John Smeaton Discovery Award

Teacher Information

CREST AWARDS

LEEDS YEAR OF CULTURE 2023

Supported by Leeds City Council

SMEATON 300

About this Award

Level: Discovery

Project title: Smeaton Park

Discovery objectives: Students work on a single challenge or series of clearly linked challenges.

- The challenge/ linked challenges have a clear real-world context – Smeaton Park.
- The challenge(s) allow students some creative freedom within a structured project – design of a product.
- Students work collaboratively in self-managed groups.
- Students record and reflect on the day through self-evaluation. You can use the CREST Discovery passport for this.
- Students communicate their findings in a group presentation.

Overview: In this project, learners will consider themes of sustainability, engineering, energy use, public and community spaces, and design innovation to develop, design and present an idea in response to a brief to create a new public space in Leeds inspired by John Smeaton, the civil engineer. Learners must work in teams and collaborate to explore real world issues and problem solve.

Curriculum links

KS3 Citizenship

"develop pupils' understanding of democracy, government and the rights and responsibilities of citizens".

KS3 D&T

Design

- Develop and communicate design ideas using annotated sketches, detailed plans, 3-D and mathematical modelling, oral and digital presentations and computer-based tools.

Evaluate

- Analyse the work of past and present professionals and others to develop and broaden their understanding.
- Investigate new and emerging technologies.
- Test, evaluate and refine their ideas and products against a specification, considering the views of intended users and other interested groups.
- Understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists.

KS3 Science (Physics):

Scientific attitudes
Understand that scientific methods and theories developed as earlier explanations are modified to take account of new evidence and ideas, together with the importance of publishing results and peer review.

Current electricity
- electric current, measured in amperes, in circuits, series and parallel circuits, currents add where branches meet and current as flow of charge.
- potential difference, measured in volts, battery and bulb ratings; resistance, measured in ohms, as the ratio of potential difference (p.d.) to current.

Learning Objectives

- To become familiar with John Smeaton and the impact he had on engineering.
- Explore the issues faced by civil engineers today in providing access to public spaces.
- Understanding renewable sources of energy from wind and water as a method of generating electricity.
- Using knowledge of renewables.

Time commitment: Learning will need to take place over 5 hours.

The Challenge

This is a 5-hour project, students aged 10-14 will work in teams to research John Smeaton, civil engineering and renewable energy to create a proposal for a new public space.

Students will
- Learn about John Smeaton and his work and how he impacted the future of engineering.
- Research and learn about renewable energy and then choose a method of energy production to power their chosen area.
- Decide on how what form of device will create the power for their context.
- Develop a design proposal for the solution and present their findings in an attempt to bid for the commission.

Resources:
- Teacher Notes.
- Powerpoint.
- CREST Awards Discovery Passport.
- Worksheets and student information sheets.

Session	Description	Timing
1. Introduction	Using the presentation, students explore the context. The session leader introduces the day and divides students into teams.	20 mins
2. Context	Public spaces, accessibility (bridges) and inclusive design.	30 mins
Break		
3. Energy	Study generating electricity and renewable energy.	30–40 mins
4. Research	Teams research various appropriate renewable energy sources ahead of them developing their proposal for the park.	30–60 mins
Break		
5. Prototype, test, improve	Teams develop their ideas by exploring by drawing and modelling in 3DTest the properties of water in this challenge – what happens to the flow and force of water when an obstacle is in its way? How do dams and water wheels work?	2 hours
Lunch		
6. Presentation	Teams finalise and deliver their five-minute presentations. Teachers and students provide constructive feedback and have a chance to ask questions.	1h* *depending on number of groups
Reflections	Students reflect on their learning and complete their CREST Discovery passport.	10 mins

Top Tips

- To inspire your students you could look at additional information included in links in the appendix.
- Teachers might want to have done some preliminary investigation into John Smeaton or other engineers. See links in the appendix.
- Plan your day so that students have as much time as possible for the design and then the presentations (consider an alternative time slot for the presentations).
- There is no limit to how the students can develop or present their ideas. Allow them to use the systems they are used to. It could be junk modelling, laser cutting, workshop based, or CAD based.

Background information about John Smeaton

John Smeaton was born in Leeds in 1724, and from being a child was fascinated by machines, science, how things work, design and engineering. He had his own workshop in his garden and made his own wood lathe.

He is known as the father of 'civil engineering' – he invented this term to describe the type of engineering which took place outside of the military. He went to Leeds Grammar School and left at 16, and then joined his father's law firm. However, law didn't really interest him and he soon left to become a mathematical instrument maker.

