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Wind Turbines S1



University
of Glasgow

Scottish Charity Number SC004401

EPSRC

Engineering and Physical Sciences
Research Council



University of
Strathclyde
Glasgow

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Also included:

Pupil Instruction Sheet

Pupil Investigation Worksheet

Pupil Reference Materials:

- NEED Project Exploring Wind Energy Booklet
- TEP Wind Turbine Help Booklet

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For further information or for queries please contact Research and Innovation at The University of Strathclyde, 50 George St, Glasgow, G1 1QE (www.strath.ac.uk/ri) or email res.reception@strath.ac.uk.

Introduction

The materials in this pack form one of a series of units which promote the teaching and learning of engineering in the secondary school curriculum.

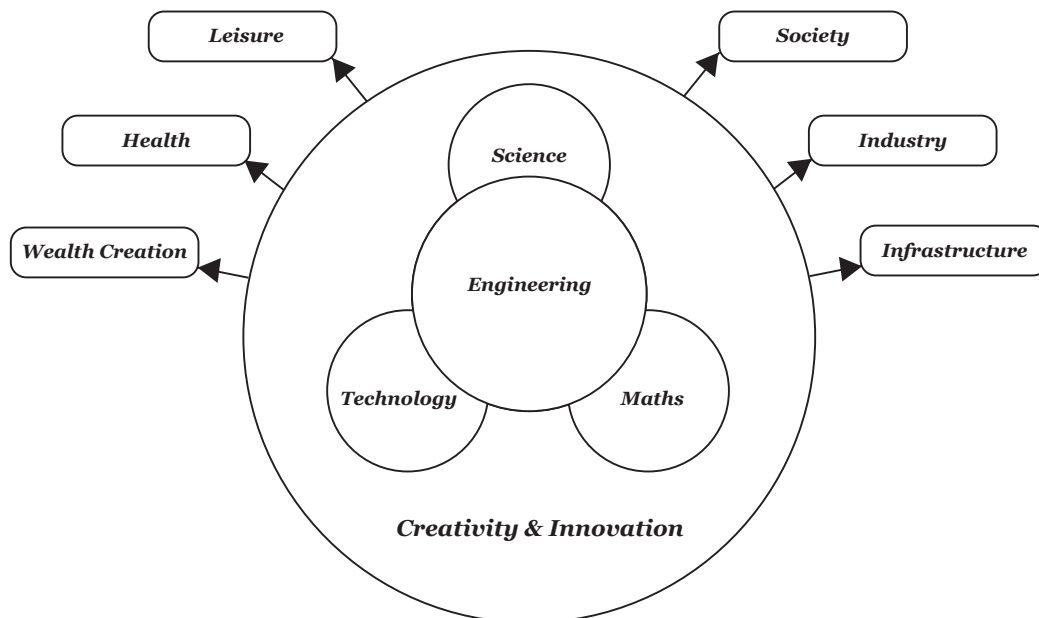
This S1 unit on wind turbines was developed by John Lethbridge and Mike Viola, Physics Department, Dumfries Academy, in cooperation with the Universities of Glasgow and Strathclyde Engineering the Future teams.

This school-university partnership was one of a number of collaborative networks of school and university staff in Electrical and Electronic Engineering (EEE) created by the Engineering the Future project. These enabled staff and students from schools and universities to work together to create exciting and innovative programmes for school pupils, supported by world leading engineering research groups. These materials have already been trialled successfully in secondary schools across Scotland.

In the words of pupils involved: 'It's more fun, so you want to know more about physics.' – 'A lot of work: challenging but you've accomplished something, it 'clicks' and you remember it.' – '... instead of being told step by step what to do you get to vary it yourself.' – '...it just made you feel really smart once you'd done it.'

Engineering the Future is a 3-year project funded by a major grant from the UK Engineering and Physical Sciences Research Council (EPSRC) which is running from October 2006 to early 2010. It involves staff from the Department of Electronic and Electrical Engineering in the University of Strathclyde and from the Departments of Electronics and Electrical Engineering and of Educational Studies in the University of Glasgow and science teachers in some 20 secondary schools in 9 education authorities in Scotland and in 2 independent schools. The financial support afforded to the project by EPSRC is gratefully acknowledged as are the advice and encouragement provided by EPSRC and by the Universities of Strathclyde and of Glasgow.

