THE JAMES DYSON FOUNDATION

CITIES IN THE OCEAN

Design and Technology scheme of work

Key stage: 3

Duration: 6 weeks (approximately 12 hours)

Project overview: Design a prototype for a space that people or communities could live in, either on or under the ocean.

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

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OVERVIEW

ABOUT THE SCHEMES OF WORK

This scheme of work has been designed to support you in delivering project-based, engaging and relevant Design and Technology (D&T) lessons that are mapped to the Key Stage 3 (KS3) national curriculum progression framework. KS3 is a key point in students' D&T learning, as it's at this stage that they need to make a choice about whether to continue studying D&T at Key Stage 4 (KS4). Offering students high-profile projects at these times can inspire them to want to continue learning about technology and engineering.

Through this resource, students will learn how to take risks, be resourceful, be innovative and be enterprising. They will also learn about design engineering and begin to develop the skills needed 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 SCHOOLS PROJECT

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

The project requires students to think about global population growth and examine its effects. It goes on to challenge them to think radically as designers and engineers to see if it would ever be possible for people to live long-term in communities on, or under, the oceans. The context is broad, but it is likely that some aspects of the challenge will already be within the experience of most students. Problems such as traffic congestion, pollution, energy supply and extreme weather events will have been observed by most students, and they should be aware of wider global phenomena such as rising temperatures and sea levels.

Autonomy

Please note that this project is designed to have open-ended outcomes. The variety of possible solutions enables students to retain a degree of autonomy over their design and making decisions. In the absence of easy and predictable solutions, original and radical ideas will be worth investigating.

In the initial stages of the project, ideas may not work or design developments may go nowhere. This should be seen as acceptable and good design practice. Students may use design techniques to combine or synthesise early ideas, through iteration, into new possibilities. Even at the iterated prototype stage, some of the designs may fail and prove unfeasible. It is important to recognise this as a normal function of the design process.

Scenarios

The overall scenario deals with alternatives to present ways of living. You may wish to focus on one or more discrete elements of the design challenge. Population growth and overcrowding, rising sea levels, global warming, extreme weather and the exploitation of the seas as an energy resource can all be used as separate focal points if necessary, but students will get the broadest understanding if their starting point is the total global challenge.

Learning management

As this project focuses on such a broad theme, with a need to engage with the dynamic nature of population, climate and other significant global trends, it is suggested that the project is managed as a whole-class, collegiate investigation. However, you may want to arrange students into teams to produce solutions for specific issues or parts of the design as it develops.

You will need to anticipate a range of skills requirements, which may include an understanding of how to make different or complex structures. You can also expect that students will need support in bringing together a range of physical parts or systems to make a coherent set of prototypes under the pressure of deadlines.

The issues covered in the project would make a great basis for collaborative work with other school subjects such as English, Maths, Science, Art and Humanities.

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 they 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. Iterations will usually be justified by evaluation and may be accompanied by research.

Mapping

This project has been mapped to the KS3 D&T Progression Framework and to the D&T Programme of Study for KS3 (PoS 2014). Please note that this mapping is indicative only and acts as a guideline for teachers. 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.

TEACHER'S NOTES CONTINUED

JDF project backbone

This scheme of work has been created in line with 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 aimed at year 8 and year 9 students and explores the contextual theme of protecting communities. It is based on the known and projected increases in the global population, the prospect of rising sea levels and extreme climate changes. It requires students to think about some of the key factors affecting life on Earth and encourages them to look for design solutions to issues that might seem, at first sight, too big to take on.

The population of planet Earth is growing. In the year 2000 there were 6 billion people in the world. Now there are 7.6 billion people – and in 2050 that figure is estimated to go up to 9.6 billion. Our world is getting more crowded.

Almost 71% of the globe is covered by sea. Only about 29% of it is land. And that 29% land is where just about everyone lives at present.

The project challenges students to explore ways that we might use that extra 71% of the globe and see if it would be possible for communities to live on or under the sea.

There are no absolutely right or wrong outcomes to this project. The aim is bold and original design thinking which is clearly articulated and evaluated. Student ideas should be as broad as their imagination and inventiveness allow. As the project progresses, students will apply design analysis and evaluation to test the engineering feasibility of their ideas.