He was a keen inventor, always wanting to find new and better ways of developing things, and he conducted tests into the efficiency of watermills and windmills, which earned him the Copley Medal in 1759. He designed bridges and water way systems, and is most famous for his design of the Eddystone Lighthouse in Plymouth.

The lighthouses on Plymouth rocks were previously made of wood and were dashed by the rocks and stormy seas, so Smeaton had the challenge of making a new lighthouse which could withstand the weather. He conducted experiments to develop a new type of concrete which could be used underwater, and through this he invited hydraulic lime! He then made his new lighthouse in the shape of an oak tree, using inspiration from nature to design a strong and sturdy shape that was wider at the bottom and narrower at the top.

Smeaton was a great collaborator and worked across a wide variety of fields – science, technology, mechanics, maths, design, and astronomy, as well as being influenced by art and nature. He was also committed to his designs and works being 'for the public good' and didn't patent a lot of his works, so his ideas were in the public realm. He only charged a flat fee for his work, was uninterested in being famous or a celebrity, and unusually for that time, made a contract for his workers ensuring they had fair pay and conditions and sick pay.

Did you know?

John Smeaton also stopped London Bridge from falling down!

The arches of the old London Bridge were widened and a central pier was removed to allow bigger boats to pass through, but the people of London soon found this caused the flow of water to increase and this started to damage the pillars keeping the bridge up! John Smeaton was summoned to solve the problem, and he made the trip down from Yorkshire. Recently the City of London gates had been knocked down and sold, so there was a pile of stones and rubble lying around. Smeaton ordered that they immediately buy back the stone pillars from the gates, and throw them in the river to slow down the water. Lots of people got to work, using horses, carts and wagons, and the bridge was saved!

Smeaton died in 1792, and his work is still hugely influential today.

STEP BY STEP GUIDE

Pre-project preparation

1. Read the discovery award pack.
2. Read through the background information on John Smeaton. (PowerPoint slide 5).
3. Print student worksheets and gather the materials needed.
4. Think about the structure of your groups and who would make strong leaders in their group.
5. You might like to do some research with the students ahead of the task.
6. Consider engineering around the world to provide a more diverse range of engineers and cultures.

SET UP

1. Every team should have a table and enough chairs for the team – 4-6 members.
2. Each team should have paper and pencils to take notes, draw and design.
3. Teams will need access to the internet/books for research.
4. Drawing and modelling equipment should be available.

Session 1

Introduction to the brief
20 mins

Introduction to Discovery Passport (5 mins)

- Guidance as to how to fill in the form and assign the various roles. (PowerPoint slides 2-4).

Introduction to the brief (5 mins)

- With reference to John Smeaton and the Smeaton 300 event as part of Leeds2023 use the PowerPoint to introduce the students to John Smeaton and to look at his various engineering projects. (PowerPoint slide 5).
- The brief is to generate a proposal for a method of supplying power to the new site and its facilities utilising renewable energy.

Session 2

Smeaton Park site design.

30 mins

Smeaton Park site design.
(Worksheet 1. Task a) Slide 7. Student information sheet 1

https://www.re-thinkingthefuture.com/2021/01/17/a2831-10-things-to-consider-when-designing-inclusive-multicultural-public-spaces/

Objective:
To introduce the question of why public spaces are important in cities, towns and communities to frame the context of this project.

- Discuss with students why public spaces are important and give them some time to debate this question in small groups.
- Make a mind map as a full class, or in their groups, of functions that a public space serves.

Some functions students may come up with may include:

- A space for relaxation.
- A space to connect with nature.
- A space for exercise.
- A space for people to meet.
- Creating connections with local community.
- Building a sense of belonging.
- Free access to outdoor space for those who don't have this at home.
- A space for trees and plants to grow, to combat climate change.
- To provide habitats for creatures.
- An event space – eg for outdoor concerts.

There are no wrong answers, and you can encourage students to think of diverse responses based on their own lived experience.

ACCESSIBILITY

ACCESSIBILITY
(Worksheet 1 task b) ***PowerPoint*** *Slide 8/9*

Student information sheet 2
Ask students to think of a public space they know – eg a park near home or near school. Ask students to either list what is in this space or draw it visually if this helps. Discuss the facilities and services this space offers and ask students how this public space could be improved.

Inclusive design. (20 mins).
Explain to students that there are a few considerations when designing for accessibility that involve age and height as well as physical disabilities. Civil engineers and designers are already addressing these in ways they may not have realised (as seen in the PowerPoint).

TASK – mind map as many access issues as possible that they can think of that people may have accessibility issues with. (Worksheet 1b).

Students will likely identify the following issues and they may also come up with some others of their own.

