Badger GCSE Science

Working Scientifically

Physics

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Badger LEARNING

Introduction

This is the third of a series of three books of Working Scientifically activities for GCSE science. They have been developed by teachers to give colleagues a range of resources to use in teaching science through the principles of Working Scientifically. These activities work well as an 'add-on' to any of the KS4 schemes of work.

Working Scientifically is an essential part of the national curriculum for science. For many science teachers, this has meant getting to grips with a new approach to science teaching. The activities in this book have been designed to encourage structured discussion, improve knowledge and understanding of Working Scientifically, and to support learners to consider a range of viewpoints and make an informed decision.

The KS4 science national curriculum sets out the parameters for Working Scientifically, and the specifications for each of the GCSE examination boards have interpreted these in a variety of ways. These activities are suitable for use in all schools, whichever exam board they use.

We have found that learners do not necessarily have the required background knowledge about scientific issues such as genetically modified food. Without this information, it is hard for them to discuss the issue and form an opinion. The tasks we have created boost this background knowledge and help learners to consider evidence from a range of contexts and make a decision.

How to use these activities

The general approach is to introduce the learners to the task, then allow them to discuss it in pairs or groups of four. During this time, the teacher should circulate amongst the groups to encourage the discussions. Once the learners have had time to talk about their ideas and make decisions, the teacher can lead a class discussion to draw out the key points.

More specifically, the activities take a variety of forms that require slightly different management. **Data analysis, graph drawing and predicting activities** follow the general approach, but note that the discussion should focus on the *process* of analysing, data presentation and prediction rather than just what the answer is.

Card sorts also take different forms, but the general approach allows learners to sort statements physically into groups. Discussion should focus on the nature of evidence, or facts and opinions in the context of the content of the activity.

Timelines require more time and can be extended by allowing learners to add their own images and additional events. They are designed so that learners can identify how ideas change, and relate images to the text. Follow-up discussion should focus on how and why the ideas have changed and, perhaps, on imagining what may happen in the future.

A note about timing

We have identified the approximate time taken for the activities based on an average ability class. More able groups may need less time on the task but more time on the discussion, and lower ability learners may need support (particularly literacy) during the activities themselves. Most tasks have some differentiation suggestions.

Authors

Dr Andy Chandler-Grevatt trains teachers at the University of Sussex. Previously he was a science teacher and Advanced Skills Teacher, where he developed an interest in producing engaging resources. This publication is dedicated to his nephews, Toby and Olly.

Dr Deborah Shah-Smith is an experienced science teacher. She has a keen interest in developing resources using practice-based evidence. She would like to dedicate this publication to her husband, Paul, and daughter, Zaveri.

Acknowledgements

We would like to thank our colleagues who have helped us to develop these tasks. These include Ben Riley of Oriel High School, West Sussex and Ross Palmer of Cardinal Newman School, Brighton and Hove.

Contents and curriculum links

A. Energy

Title	NC WS	WS Programme of Study	Activity Type
1. Solar power: the issues (PSEE)	1c, 1d	The development of scientific thinking	Card sort and discussion
2. History of steam energy	1a	The development of scientific thinking	Card sort and discussion
3. Investigating Specific Heat Capacity	2b, 2c, 2d	Experimental skills and strategies	Planning written task and discussion
4. Investigating wind turbines	2c, 2d, 2g	Experimental skills and strategies	Planning written task and discussion
5. Appliances data analysis	3c, 3e, 3f	Analysis and evaluation	Analysing and drawing conclusions, and discussion
6. The cost of electricity	3e, 3f	Analysis and evaluation	Analysing and drawing conclusions, and discussion
7. Energy diagrams	4a, 4b	Vocabulary, units, symbols and nomenclature	Interpreting data and discussion
8. Energy equations and units	4b, 4c, 4d	Vocabulary, units, symbols and nomenclature	Card sort and discussion
9. Reducing energy transfers	Experimental focus	Experimental skills and strategies	Planning written task and discussion
10. Power at home	Maths skills	Analysis and evaluation	Calculations and discussion

