TEST METHODOLOGIES

### Practical test method

Use two electric kettles:

One kettle of 3Kw

One kettle of 1.0Kw

Add 0.5 litres of cold water from the same source to each kettle.

Record the time taken for each kettle to boil.

### Mathematical test method

Assume that water is being heated from 15 degrees to 100 degrees (boiling).

Increase in temperature is 85 degrees.

The latent heat of water is approx. 4.2KJ/kg

Mass of water is approx. 1kg/litre

### Formula:

$$T \text{ (seconds)} = \frac{(\text{latent heat} \times \text{mass of water} \times \text{increase in water temperature})}{\text{input power (Kw)}}$$

### Risk assessment

For the practical test method, teachers should carry out a risk assessment in accordance with their school policies. Typically, this will cover:

Electrical safety of the kettles

Heat of the kettles in use

Avoiding spills

Avoiding overflow from kettles

Avoiding slips on any spilt water

Age of participating students

Safe use of power cables