- Toilets.
- Signage.
- Wheelchairs.
- Ages.
- Surfaces.
- Stairs.
- Ramps.

Students should be reminded that some or all the above should be included in their final proposal.

Bridges

LOCATION and ACCESS
(Site map and worksheet 2) **PowerPoint slide 10/11**

Using the map of the proposed park – identify where visitors could access the island. Create your own Key to illustrate your method(s). Add notes to suggest ways you could address the issues.

Students should consider existing access as well as potential access to the island and should think about making use of existing services.

(This map may be used later in the project to identify the location of the renewable energy).

Knights Way Bridge – http://happypontist.blogspot.com/2018/04/yorkshire-bridges-23-knights-way.html

Session 3

Understanding more about renewable energy

30 – 40 mins

Renewable energy overview - PowerPoint Slide 12

Key to the success of this project is the small-scale use of renewable energy sources to help power the site. You will look at hydro power and wind power but could also go and look at solar and geothermal. Encourage students to explore the topic further and be creative.

Starter:
What will need to be powered as part of the site? This will need to link with what they have looked at already.

- Lighting – access, installations, wayfinding, night-time vs daytime.
- Visitor's Centre.
- Toilets.

What are the relative power demands of each part. Could LEDs be used to lower consumption?

Possible practical investigations (slide 13)

Motor and LED – power in and power out.

https://youtu.be/cgsD7i4CkVc

https://www.goethe.de/resources/files/pdf206/checked-build-your-own-wind-powered-generator.pdf

What are renewables?

Advantages and disadvantages of renewables

Source	Advantages	Disadvantages
Solar	Clean energy	Sun is intermittent. PV cells can't convert all the energy form the sun. Need careful positioning
Biofuels	Can use waste materials from other industries	Need to be burnt, can release carbon. Takes up space for growing other plants.
Wind	Plentiful, clean. Simple concept	Intermittent. Can be an eyesore.
Hydro	Powerful	Can damage environment, expensive to install large systems

Hydropower

Teacher led discussion using PowerPoint. Students to answer questions on worksheet 3

Session 3

Continues

Hydropower – how does it work? (Worksheet 3) 10 mins
Hydropower or hydroelectricity refers to the conversion of energy from flowing water into electricity. It is considered a renewable energy source because the water cycle is constantly renewed by the sun.

There are three types of hydropower (explained in PowerPoint):
- Impounded systems.
- Pumped storage.
- Run of river.

Windpower how does it work? (10 mins)
The UK is the windiest country in Europe, and when sited in the right place wind turbines are a great way to generate renewable energy. In some instances, simple windmills can be used to pump water.

As wind is less reliable, battery storage systems should be considered to store energy when demand is low.

Wind is created by the unequal heating of the Earth's surface by the sun. Wind turbines convert the kinetic energy in wind into mechanical power that runs a generator to produce clean electricity. Today's turbines are versatile modular sources of electricity. Their blades are aerodynamically designed to capture the maximum energy from the wind. The wind turns the blades, which spin a shaft connected to a generator or the generator's rotor, which makes electricity.

Different types of devices

Wind turbine designs
Horizontal mounted (HAWT)– similar to propeller blades
Vertically mounted (VAWT)
- Savonius.
- Darrieus.
- H-rotor or revolving wing.

Image from https://windexchange.energy.gov/small-wind-guidebook

Hybrid Systems 10 mins
It is worth explaining how renewable energy forms part of a wider system to deliver on demand power. This may be backed up by diesel generators.
Further research could be done later into ground source heat pump or the use of biofuels.

Storage

Key technical information - Power loads
A site of this size will have varying needs for power. This will be delivered on demand from existing infrastructure, or direct from sustainable sources. On demand power via the national grid is dependable, but not a guaranteed sustainable source. Using renewable sources may need additional storage systems installing to balance peak power demands.

Session 4

Research

30 – 60 mins

Student Worksheet 4

These tasks should be divided between the team members with the students responsible for finding out the necessary information and feedback to the team leader before making a decision.

Split the case studies up between your group. Read them through and then discuss as a group.

One person can focus on each of the following areas:

- Hydro solutions.
- Wind power solutions.
- Energy storage.
- Alternative methods of energy generation.
- What are the power demands of the site?

They should be encouraged to take notes and work independently.

Research

Hydropower – how does it work?
Students should look at 'run of river' applications. These would be more suited to this site as they would provide continuous levels of power from a river source. They should try to find out the nominal power loads that these systems can deliver, and record these.

