THE JAMES DYSON FOUNDATION

INDOOR NAVIGATION

Design and Technology scheme of work

Key stage: 4

Duration: 6 weeks (approximately 15 hours)

Project overview: Design a prototype that helps people navigate their way around unfamiliar buildings.

The James Dyson Foundation is a charity supported by Dyson Ltd.

dyson

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OVERVIEW

ABOUT THE SCHEMES OF WORK

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.

LEARNING OBJECTIVES

Objectives
Understand how to use real design techniques to solve real problems.
Analyse and apply iterative design processes.
Identify and master the technical skills needed to produce design solutions.
Produce a functioning prototype that could solve a relevant problem.

ABOUT THE JAMES DYSON AWARD

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:

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

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.

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

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.

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

TEACHER RESOURCES

TEACHER'S NOTES

Context

Many large buildings in use by the public have been designed and constructed to meet the needs of the departments or functions housed within them. Sometimes the needs of people, especially visitors and members of the public, are not so well catered for. Uncertainty over where to go, or even where you are, can undoubtedly cause frustration, but in locations such as hospitals or welfare settings, lack of clarity can be very stressful or even dangerous.

A system or device to tell people where they are, and where to go, could be immensely valuable. Since the widespread use of satellite navigation, direction-finding out of doors has become relatively easy. However, GPS does not work well, or at all, inside buildings and it can't identify which floor it is on.

Students are asked to think like real designer engineers and to approach the problem with some radical thinking. They are asked to devise a tool to help people get to where they need to be. The types of design solutions they come up with may range from very simple to highly complex. The project works best if students are able to experience first-hand what it is like to find their way around an unfamiliar building or facility.

Autonomy

Please note that this project is designed to have open-ended outcomes. It is important for students to feel that they can think the unthinkable and try things which may or may not work. The ideas generated may not develop into well finished artefacts, but the design journey leading to prototypes should reflect students' own evaluations and decisions. This may mean that some students create prototypes which do not achieve great functionality. It is important to recognise this as a normal and useful function of the design process.

Scenarios

The project involves one central scenario based on large buildings or complexes with public access. However, user needs may vary. Some situations may require very fast information, while others may demand that guidance information is communicated to users under physical or emotional stress. Students must show how they have met user needs in their specific situation.

Learning management

If possible, this project will involve an initial visit to a relevant building or campus. Students will form individual and personal views about the difficulty or ease of navigation. They are likely to have similarly personal views about potential ways to come up with solutions, and will benefit from being reminded that the best solutions work for the greatest possible range of people – not just themselves.

There are many possible approaches to this challenge, from handheld devices to signage and route mapping. Each presents its own skills and resource needs, which can pose a classroom management challenge for teachers. However, without constraining students' imaginations, you may anticipate the kinds of solutions students might examine. Teams may investigate the use of vision, touch, sound or vibration as methods of directing people. They may also consider position sensing using technologies such as Wi-Fi, Bluetooth, RFID etc. Whatever the methodologies used, the outcome should be a well-researched and evidenced developmental journey, supported by appropriate technical skills.

TEACHER'S NOTES CONTINUED

Design iteration

While students should aim to create a high-quality final prototype, our goal is for students 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.

Iterations will usually be justified by evaluation and may be accompanied by research. Students should understand that they need to master technical skills in order to realise good design solutions. The outcomes from students' work may be products or systems, but they will be prototypes and not finished products. Some systems, especially if students opt for electronic devices, may have many flaws in the detail, but still demonstrate a good design overall.

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. Some project work will involve a significant degree of electronics but others may use none at all. 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!

SCHEME OF WORK

OVERVIEW

Project overview

This project is designed for Key Stage 4 GCSE students, but it also covers appropriate learning for A Level students.

It is becoming more and more difficult for people to find their way around large buildings. As buildings get larger, the problem gets worse. The world's largest building is Boeing's Everett site in Seattle, where airliners are made. The building is 398,000m^2 in area and houses 30,000 employees. The circumference of the building measures 3.5km and the doors are the size of a football pitch.