Engineering the Future was planned in response to the general recognition that engineering in this country, in particular electrical/electronic engineering, faces serious challenges. The number of young people taking up university engineering



courses is low and becoming lower. Many young people – including ambitious high achievers – have very limited or distorted ideas about what engineering involves. In particular, they do not associate a creative, inventive, problem-solving and entrepreneurial approach to life and work with their science and mathematics work – an approach essential for equipping individuals with the skills necessary to meet the needs of today and the demands of tomorrow.

This is not a matter of academic interest. Engineers use science and mathematics, in conjunction with the tools of technology, to create new systems, infrastructures, devices, products and commodities for the overall benefit of society.

There is an urgent economic need to embed and highlight engineering in the school curriculum. Engineering, the application of scientific and mathematical knowledge to practical issues, needs and problems, is fundamental to the creation of new technologies and sustainable industries. Engineering requires and supports the development of high levels of scientific and mathematical competence in the service of useful design, creativity, innovative thinking and problem-solving. It requires and fosters the confidence, drive, determination to succeed, teamwork and business acumen necessary to promote economic enterprise. There is an economic need for a larger number of engineers, high level engineering graduates and very capable technician engineers, with such skills to build a strong indigenous high-tech economic base.

We hope that you find these materials useful.

Teacher Guide

Outline of engineering activity

The project is built into an S1 Energy Unit – such as the one in Spotlight Science Book 7, Chapter 3. (Nelson Thornes Ltd).

It is easy to build on the general knowledge pupils will have about energy-sourcing problems – from the finite stocks of fossil fuels, through climate-change implications, to the availability of ‘alternative’ energy sources. Discussion of these topics can be used to focus on one example, a wind turbine, eventually to be investigated.

Pupils will build a model wind turbine from a part-assembled kit and measure the power output from this, while having to consider the control of a number of variables. This should follow a period of research into the background of energy needs and wind power.

Engineering and learning principles

The project enables pupils to become aware of the important role of engineering in addressing energy problems. There is a focus on such specific aspects of engineering as designing to optimise the performance of a wind turbine, using effective means of measuring its output, and comparing different designs. The learning activities promote deep learning: they include independent and collaborative internet research and investigation of wind turbine design factors, leading to an explanation of findings in an illustrated presentation.

Pupils will develop an appreciation of the use of models to test ideas, of the need for measurements, of the usefulness of research into existing knowledge, and of the consideration of environmental and social impact of engineering activities.

The nature of this investigation should enable individuals to interact cooperatively and achieve progress that would not so easily result from lone activity.

Learning outcomes

Pupils will

- know about alternative sources of energy, in particular wind power (through internet research), and the consequences of continued dependence on fossil fuels
- develop the skills required for cooperative (team) efforts help in solving problems
- develop the skills needed to communicate productively – presenting/discussing findings and views
- know that evaluation is necessary and that there is a need to identify and control variables
- understand key ideas about the role of engineering in addressing problems arising from global warming and finite fossil fuel resources, in particular, through the use of wind turbines
- explain in an illustrated presentation how a particular selected aspect of wind turbine design achieves the highest power – and how this was investigated and measured.

Curricular links

The following Curriculum for Excellence statements of experiences and outcomes relate directly to the activity. In addition it is readily possible to develop links with social studies and with education for enterprise.

Sciences

SCN 2-04a By considering examples where energy is conserved, I can identify the energy source, how it is transferred and ways of reducing wasted energy.

SCN 2-04b Through exploring non-renewable energy sources, I can describe how they are used in Scotland today and express an informed view on the implications for their future use.

SCN 3-04b By investigating renewable energy sources and taking part in practical activities to harness them, I can discuss their benefits and potential problems.

Technologies

TCH 2-02b I can investigate the use and development of renewable and sustainable energy to gain an awareness of their growing importance in Scotland or beyond.

Numeracy and mathematics

MNU 3-11a I can solve practical problems by applying my knowledge of measure, choosing the appropriate units and degree of accuracy for the task and using a formula to calculate area or volume when required.

MTH 2-21a I can display data in a clear way using a suitable scale, by choosing appropriately from an extended range of tables, charts, diagrams and graphs, making effective use of technology.

Literacy

LIT 3-02a When I engage with others, I can make a relevant contribution, encourage others to contribute and acknowledge that they have the right to hold a different opinion. I can respond in ways appropriate to my role and use contributions to reflect on, clarify or adapt thinking.

LIT 3-06a I can independently select ideas and relevant information for different purposes, organise essential information or ideas and any supporting detail in a logical order, and use suitable vocabulary to communicate effectively with my audience.