B. Electricity and Magnetism

Title	NC WS	WS Programme of Study	Activity Type
11. Rechargeable batteries: the issues	1d, 1e	The development of scientific thinking	Card sort and discussion
12. The history of electricity	1a	The development of scientific thinking	Card sort and discussion
13. Investigating magnetic fields	2b, 2c, 2d	Experimental skills and strategies	Improving a plan, written task and discussion
14. Fruit electricity planning	2a, 2b, 2d	Experimental skills and strategies	Planning written task and discussion
15. Which component?	3a, 3b, 3c, 3e	Analysis and evaluation	Graph interpretation and discussion
16. Current v Voltage	3a, 3c, 3e	Analysis and evaluation	Graph drawing and interpretation
17. Electrical units	4a, 4c	Vocabulary, units, symbols and nomenclature	Card sort and discussion
18. How does a bicycle dynamo work?	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
19. Investigating electrical components	Experimental focus	Experimental skills and strategies	Planning and discussing an investigation, written task
20. Transformer calculations	Maths skills	Analysis and evaluation	Calculations and discussion

C. Wave Motion

Title	NC WS	WS Programme of Study	Activity Type
21. Nuclear energy: BDR	1d, 1e	The development of scientific thinking	Card sort and discussion
22. Is the Sun causing global warming?	1f	The development of scientific thinking	Literacy activity and discussion
23. How do lenses affect light?	2b, 2c	Experimental skills and strategies	Planning writing activity and discussion
24. Investigating sounds	2g	Experimental skills and strategies	Evaluating method and discussion
25. Microwaves: text to table	3b	Analysis and evaluation	Literacy activity and discussion
26. Measuring the speed of sound	3g	Analysis and evaluation	Card sort and discussion
27. Electromagnetic spectrum in hospital	4b	Vocabulary, units, symbols and nomenclature	Card sort and discussion
28. Definitions: light and sound	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
29. Testing sound insulation	Experimental focus	Experimental skills and strategies	Literacy activity and discussion
30. Calculating wavelength	Maths skills	Analysis and evaluation	Calculations and discussion

D. Forces and Motion

Title	NC WS	WS Programme of Study	Activity Type
31. Timeline of car safety	1a	The development of scientific thinking	Card sort and discussion
32. Drink driving: the issues	1d, 1e	The development of scientific thinking	Card sort and discussion
33. Investigating acceleration	2b, 2c, 2d	Experimental skills and strategies	Discussion and selection of sampling techniques
34. Does GPS decrease journey times?	2b, 2c	Experimental skills and strategies	Planning written task and discussion
35. Stopping distances	3a, 3b	Analysis and evaluation	Analysing and drawing conclusions, and discussion
36. Velocity v. Time	3a, 3c, 3e	Analysis and evaluation	Graph drawing and analysis
37. Forces: key words and definitions	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
38. Matching force equations	4a, 4b, 4c, 4e	Vocabulary, units, symbols and nomenclature	Card sort and discussion
39. Investigating spring extension	Experimental focus	Experimental skills and strategies	Planning and discussing an investigation, written task
40. Forces subject equations	Maths skills	Analysis and evaluation	Rearranging equations and discussion

E. Atomic Structure and Radiation

Title	NC WS	WS Programme of Study	Activity Type
41. Radioactivity discovery timeline	1a	The development of scientific thinking	Card sort and discussion
42. Nuclear energy: BDR	1c, 1d, 1e	The development of scientific thinking	Card sort and discussion
43. Working safely with radioactive materials	2d	Experimental skills and strategies	True or false quiz, and discussion
44. Mobile phones and seed germination	2b, 2c	Experimental skills and strategies	Planning writing activity and discussion
45. Radiation from Chernobyl	3d, 3e	Analysis and evaluation	Graph interpretation and discussion
46. A study of the effects of mobile phone radiation on skin cells	3f, 3g	Analysis and evaluation	Data analysis, evaluation, and discussion
47. Radioactive medical tracers	4e	Vocabulary, units, symbols and nomenclature	Graph interpretation and discussion
48. Definitions: radioactivity	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
49. Screening objects for radiation	Experimental focus	Experimental skills and strategies	Literacy activity, suggesting improvements and discussion
50. Half-life of a new element	Maths skills	Analysis and evaluation	Graph drawing, analysis and discussion