Many large buildings, such as hospitals and universities, are open to the public and visitors can face a major challenge in locating their destination. For members of the public, this can be frustrating. For employees it can mean missed meetings, being late for key activities and a serious financial loss to the organisation.

The text below is a genuine explanatory guide to a real collection of buildings in the city of Bath:

"Building names are based on their location and distance vis-à-vis the library (e.g 1 East, 2 East). Odd-numbered buildings are on the same side of the parade as the library, and even-numbered buildings are on the opposite side. Buildings along the east-west axis are mostly directly accessible from the parade, which is generally considered to be "level two", but later additions, such as 7 West, 9 West, 3 West North and 8 East, follow the rule less strictly. 7 West is generally accessible only via 5 West or 9 West, and 3 West North, 9 West and 8 East have entrances at ground level at varying distances from the main parade. Buildings on the south of the campus, 1 South to 4 South, are accessible via roads and pedestrian walkways."

Guidance like this would be hard to understand even if you had plenty of time and nothing else on your mind. But many people visiting large public buildings, such as hospitals, find themselves in a hurry and under a great deal of stress.

This project challenges students to create and develop a reliable self-guidance system which is durable, easy to use and accessible for a wide range of people in different situations and with different abilities.

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
Take part in a learning visit and identify key features of finding a location with some support.	Take part in a learning visit and understand the relevant signage. Identify key features of finding a location independently.	Take part in a learning visit and understand the main issues other users might experience in finding a location.
Identify at least one possible idea to address the challenge of location-finding in the given situation.	Identify at least two ideas which are relevant to solving the challenge of location-finding and explain their characteristics.	Investigate and analyse at least two relevant original ideas and explain their potential for solving a location-finding challenge in the given situation.
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.
Carry out technical tasks to achieve a given outcome.	Identify most skills needed to carry out a technical task required to achieve a team outcome.	Identify all skills needed to carry out a technical task, negotiate how to master skills and achieve a team outcome.
Present some evidence of 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 original 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.
Understand some key new tasks and carry them out as a result of an evaluative process.	Understand all new tasks required as the result of an evaluative process. Plan revisions to own and team activities.	Understand all new tasks and planning required as the result of an evaluative process. Understand and negotiate new skills and resources as necessary to carry out the tasks.
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 and show some ways in which user needs have been met.	Make a relevant contribution to a presentation which effectively explains the project process and outcomes. Demonstrate an understanding of most key user needs and how they have been met.	Make a relevant contribution to a presentation which effectively explains, analyses and justifies the project process and outcomes. Show a full understanding of all user needs and how they have been incorporated into design and evaluation.

WEEK 1: CONCEPTION

Overview

Students visit a large building or complex to see, first-hand, the issues involved in navigating around unfamiliar places. If a visit is not possible, the news article found under Useful references can be used to examine an example of a large site.

Resources

Large building or resource with public access (with permission from site owners or managers)

Cameras

Notepads

Sticky notes

Whiteboard

Useful references

Inside the biggest building in the world:
dailytelegraph.com.au

Planning

Learning objectives	Teaching and learning activities
List and classify types and nature of issues observed in locating a destination.	Students visit a hospital, university or similar campus and are tasked with finding their way to a number of given on-site destinations. All students make notes of the issues they encounter in their journeys. Students take photos or videos (subject to rules and if appropriate).
Appraise main features of guidance in a large building.	As a class, students discuss the good and bad features of the existing direction guidance systems in the building, and any problems they encountered during their visit. Good and bad features can be written up on sticky notes and placed on the + or – side of a whiteboard. **Table contined overleaf**

WEEK 1: CONCEPTION CONTINUED

Select and explain key features of a problem and how they have been categorised as high priority.	Students are divided into research and design teams of 4–5 members. Each team identifies a minimum of two features that frustrated them most when finding their way. All teams prepare sketches and visuals and carry out a 5-minute presentation explaining their priorities to the whole class.