Depending on the age and maturity of students, scenarios can look at solutions which operate purely underwater, on the ocean surface, or incorporate both.

Curriculum mapping

This project is mapped to KS3 Design and Technology national curriculum/Programme of Study (PoS) 2014.

The Programme of Study identifies seven key areas:

- Design – understand contexts
- Design – generate, develop, model and communicate ideas
- Make – planning
- Make – practical skills and techniques
- Evaluate – own ideas
- Evaluate – existing products
- Technical knowledge – making things work

OVERVIEW CONTINUED

Success criteria		
All	**Most**	**Some**
Recognise key trends in global population developments from given sources.	Understand key trends and extrapolations of global population growth and identify some associated pressures and challenges.	Demonstrate a wide-ranging understanding of global population growth and the main impacts on human and wider environmental issues.
Define at least two requirements to sustain life on or under the oceans and explain with assistance how these might be met.	Identify independently most of the key requirements to sustain life on or under the oceans. Explain a range of creative techniques to achieve solutions to these requirements.	Categorise a full range of requirements to sustain meaningful life on or under the oceans and invent design solutions with novel and unexpected features.
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 and 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 and evaluate most skills needed to carry out a technical task required to achieve a team outcome.	Identify, evaluate and prioritise all skills needed to carry out a technical task, negotiate how to master skills and achieve a team outcome.
Present 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 combine, synthesise and extend ideas into new concepts. Demonstrate creative originality which is sustained into the final prototype.
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.
Learn and apply a range of new skills relevant to the design challenge.	Understand and apply most of the relevant new skills required to make a prototype solution to the design challenge.	Understand and negotiate new skills and resources as necessary to make a prototype design solution which is fit for purpose in terms of structure and materials.
Produce a final prototype that is generally functional or demonstrates the main intended functions.	Produce a final prototype that is made with enough structural precision to demonstrate key functional aspects and comprises generally appropriate materials.	Produce a final prototype that is made with accuracy and precision. Functions are appropriately demonstrated and show the use of a range of appropriate structural techniques and materials.
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 of the key user needs and some societal/environmental 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, societal and environmental needs and how they have been incorporated into design and evaluation.

WEEK 1: CONCEPTION

Overview

Students examine current and future population trends and examine a range of effects.

Resources

Population factsheet (page 25)

Examples of high population density (page 26)

Useful references

Human population growth and climate change:
biologicaldiversity.org/programs/population_and_sustainability/climate/

Population and climate change:
populationmatters.org/the-facts/climate-change

Planning

Learning objectives	Teaching and learning activities
Identify key features from given sources.	Students research population information themselves or refer to **Population factsheet** (page 25). The whole group discusses the subject of global population growth and its impact. Students refer to **Examples of high population density** (page 26) for images of Manhattan, Rio de Janeiro and Gibraltar to use as stimulus material.
Classify, rank and categorise recognised features according to set criteria.	The group compiles an agreed list of the potential effects of global population increase on: – The environment – People The working list should be categorised into a hierarchy, ranking the severity of each of the effects.
Research and carry out basic analysis of evidence from secondary sources.	Students carry out individual secondary research into the effects of population growth on climate, sustainability, global warming and rising sea levels. If suggested sources are needed, students can be referred to the video resources on population growth and climate change (see useful references).

WEEK 1: CONCEPTION CONTINUED

Curriculum mapping

Design skills	Technical skills
DA4 Develop design specifications that include a wider range of requirements such as environmental, aesthetic, cost, maintenance, quality and safety. **DA5** Research the health and wellbeing, cultural, religious and socio-economic contexts of their intended users. **DA8** Consider the influence of a range of lifestyle factors and consumer choices when designing products.	

WEEK 2: CONCEPTION

Overview

Student focus groups carry out research to gain a deeper understanding of population and pressures on land area. They start to generate ideas and use design techniques to add breadth to their thinking.