LIT 3-09a When listening and talking with others for different purposes, I can:

- communicate information, ideas or opinions
- explain processes, concepts or ideas
- identify issues raised, summarise findings or draw conclusions.

LIT 3-15a I can make notes and organise them to develop my thinking, help retain and recall information, explore issues and create new texts, using my own words as appropriate.

LIT 3-21a I can use a range of strategies and resources and spell most of the words I need to use, including specialist vocabulary, and ensure that my spelling is accurate.

There are considerable opportunities, noted below, for interdisciplinary work with both technology and social studies.

Structure and timing

It is assumed that pupils would carry out these activities at the end of an energy unit which had covered such matters as types of energy, the energy law, the creation of fossil fuels, and the depletion of fossil fuels.

The wind turbine project would itself require 6 to 8 periods.

Key resources

The essential requirements are:

- A planned unit of work on energy, such as the one in Spotlight Science Book 7, Chapter 3 (Johnson, K., Adamson, S. and Williams, G., published by Nelson Thornes Ltd)
- Video support for this work
- Internet access for pupils working alone or in groups
- Wind Turbine Kit(s) available from the MUTR company, in association with Middlesex University –

http://www.mutr.co.uk/product_info.php?products_id=1428

Each kit contains a set of pre-cut parts for final machining and press-forming to create the engineered wind turbine – sufficient to make 10 wind turbines. The site includes a PDF document which provides details on the engineering processes involved. This has been downloaded within the package.

- Energy Transfer Units, developed in collaboration with the Science Enhancement Programme and available from the MUTR company, in association with Middlesex University
- Digital meters, ~ 1K_ load resistor and leads
- Desk fans (2 or 3)
- Access to computers and internet
- Smartboard

Core activities

In twos or threes, pupils work, using internet research, to prepare a PowerPoint presentation on the problems associated with global warming and fossil fuels, the expected exhaustion of fossil fuel reserves, and alternative sources of energy, in particular wind power.

The presentation also explains what they learn about turbine design and a particular aspect of this (such as blade design or configuration). In the presentation they also report on an experiment to measure the effects on the power generated by the wind turbine of varying the particular aspect of the design that they investigate.

Organisation

1. Provide each pupil with a copy of the Pupil Instruction Sheet.
2. Using the Instruction Sheet, get the pupils to discuss and agree what a very good account of their work should contain and how it should be presented.
3. Remind pupils of the value of generating their own questions for research.
4. It is important to highlight the advice to pupils in the Pupil Instruction Sheet about note-making and use of own words, rather than just downloading material.
5. Provide each group with a copy of the NEED Project Exploring Wind Information Booklet which provides both information and a list of useful websites to begin the search for further information; engineers need to know the credibility of the information they are using; pupils should be encouraged to read and note critically.
6. Within this booklet the following pages seem particularly useful both in providing information and in developing literacy skills:
 - p2: summary of types of energy and energy transformations
 - p3: diagram on sources of electricity generation
 - pp 5-9: wind (particularly useful if developing interdisciplinary project with social studies teachers)
 - pp 10-18: development of windmills and related technology (particularly useful if developing an interdisciplinary project with social studies – geography and history – and technology)
 - p33: Web resources

7. The internet research work could be done immediately after the introduction or undertaken in parallel with the practical windmill investigation, according to the availability of computers.
8. Encourage pupils throughout this to refer to any relevant text book and supporting video material and to the practical work they have done using Energy Transfer Units.
9. Provide each group with a copy of the Technology Enhancement Project Wind Turbine Help Booklet and a copy of the Pupil Investigation Worksheet.
10. There is a choice of approaches to constructing the windmill:
 - If time is limited and teachers wish to focus on the experimental determination of the factors which affect power output, pupils can be provided with ready built models.
 - If there is more time available, it is possible to provide each group with a set of finished components and have them use page 4 of the Help Booklet to construct their windmill.
 - If it is appropriate to develop an interdisciplinary project with technology teachers, then pupils could follow the instructions of pages 4 to 33 to build their windmills.
11. In all cases, pupils should be directed to relevant pages of the booklet; the choice of these will depend on the extent to which pupils are provided with ready constructed models.
12. In all cases, pupils can have their attention directed to the engineering principles referred to in this booklet.
13. Groups should carry out the investigation into the factors affecting power output from their turbine as detailed in the Pupil Instruction Sheet.
14. They should complete the results table in the Worksheet.
15. As each group eventually makes its presentation, the class (and the teacher) can compare it against their agreed criteria and, if desired, a winning presentation can be identified.