Curriculum mapping

Design skills	Technical skills	Assessment of iteration
1.1. Explore a context: a. Considerations for exploring a context should include: i. Where and how a product is used. ii. Identifying user and wider stakeholder requirements. iii. Understanding social, cultural, moral and economic factors. **4.2. Information and thinking when problem solving:** b. Collaboration to gain specialist knowledge.	**1.2. Usability:** a. Considerations in relation to user interaction with design solutions, including: i. User lifestyle. iv. Aesthetic considerations.	**Strand 1:** Investigate context. Investigations of user and stakeholder needs and wants, and the outlining of stakeholder requirements. **Strand 2:** Design developments.

WEEK 2: CONCEPTION AND DEVELOPMENT

Overview

Students start to look at the problems of navigation and think rapidly about ideas. They use specific techniques to help generate and assess ideas as they arise.

Student teams make systematic and defensible design decisions about their ideas.

Resources

COCD box template

Stickers

Card, paper, glue, tape

Small tools

Useful references

tuzzit.com/en/canvas/COCD_box

Planning

Learning objectives	Teaching and learning activities
Interpret ideas demonstrating innovation and original thinking. Analyse and categorise ideas using systematic techniques.	Student teams carry out rapid ideas generation to tackle each of their two identified features. Their task is to consider the feasibility of improvements to each feature. At this stage, teams should consider all ideas to have potential. They may be anything from colour coding buildings to self-driving transport pods – nothing should be considered wrong or ruled out. Teams should make sketches and very rapid models from simple materials to help them visualise their ideas in 2D and 3D.
Prioritise ideas so that effective design decisions can be made based on known criteria.	Having modelled design ideas, student teams carry out a prioritisation exercise to evaluate the feasibility of their design ideas. This can be done by: – Making a numbered list of ideas for each feature – Carrying out COCD box (or similar) matrix of ideas – Ranking ideas according to their innovation, originality, risk, user acceptability, challenge and implementation potential.

WEEK 2: CONCEPTION AND DEVELOPMENT CONTINUED

Justify choices made, referring to research and coherent information from team discussions or reference to secondary sources.	Students carry out secondary research to establish what existing technology and products might impact on their proposals. Teams select one potential design solution to take forward, based on their evaluation. Students should use notes and sketches to record the justifications for their selection. They should also record their reasons for rejecting the alternatives. **Note:** At this point, the scope of the student teams' design ideas will be known. Teachers need to assess whether all the propositions can be prototyped and realised in their school context, and negotiate with teams on the basis of what is practicable.

Curriculum mapping

Design skills	Technical skills	Assessment of iteration
2.1. Opportunities and constraints: a. Initial critique of existing designs, systems and products. **3.3. Influences on the processes of designing and making:** a. Environmental, social and economic influences. iii. Social and ethical awareness.	**1.2. Useability:** a. User interaction: i. Impact on user's lifestyle. iii. Ergonomic considerations.	**Strand 2:** Generation of initial ideas. Design developments. **Strand 3:** Quality of initial ideas. **Strand 5:** Ongoing evaluation to manage design progression.

WEEK 3: DEVELOPMENT

Overview

The teams have considered a wide range of possible ways to assist navigation around buildings. Some involve existing knowledge and skills, but some require new learning to progress. The relevance of the new skills to their projects should assist interest and learning. Armed with the necessary skills, student teams now develop project plans and begin making prototypes.

Resources

Project plan template worksheet (page 26)

Masterclasses (these may require input from other school departments or external partners)

As appropriate:

Access to coding and programmable devices

Access to CAD and 3D printing equipment

Access to low-voltage lighting and power devices, buzzers and vibrating devices

Planning

Learning objectives	Teaching and learning activities
Understand and explain design intentions. Describe and negotiate relevant ways to gain and master new skills to achieve stated design outcomes.	**Masterclasses** This is an appropriate stage to carry out skills masterclasses. They will be relevant and in context for students and can be applied to their projects immediately. Students and teachers will need to anticipate the particular skills required to develop and make prototypes of their design ideas. These will vary widely according to the proposed solutions, but may include: – CAD design and 3D printing – Use of lighting, especially LED strips – Creation and use of sound or vibration signals for users – Creation and use of mapped zones and/or colours – Handheld devices – RFID, Bluetooth, phone signal, Wi-Fi – Coding and programming.
Estimate future individual, team and task needs.	This is a team project with some potentially complex new learning to apply to practical tasks. Student teams will manage this challenge best if they produce a basic project plan to guide their work through to completion. **Table continues overleaf**