F. Space – the final frontier

Title	NC WS	WS Programme of Study	Activity Type
51. History of manned space flight	1a	The development of scientific thinking	Card sort and discussion
52. Civilian space travel: the issues (PSEE)	1c, 1d, 1e	The development of scientific thinking	Card sort and discussion
53. Growing plants on Mars	2b, 2c	Experimental skills and strategies	Planning and discussion
54. Modelling the Solar System	2g	Experimental skills and strategies	Evaluation, literacy and discussion
55. Interpreting sunspot data	3b, 3d, 3e, 3g	Analysis and evaluation	Data analysis, graph drawing and discussion
56. Discovering exoplanets	3b, 3e, 3f	Analysis and evaluation	Graph drawing, data analysis and discussion
57. Discovering life cycles of stars	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
58. Distance in space	4a, 4c, 4d	Vocabulary, units, symbols and nomenclature	Data analysis, card sort and discussion
59. Designing a space suit for a walk on Mars	Experimental focus	Experimental skills and strategies	Planning, using models, and discussion
60. Planetary atmospheres	Maths skills	Analysis and evaluation	Data presentation and discussion

1 Energy
Solar power: the issues (PSEE)

KS4 National Curriculum WS link

1. *The development of scientific thinking*
   c. appreciating the power and limitations of science and considering ethical issues which may arise
   d. explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments

Resources:
Task sheet 1, cut into cards, with instructions:
1 set between 2/4

Time:
Activity: 10 minutes
Discussion: 10 minutes

Notes

- **Suitable for:** Starter, Main activity or Plenary
- **Key words/concepts:** social, economic and environmental issues

Suggested answers

A.	By installing solar panels, we are able to heat our own water through the year without relying on gas or electricity from the national providers.	**Social/ Environmental**
B.	Since we have installed the solar panels my heating costs have halved. It's free energy!	**Economic/ Personal**
C.	My carbon footprint is much smaller since I installed the solar panels, so I feel I am doing good for the planet.	**Environmental/ Personal**
D.	We would love to install solar panels to heat our water, but we cannot afford to get them. They cost over £2000 and it would take over 10 years to recover the cost of it.	**Economic/ Personal**
E.	All our new-builds have solar panels for heating water. The cost is absorbed into the house prices and it helps to keep our projects carbon-neutral.	**Environmental/ Economic**
F.	If everyone in the village installed solar panels, it would reduce pollution elsewhere in the country.	**Social/ Environmental**

Extension suggestion

Suggest other reasons for using solar panels at home.

Energy

Solar power: the issues (PSEE)

1

Task

Cut out the statement cards. Discuss each one and decide which issues about installing solar panels are being put forward.

- **Personal:** to do with how the issue affects an individual.
- **Social:** to do with people's lives and the effect on running a society.
- **Economic:** to do with money, either making money or keeping costs down.
- **Environmental:** to do with keeping our environment unpolluted.

A By installing solar panels, we are able to heat our own water through the year without relying on gas or electricity from the national providers. **The Wilburn family**	**B** Since we have installed the solar panels my heating costs have halved. It's free energy! **Brenda and Steven, retired house-owners**
C My carbon footprint is much smaller since I installed the solar panels, so I feel I am doing good for the planet. **Steve and Frances, house owners**	**D** We would love to install solar panels to heat our water, but we cannot afford to get them, they cost over £2000 and it would take over 10 years to recover the cost of it. **Sarah and Stuart, first-time home owners**
E All our new-builds have solar panels for heating water. The cost is absorbed into the house prices and it helps to keep our projects carbon-neutral. **John, Building Contractor**	**F** If everyone in the village installed solar panels, it would reduce pollution elsewhere in the country. **Lisa, Local Councillor**

2 Energy
History of steam energy

KS4 National Curriculum WS link

1. *The development of scientific thinking*
   a. the ways in which scientific methods and theories develop over time.

Resources:
Task sheet 2: 1 each
Scissors and glue

Time:
Activity: 20–30 minutes
Discussion: 10 minutes

Notes

- **Suitable for:** Main or Homework activity
- **Key words/concepts:** steam, energy, timelines

Suggested answers

J. As early as 10–70AD the first steam machines were invented, but were more a novelty than of any practical value.
G. 1630, a patent for 'fire engines' was given to David Ramsey who had designed several machines that used steam.
D. In around 1705 Thomas Newcomen develops the atmospheric steam engine that uses pistons. Following this, many applications of the engine are created particularly for working in the mills, factories and mines.
B. 1769, the Scottish scientist, James Watts, patented the first practical steam engine.
I. In France in 1769, the first steam-powered cart was made for the French army.
F. 1829, first steam train carries passengers between Liverpool and Manchester.
C. 1884, the first modern steam engine was invented by Charles Parsons. The basic design is used in most of our electricity generation today.
A. 1968, British Rail stops using steam-powered trains.
H. 1993, the first working nanoscale steam engine prototype was made by a physicist in the USA. It is just 5 micrometres across.
E. Nanoscale machines that are powered by steam could be made by 2020.