Resources

Population factsheet (page 25)

Card, glue, tape, string, Velcro

Useful references

Biomimicry project ideas:
asknature.org/collections/biomimicry-project-ideas

Sharing biomimicry with young people:
mailchi.mp/biomimicry/sharing-biomimicry

Planning

Learning objectives	Teaching and learning activities
Share and review research.	Students are divided into six focus groups of approximately four students. They share their individual research and personal responses with the group.
Carry out analysis of findings to argue and assess the scale of a potential problem.	Each focus group gives a 5-minute presentation of their key findings. The purpose is to agree whether or not there is a problem to be addressed and to identify the essential features of the problem.
Investigate how ideas can relate to specific problems.	Students are again referred to **Population factsheet** (page 25). They consider the specific possibilities of extending living beyond existing land areas. The whole group is now set the design challenge: **To produce design proposals for living on or under the world's oceans.** The group is specifically tasked with demonstrating how their designs can eliminate or alleviate any or all of the global problems they have identified.
Create new ideas and combinations of ideas by synthesising and extending existing thinking.	Students imagine and note down as many early and creative ideas as they can. At this stage, feasibility and practicability should not be constraints – the objective is to think in fresh and original ways. There are no wrong answers. **Note:** To help the creative process for all students and to provide a methodology for more inhibited students, some ideas-generation techniques can be used at this point. For example, students may carry out a biomimicry exercise as detailed under useful references. Biomimicry works well for this creative project, but other techniques such as use of analogy can also be successful.

WEEK 2: CONCEPTION CONTINUED

Convert ideas into new design forms.	Students use basic materials to make very rapid indicative 3D prototypes to visualise their ideas. The process of making will also help students better understand their design thinking. This exercise is normally carried out as individuals, but if there are very similar ideas from more than one student, pairs or groups can work together.

Curriculum mapping

Design skills	Technical skills
DA6 Understand how to reformulate design problems. **DA9** Take creative risks when making design decisions. **DA11** Analyse where human values may conflict and compromise has to be achieved. **DB6** Combine ideas from a variety of sources. **DB7** Use a variety of approaches, for example biomimicry and user-centred design, to generate creative ideas and avoid stereotypical responses. **DB10** Produce 3D models to develop and communicate ideas. **EB2** The positive and negative impact that products can have in the wider world	

WEEK 3: DEVELOPMENT

Overview

Students work in a variety of forums to find the best ways to produce design solutions. They use objective design and project tools and identify their additional skills needs.

Resources

Project plan template (page 27)

Masterclasses

Useful references

Ocean living: A step closer to reality?
bbc.com/future/story/20131101-living-on-the-ocean

Planning

Learning objectives	Teaching and learning activities
Compare and evaluate design ideas. Consider ideas according to agreed criteria and decide which ones to progress.	Students read the **Ocean living: A step closer to reality?** webpage. The whole group now has to act together in a collegiate way to evaluate the first design ideas and decide which ones to take forward for further development. An assessment matrix should be used to make the evaluations. It should assess, as a minimum: – The seriousness of the problem – The impact of the solution (e.g. how many people are benefitting) – The feasibility of producing an in-dicative prototype in the time available All students should complete an evaluation matrix. These should be aggregated and the top six (or so) design ideas put forward for further development.
Use a range of planning and implementation tools to outline a systematic method of carrying out design challenges.	Students can re-form their original focus groups or form new groups. Each group should be tasked with producing one of the design ideas as a functional prototype for testing and demonstrating. Each group will complete the following outline documents to guide their design process: 1. Design specification indicating, as a minimum: – Needs of users – must have – Needs of users – would be good to have – Key functions of the design – Social and ethical issues **Table continues overleaf**

WEEK 3: DEVELOPMENT CONTINUED

	2. Outline project plan see **Project plan template** (page 27) Indicating, as a minimum: – Tasks to do – Person responsible – Resources required – Skills or knowledge needed – Costs (if relevant) – Timeline to end of project
Identify and negotiate access to and acquisition of new and relevant skills to achieve 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 should, at this point, anticipate the particular skills required to develop and make prototypes of their design ideas. There are some technical areas where support is almost certain to be needed. For example, robust artefacts will require attention to structures and forces, and the marine environment will need an understanding of the effects of electrochemical and galvanic corrosion and appropriate materials. This is also a good opportunity to liaise with colleagues from other curriculum areas to determine whether they can help deliver effective, contextualised masterclasses using their specialist input.