WEEK 3: DEVELOPMENT CONTINUED

	As a minimum, it should cover: – Tasks to complete – Person responsible – Resources needed – Any further skills needed – Timeline through to completion – Coding and programming (See **Project plan template** (page 26) for guidance.)
Analyse and identify key requirements for a design-and-make task.	Teams use the decision-making analysis carried out in week 2 to list the key requirements for their designs (basic design brief). Students use the key design requirements to construct first prototypes or systems. These should demonstrate the outline functions of their intended solutions. Teams can construct more than one prototype, if necessary, to show alternative functions.

Curriculum mapping

Design skills	Technical skills	Assessment of iteration
2.1. Opportunities and constraints: a. Initial critique of existing designs, systems and products. ii. Impact on usability. **4.1. Communication of design solutions:** a. Use of graphic techniques, including: – Flow charts **4.2. Information and thinking when problem solving:** a. Awareness of different design approaches, including: i. User-centred design.		**Strand 2**: Exploration of materials and possible technical requirements. **Strand 3:** Critical thinking. **Strand 5:** Use of specialist techniques and processes.

WEEK 4: DEVELOPMENT AND REALISATION

Overview

Students have some early prototypes to test. They use the collated data and information to improve and develop their designs.

Resources

Prototype user review (page 27)

Design engineering and iteration (page 28)

Survey software

Selection of Arduino, Micro:bit and RFID sensors

Soldering, breadboards and multimeters

Access to materials for signage

LED lighting

Hand tools

Mapping software

Planning

Learning objectives	Teaching and learning activities
Experiment, test and evaluate design prototypes.	Student teams carry out testing and evaluation of their first prototypes. This can be carried out in school, with other students acting as 'users'. See **Prototype user review** (page 27). If the project is being carried out in partnership with external organisations, student teams should, if possible, meet with partners to demonstrate and discuss their ideas.
Compare designs against evaluation. Carry out further innovation and synthesis of a number of existing design ideas into new and improved versions.	Student teams review their prototype products or systems in the light of feedback received from testing. They may need to adapt project plans, especially resource and skills requirements, to produce further iterated designs. Refer students to **Design engineering and iteration** (page 28) to help them understand the importance of iteration to improve their designs. Students make their revised prototypes using suitable materials and techniques. These iterated prototypes should be made with sufficient precision, either to be functional or to demonstrate functionality. Students who opt for position-fixing or direction-finding electronic systems may need additional skills as they develop their expertise. Teams may find it simpler at this stage to make prototypes which are not to scale, if this makes functions clearer to see and understand.

WEEK 4: DEVELOPMENT AND REALISATION CONTINUED

Curriculum mapping

Design skills	Technical skills	Assessment of iteration
4.1. Communication of design solutions: a. Use of graphic techniques, including: – Sketch modelling. **7.3. Accuracy when making prototypes:** a. Use of appropriate and accurate marking- out methods, including: iii. Working with tolerances.	**1.2. Usability** a. User interaction i. Impact on a user's lifestyle. ii. Ease of use and inclusibity of design solutions. **3.1. Impact of new and emerging technologies when developing design solutions:** a. Exploration of impacts on: iii. People in relation to lifestyle, culture and society.	**Strand 2**: Design developments. Development of final design solutions. **Strand 3**: Quality of design developments. **Strand 5**: Ongoing evaluation to manage design progression.

WEEK 5: REALISATION

Overview

Teams make their final prototypes to judge against their design ideas and the plans they set out for completing the task. They will experience pressure as things fail and prototypes do not always function as expected. This helps them to understand the context in which design engineers operate and how to have resilience to keep producing better solutions.