Case studies and further information (included on the student worksheet)

Hydro power (PowerPoint slide 15)
Students should investigate common wind turbine designs
Use this site as a starting point –
https://www.dezeen.com/tag/wind-power/

They can use these to explore designs for turbines:

River Don hydro scheme –
https://www.bbc.co.uk/news/uk-england-south-yorkshire-34553635

Reading hydroelectric scheme –
https://www.bbc.co.uk/news/uk-england-berkshire-58187804

Community-led hydroelectric plant in Caversham –
https://www.itv.com/news/meridian/2021-08-14/community-run-hydroelectric-plant-opens-on-thames-in-reading - video

Center for Alternative Technology –
https://cat.org.uk/info-resources/free-information-service/energy/micro-hydro/?gclid=CjwKCAjw1MajBhAcEiwAagW9MTLYVKmiVXThERg_aiKHfTQ4AYcestYVL4GWuZNH4DPgjP1fL_-LSxoCoU4QAvD_BwE

Session 4

Continued

Hydropower 101 –
https://youtu.be/q8HmRLCgDAI

Overview of renewable energy –
https://studentenergy.org/map/

Energy Saving Trust –
https://energysavingtrust.org.uk/advice/hydroelectricity/?gclid=CjwKCAjw1MajBhAcEiwAagW9MckLmQ-bLQQQRN9Uro5Ze1Xymhdmd1nk5FZwqQW41Q7qfw9bGSBJkBoCk64QAvD_BwE

Waterwheels –
https://www.british-hydro.org/waterwheels/

Windpower (PowerPoint slide 17)

Dezeen articles on wind power –
https://www.dezeen.com/tag/wind-power/

Manufacturer of wind turbines –
https://www.quietrevolution.com/

Renewable energy specialists –
https://www.renewablesfirst.co.uk/

Turbine designs –
https://en.wikipedia.org/wiki/Vertical-axis_wind_turbine

Savonius –
https://en.wikipedia.org/wiki/Savonius_wind_turbine

Darrieus –
https://en.wikipedia.org/wiki/Darrieus_wind_turbine

https://www.arup.com/perspectives/publications/research/section/future-of-energy-storage

Plenary

Before breaking for lunch they should have a good idea of what needs to be done for the final part of the day. Who will be doing what for the presentation?

Lunch — Time as appropriate/available.

Session 5

Engineering challenge

Prototype, test, improve

120 mins

Challenge -
Working in teams; you will design a layout for Smeaton Park that considers access, inclusivity, informative displays about John Smeaton and his work and you must also use your knowledge of renewable energy sources to identify a renewable energy source that will be used to generate the electricity for the park.

Specification.

- The park must be contained in the area identified on the map.
- You should propose how and where visitors will access the island.
- You must consider accessibility to the site for visitors of all abilities and ages.
- The park must suggest what you would include in features and information displays about John Smeaton.
- Your renewable energy source(s) must be shown on the plan and be justified in your proposal.
- Your proposal must clearly show the location of all of your features on the map.
- Consider the environmental impact of the site from construction to use.

Project ideas
This can be completed in several ways, but students should aim to meet the specification points as set out above.

Some outcomes may be:

- A presentation that pulls together their drawings, maps, and ideas.
- A 3D model of the site made from traditional modelling materials.
- Drawings and further information included in a short, printed pack.
- A CAD 3D model generated in Sketchup/TinkerCAD or similar with a supplementary pack of information

Starting point
Encourage students to start by drawing. They can start by looking at the map of the site and identifying key areas to site different parts of their design. Encourage teams to allocate roles to team members (designer, electrical engineer, project manager).

Reminder of roles in the team
Project Manager
Research Manager
Engineer
Communications Manager
Design Lead
Marketing Lead

Session 6

Presenting and assessing

60 mins – depending on groups

Starting point. Worksheet 5: PowerPoint slide 14/15

Organise a venue for the presentations, plan a running order for each presentation leaving time in between each presentation to allow the next group to set up. The following mark scheme could be used (and shared with the groups) to assess the presentations.

Presentations should be no more than 5 minutes (adjust according to your groups and the dynamics of the group) Allow access to various methods of presenting – whiteboard, display space, flip charts etc.

Suggested mark allocation.

1. Quality of the plan/layout (10 marks).
2. Accessibility – different users – uses/times of the day etc. (10 marks).
3. Renewable energy source. (10 marks).
4. Features/information (reference to Smeaton and engineering) (10 marks).
5. Environmental impact. (5 marks).
6. Quality of presentation. (5 marks).

Total 50 marks.

Completing Crest Award Discovery Passport (10 mins).