Curriculum mapping

Design skills	Technical skills
DA1 Develop detailed design specifications to guide their thinking. **DB5** Use specifications to inform the design of innovative, functional, appealing products that respond to needs in a variety of situations.	**MA4** Make simple use of planning tools. **MA5** Communicate their plans clearly so that others can implement them. **MB6** Recognise when it is necessary to develop a new skill or technique. **TK1** How to classify materials by structure. **TK2** About the physical properties of materials. **TK16** Use learning from science to help design and make products that work.

WEEK 4: REALISATION

Overview

Student teams start to apply the skills and knowledge gained through investigation and research. They start making prototypes and using test techniques to develop their designs.

Resources

Small test tank and saline solution

Range of materials as negotiated – including metals, polymers, woods and composites

3D printer, laser cutter, forming equipment, as required

Design engineering and iteration (page 28)

Useful references

Ocean spiral:
youtube.com/watch?v=uFG89OiFIbI

Lilypad: Floating ecopolis for climate change refugees:
vincent.callebaut.org/video/rJmB-dtt_ql/LILYPAD

Planning

Learning objectives	Teaching and learning activities
	Student teams view the **Ocean spiral** and **Lilypad: floating ecopolis for climate change refugees** videos. Other resources can also be used as stimulus prompts and to support their learning from masterclasses.
Develop and communicate ideas through the use of 3D models and prototypes. Understand that iteration is a cyclic, not a linear process.	Students commence making their developed prototypes for ocean living. Successful prototypes will accurately demonstrate the functions and key ideas that have emerged from their design thinking. During the prototyping process, students will evaluate their designs as necessary to justify each of their iterated.
Test materials and evaluate effects. Refine choices and decisions in the light of findings.	Students will need to justify the categories, properties and performance of their selected materials in a potentially hostile marine environment. At this stage, a small test tank containing a saline solution of about 36 parts per thousand (3.5%) should be made available for students to test samples of materials for electrochemical or galvanic corrosive activity. Refer students to **Design engineering and iteration** (page 28) to help them understand the importance of iteration to improve their designs.

WEEK 4: REALISATION CONTINUED

Curriculum mapping

Design skills	Technical skills
DB3 Use 3D CAD to model, develop and present their ideas. **DB8** Decide which design criteria clash and determine which should take priority. **EB3** Products that they are less familiar with using themselves.	**MA6** Match and select suitable materials considering their fitness for purpose. **MB8** Use a wider, more complex range of materials, components and ingredients, taking into account their properties. **TK18** Understand the properties of materials, including smart materials, and how they can be used to advantage.

WEEK 5: EVALUATION

Overview

Student teams apply increasing precision to their prototypes to provide functionality. They check that their developed ideas meet the objectives of their design briefs.

Resources

- Large test tank (c. 1500mm x 820mm x 190mm)
- Jointing equipment e.g. riveting, drilling, screwing
- Measuring equipment
- Hooks, catches etc
- Hand and machine tools e.g. drills, sanders, saws

Planning

Learning objectives	Teaching and learning activities
Teams refine evaluative techniques and learn how to apply them at appropriate points in the design process.	Students continue evaluating and developing their prototypes. They should refer to their design specifications and their project plans to monitor progress and replan if necessary. Teams will develop the structural integrity and functionality of their prototypes to prepare them for demonstrations.
Students record and reproduce evaluation outcomes.	At this stage, student teams may require a larger test tank to test and evaluate the structural performance of their prototypes (see Resources). Teams should record test results, conclusions taken from them, and note any new design decisions made. Students will complete sketches and diagrams, which should be annotated to describe key features of their prototypes.
Students make judgements and justify their prototyping and design solutions against a range of criteria.	Teams should check that their prototypes meet the fundamental conditions to sustain life and for people to carry out useful work and activities in the context of their design solutions.