Resources

Wi-Fi module ESP8266
Compass HMC 5883L
Barometer BMP180
3D printer (use of ABS filament suggested)

Planning

Learning objectives	Teaching and learning activities
Share and explain design progress so far. Consider and adopt relevant feedback.	Students review prototyping progress against their design brief and project plan. They identify features which have failed or require revision. All student groups deliver a 5 minute update presentation to the whole class, to share successes and failures.
Rework design solutions to achieve feasibility in an environment with time and resource constraints.	Teams continue the development of their prototypes, applying revisions from their evaluation review. If teams are working on systems which identify a user's location, they need to test the relative accuracy of different systems and the range at which they can communicate. For these reasons, mobile phone and Bluetooth communication will be unlikely to meet their needs. Students will need to test their prototypes constantly so that they can measure when functionality is compromised.
Record, classify and describe designs using a variety of media.	If students have created systems, they will need to consider how they are to be housed. If design solutions involve handheld maps or devices, teams will need to consider ergonomics across a range of users. Annotated sketches and diagrams describing key features should accompany prototypes.

WEEK 5: REALISATION CONTINUED

Curriculum mapping

Design skills	Technical skills	Assessment of iteration
1.1. Explore a context: a. Considerations for exploring a context should include: i. Where and how a product is used. ii. Identifying user and wider stakeholder requirements **4.1. Communication of design solutions:** a. Use of graphic techniques, including: – 2D/3D sketching. – Sketch modelling. – Exploded drawings.	**5.1. Categories of design materials:** As used in prototypes f. Awareness of developments in: i. Modern and smart materials. ii. Composite materials. iii. Technical textiles. **5.2. Selecting appropriate materials:** a. Characteristic properties of materials, including density, hardness, durability, elasticity and, resistance, as appropriate. **6.4. Electronics systems providing functionality:** a. Response of sensors and control devices. b. Use of devices to produce outputs. c. Programmable components. **7.4. Digital design tools:** a. Use of 2D and 3D digital technology: – Rapid prototyping. – CAD/CAM.	**Strand 1:** Exploration of materials and possible technical requirements. **Strand 2:** Development of final design solution. **Strand 3:** Quality of chronological progression. Quality of design developments. Quality of final design solution. **Strand 4:** Use of specialist techniques and processes. Use of specialist tools and equipment. **Strand 5:** Ongoing evaluation to manage design progression.

WEEK 6: PRESENTATION AND EXPLANATION

Overview

Student teams are making their prototypes as functional as possible, so they can share their design solutions with an audience. They demonstrate their designs and how they are intended to work in the real contexts that they have observed. Ideally, they receive feedback on their designs from people who manage the buildings they initially visited.

Resources

Top tips from Dyson engineers: Giving presentations (page 30)

Top tips from Dyson engineers: Providing peer feedback (page 31)

Appropriate setting for presentation and demonstration of student prototypes. This may be in school or off-site, in the building or campus which is the subject of the project.

Planning

Learning objectives	Teaching and learning activities
Explain design prototypes or systems using a variety of methods. Justify decisions made and design and technical methods used. Demonstrate how needs of users have been maximised and organisational requirements have been met. Debate and make judgements on the final prototypes produced.	Teams should carry out final tests and make sure prototypes are functioning as intended. If possible, representatives of buildings or facilities that students have visited should be present to see the outcomes of their work. Sketches, models, visual records of design iterations and research data should be available. Student teams present their projects and an explanation of: – How they met the design challenge of helping people navigate unfamiliar buildings – Ideas generated by their team – Research carried out – Ideas rejected and why – Ideas taken forward and the design reasons why – Descriptions, sketches and diagrams of the design journey to the final versions – Presentations of final prototypes or systems, demonstrating how they function. If outside representatives attend the presentations, it is a great opportunity for them to provide a briefing and feedback to students about the practicality (or otherwise) of adopting their designs. Refer students to **Top tips from Dyson engineers: Giving presentations** (page 30) and **Top tips from Dyson engineer: Providing peer feedback** (page 31).