Appendix

Useful web links

CREST Discovery Award

https://www.crestawards.org/crest-discovery

https://discoverylibrary.crestawards.org/crest-discovery-passport/62595428

John Smeaton

https://leeds2023.co.uk/smeaton300

https://leeds2023.co.uk/news/foxglove-on-john-smeaton

http://www.elhas.org.uk/reports/smeaton.htm

ICE.org engineers website

https://www.britannica.com/biography/John-Smeaton

http://aviation-history.com/early/smeaton.htm

Research

https://unhabitat.org/sites/default/files/2020/07/indicator_11.7.1_training_module_public_space.pdf

https://www.publicspace.org/about-the-prize

https://www.gov.uk/government/organisations/disabled-persons-transport-advisory-committee

https://thecityfix.com/blog/public-spaces-10-principles-for-connecting-people-and-the-streets-priscila-pacheco/

https://www.leedsdock.com/whos-here/watertaxis/

http://happypontist.blogspot.com/2018/04/yorkshire-bridges-23-knights-way.html

Energy.

https://www.oxford.gov.uk/news/article/1282/leys_pools_car_park_transformed_into_energy_hub_to_generate_green_electricity_for_leisure_centre

https://theforumnorwich.co.uk/about-us/news/new-car-park-lighting-system

https://www.queenelizabetholympicpark.co.uk/-/media/qeop-sustainability-report20-21-final.ashx?la=en

https://www.theguardian.com/environment/2012/jul/31/olympic-park-erects-wind-turbines

Technical information

	Energy use (kwh)	
	Year	Month
Visitor centre	240,000	20,000
Park LED lighting	50,000	
Coffee shop	100,000	
Car chargers (each)	20,000	

	Energy generation (kwh)	
	Year	Month
Solar canopy over carpark (48 spaces)	80,000	20,000
QR6 wind turbine (single)	7500	
Small run of river hydro	40,000	
Waterwheel	7500	

Useful Calculations

https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/smeaton-coefficient/

https://www.schoolphysics.co.uk/age14-16/Electricity%20and%20magnetism/Current%20electricity/text/Electrical_power/index.html

To Find	Direct Current	AC / 1phase 115v or 120v	AC / 1phase 208,230, or 240v	AC 3 phase All Voltages
Amps when Horsepower is Known	$\frac{HP \times 746}{E \times Eff}$	$\frac{HP \times 746}{E \times Eff \times PF}$	$\frac{HP \times 746}{E \times Eff \times PF}$	$\frac{HP \times 746}{1.73 \times E \times Eff \times PF}$
Amps when Kilowatts is known	$\frac{kW \times 1000}{E}$	$\frac{kW \times 1000}{E \times PF}$	$\frac{kW \times 1000}{E \times PF}$	$\frac{kW \times 1000}{1.73 \times E \times PF}$
Amps when kVA is known		$\frac{kVA \times 1000}{E}$	$\frac{kVA \times 1000}{E}$	$\frac{kVA \times 1000}{1.73 \times E}$
Kilowatts	$\frac{I \times E}{1000}$	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times 1.73 \ PF}{1000}$
Kilovolt-Amps		$\frac{I \times E}{1000}$	$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$
Horsepower (output)	$\frac{I \times E \times Eff}{746}$	$\frac{I \times E \times Eff \times PF}{746}$	$\frac{I \times E \times Eff \times PF}{746}$	$\frac{I \times E \times Eff \times 1.73 \times PF}{746}$

Power is measured in watts with current in amps and voltage in volts
Large amounts of power use kilowatts kW (1 kW = 1000 W) and megawatts (1 MW = 1000 000 W).

RESOURCES

- Student information sheet 1 – Public spaces (session 1)
- Worksheet 1 – Task a) public spaces, Task b) accessibility (session 1)
- Student information sheet 2 – Accessibility – inclusive design. (session 2)
- Worksheet 2 – Site map (session 2)
- Student information sheet 3 – Bridges. (session 3)
- Worksheet 3 – Generating Electricity. (session 4)
- Worksheet 4 – Research. (session 4)
- Worksheet 5 – The presentation. (session 5, session 6)

The Superstar Crest Award was created as part of Smeaton300, an original idea developed by Foxglove, enabled by Leeds City Council in partnership with LEEDS 2023. Supported by National Lottery Heritage Fund, Arts Council England, Bruntwood, Burberry and Scottish Power Foundation.

FOXGLOVE

Leeds City Council

LEEDS YEAR OF CULTURE 2023

Made possible with Heritage Fund

LOTTERY FUNDED

Supported using public funding by ARTS COUNCIL ENGLAND

bruntwood

BURBERRY

Canal & River Trust
Making life better by water

ScottishPower Foundation