Curriculum mapping

Design skills	Technical skills
DA10 Consider additional factors such as ergonomics,, anthropometrics or dietary needs. **EA3** Select appropriate methods to evaluate their products in use and modify them to improve performance. **EA5** Test, evaluate and refine their ideas and products against a specification, taking into account the views of intended users and other interested groups.	**MA7** Select appropriately from specialist tools, techniques, processes, equipment and machinery, including computer-aided manufacture. **MA8** Select appropriately from a wider, more complex, range of materials, components and ingredients, taking into account their properties such as water resistance and stiffness. **MB5** Adapt their methods of manufacture to changing circumstances. **TK19** Understand the performance of structural elements to achieve functioning solutions.

WEEK 6: PRESENTATION

Overview

The student design teams bring together their learning, skills and design thinking into coherent prototypes. They show how their prototypes function, or demonstrate functionality, and justify design decisions they have made and engage with a wider cross-curricular agenda.

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 (including test tank and water where possible).

Planning

Learning objectives	Teaching and learning activities
Students demonstrate learning and understanding from a range of curricular sources and how it has enhanced their ability to explain and communicate their design decisions.	This is a great opportunity for participating curriculum areas to come together and showcase their contributions to the design task in a celebratory presentation to the whole school.
Teams describe, explain and justify a comprehensive set of design outcomes by reference to experimentation, research, testing and evaluation.	Student teams present and explain their prototypes. They should describe how the prototypes meet the objectives of their design specifications and how they fit into the context of population growth and pressures on environment and climate. The prototypes themselves should exemplify the functions of the teams' designs and how they overcome specific problems or challenges. Students should justify their design decisions by referring to tests and evaluations, particularly in terms of materials they used and the structures they made. The results of materials tested in the saline test tanks should be recorded and the analysis/outcomes discussed. Refer students to **Top tips from Dyson engineers: Giving presentations** (page 30) and **Top tips from Dyson engineer: Providing peer feedback** (page 31).
	The provision of a suitable setting for presentations will enhance their impact. A test tank to display the ocean-living prototypes will make the presentations more realistic and much more fun. Subject to the usual risk assessments, the provision of a power source such as a cordless leaf blower to mimic wind and wave forces makes for an impressive (although messy) test setting.
	Progression Student presentations can form a very good basis for continuing discussion around climate, environment, populations, ethics and 'climate refugees', which may lead on to future challenges.

WEEK 6: PRESENTATION CONTINUED

Curriculum mapping

Design skills	Technical skills
EA4 Produce short reports, making suggestions for improvements.	

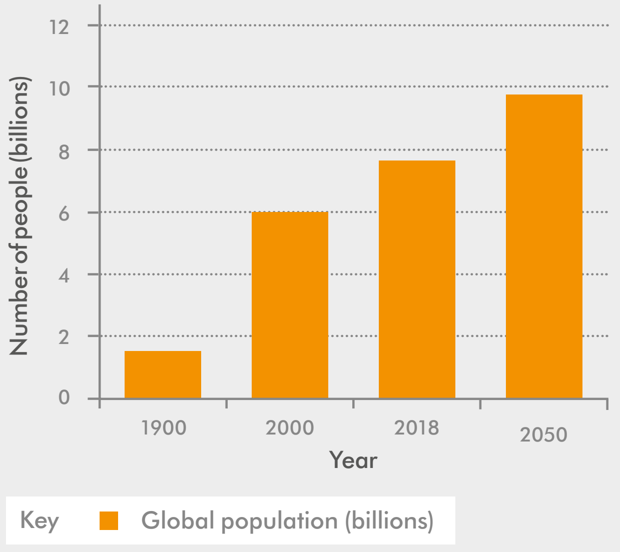
STUDENT WORKSHEETS

POPULATION FACTSHEET

1. Global population

Year	Number of people
1900	1.5 Billion
2000	6 Billion
2018	7.6 Billion
2050	9.6 Billion (est.)

Global population (billions)



2. Planet earth land/sea percentages of global surface area

	Percentage
Sea	71%
Land	29%
Desert	10%
Land for population	19%

3. Global population density

Year	Density
2018	51 people per sq km of land

EXAMPLES OF HIGH POPULATION DENSITY

Manhattan Island, New York

Favela, Rio de Janiero

Sunborn yacht hotel, Gibraltar

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											

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.

The design process is iterative. 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.'