WEEK 6: PRESENTATION AND EXPLANATION CONTINUED

Curriculum mapping

Design skills	Technical skills	Assessment of iteration
4.1. Communication of design solutions: a. Use of graphic techniques, including: – 2D/3D sketching. – Sketch modelling. – Exploded drawings. **7.3. Accuracy when making prototypes:** a. Use of appropriate and accurate marking out methods, including: i. Measuring and using reference points, lines and surfaces. ii. Templates, jigs and/or patterns. iii. Working within tolerances.	**5.2. Selecting appropriate materials:** b. Physical and working properties. c. Factors influencing: i. Required functionality of the design solution. ii. Aesthetic attributes.	**Strand 3:** Quality of final design solution. **Strand 4:** Quality of final prototype. Viability of final prototype. **Strand 4:** Feasibility of final prototype. Evaluation of final prototype.

STUDENT WORKSHEETS

PROJECT PLAN TEMPLATE

Task	Person	Resources	Skill	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8
Conception: Creating ideas											
E.g. Investigate existing solutions	Design team	Computer/ internet	NA								
Development: Research and analysis											
Realisation: Prototyping and evaluation											
Presentation: Presenting and justifying											

PROTOTYPE USER REVIEW

Providing constructive feedback is an essential role of a stakeholder in the design process. It ensures the design team is incorporating your needs and opinions into their plans as they develop and test new iterations of their prototype.

Things we like most about the current design are:
We think the design is easy to use because:
We think the design will help people find their way quickly because:
Some additional things you might consider are: (Use this space to describe how the design could be improved)
Some questions we have for you:

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.

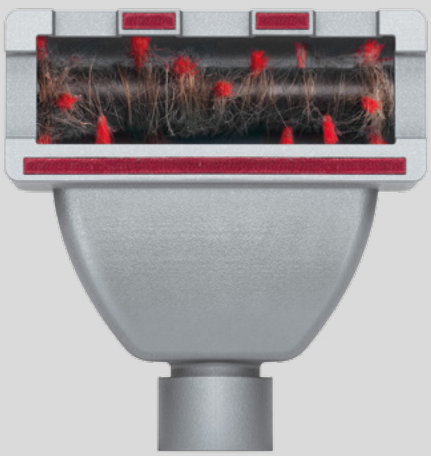
Design engineers thought about the fact that rubbing hair in a circular motion creates a ball – easy to suck up and no tangles. With this theory in mind, they tested dozens of ways to simulate the circular motion. The result was two counter-rotating discs, each with sturdy bristles, enclosed in polycarbonate 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.

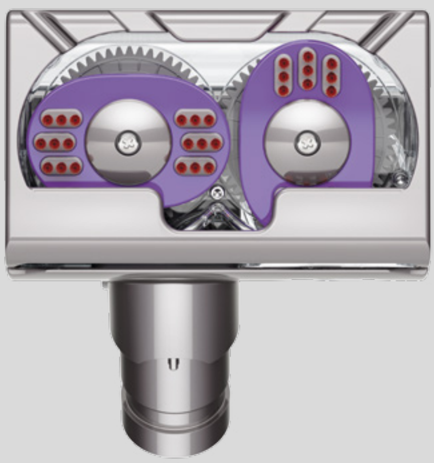
Repeat:

1. Explore
2. Create
3. Evaluate

Regular brush bar.
Tangles.



Counter-rotating discs.
No tangles.

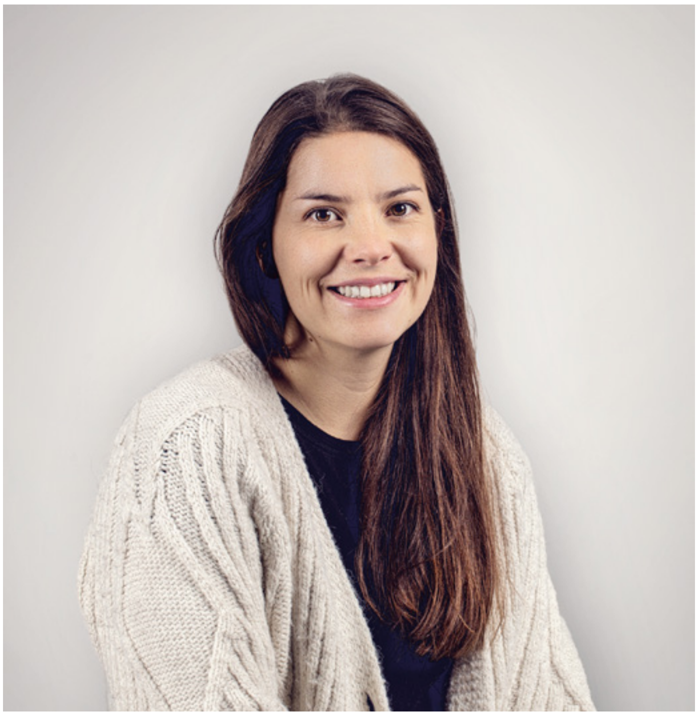


MEET THE DYSON ENGINEERS

Laura

Design Engineer at Dyson

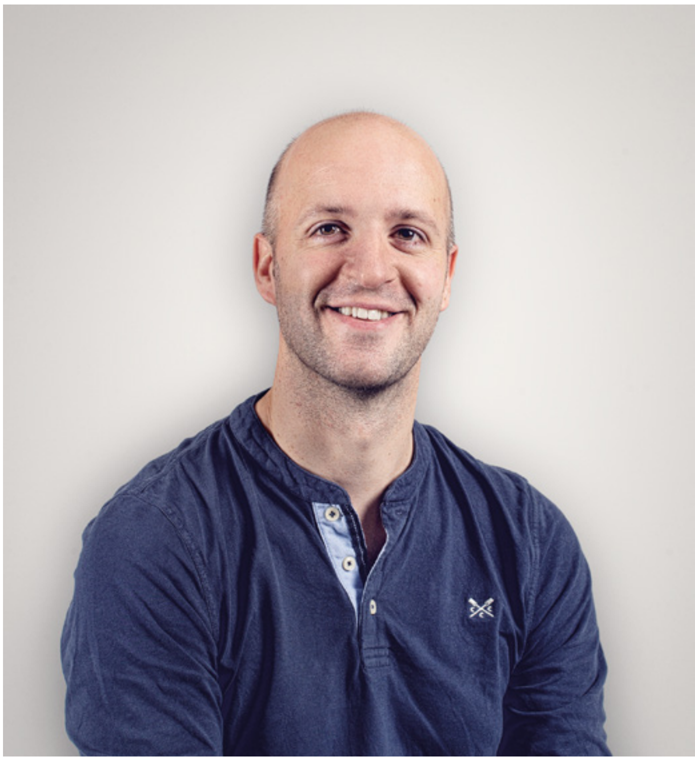
I found engineering through a combined enjoyment of art and maths. While I loved both, I didn't want to spend my time solely doing one. Engineering is a great combination of the two, with the logic of maths but the creativity of art. I wasn't aware of engineering as a potential career option until I 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.



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 Reed, 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.	Welcome your stakeholders with a thank you. State how you would like to deal with questions. Maintain eye contact and smile.	'Hello, welcome and thank you for joining us today!' 'We would like you to ask questions at the end of the presentation.'
Clearly state the purpose of your presentation.	Summarise the aims of your presentation in one or two sentences. Your presentation must make sense to anyone who watches it.	'We're going to present our prototype…' 'It solves the problem in this way…'
Be concise.	Follow a simple structure. Organise who is speaking and when.	We chose this **design** because…' 'We used these **techniques** to develop it…' 'Our prototype **functions** in this way…'
Be confident.	Practice beforehand to ensure you are clear on what you want to say and can deliver it with confidence. Speak loudly and clearly. Believe in your design and prototype. 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. Keep on topic! Time yourself, practising your presentation to make sure you don't overrun.	

TOP TIPS FROM DYSON ENGINEERS

Providing peer feedback

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