Extension suggestion

Research and add some other big events in the use of energy from steam.

Energy

History of steam energy

2

Task

Cut out the statements, then arrange them in the correct chronological order on the timeline below. Match the pictures to illustrate it.

Timeline

1600 AD

1700 AD

1800 AD

1900 AD

2000 AD

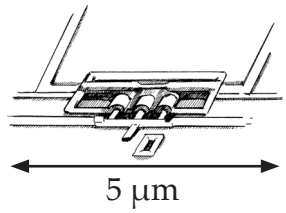
2100 AD

A. 1968 – British Rail stops using steam-powered trains.

B. The Scottish scientist, James Watts, patented the first practical steam engine in 1769. This was the start of the industrial revolution.

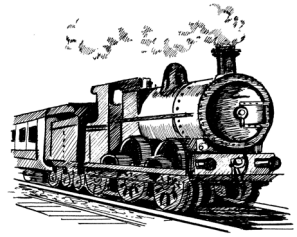
C. The first modern steam engine was invented by Charles Parsons in 1884. The basic design is used in most of our electricity generation today.

D. In around 1705, Thomas Newcomen develops the atmospheric steam engine that uses pistons. Following this, many applications of the engine are created, particularly for working in the mills, factories and mines.



E. Nanoscale machines that are powered by steam could be made by 2020.

F. 1829 – First steam train carries passengers between Liverpool and Manchester.

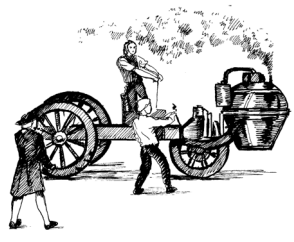


G. 1630 – A patent for 'fire engines' was given to David Ramsey who had designed several machines that used steam.

H. The first working nanoscale steam engine prototype was made by a physicist in the USA in 1993. It is just 5 micrometres across.

I. In France in 1769, the first steam-powered cart was made for the French army.

J. As early as 10–70 AD, the first steam machines were invented, but were more a novelty than of any practical value.



3

Energy

Investigating Specific Heat Capacity

KS4 National Curriculum WS link

2. *Experimental skills and strategies*
   b. planning experiments to make observations, test hypotheses or explore phenomena
   c. applying a knowledge to a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments
   d. carry out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations

Resources:
Task sheet 3: 1 each or 1 between 2

Time:
Activity: 20 minutes
Discussion: 10 minutes

Notes

- **Suitable for:** extended Starter, Main activity or Plenary, or Homework activity
- **Key words/concepts:** planning an investigation, thermal heat capacity

Suggested answers

A. Use the opportunity to discuss terms such as 'precision', reasons for using polystyrene cup, approach to measuring the mass and temperature of water.

B. The design should be based upon the control method, but with specific mention of placing rock samples in the ice bucket and reaching equilibrium; ensuring the water in the cup covers the rock samples; a means of transferring the rock samples without touching them.

C. As for B. Prediction should include a science-based justification. Safety should include: risks of water and electricity; water and ice spillages.

Extension suggestion

Draw a results table for the investigation.

Energy

Investigating Specific Heat Capacity

3

The following procedure can be used to determine Specific Heat Capacity of water.

Equipment:
3 buckets, 2 x polystyrene cups, 2 x thermometers, ice, electronic balance

Method:
The day before, fill two buckets with water and leave to stand overnight to reach room temperature.

Before doing the experiments, fill the remaining bucket with water and ice. Place any objects you wish to investigate in this bucket.

The following method acts as a control:

1. Record the mass of the empty polystyrene cup using the electronic balance.
2. Fill the polystyrene cup halfway with water from one of the room-temperature buckets.
3. Measure the temperature of the water as precisely as possible.
4. Measure the mass of the water by placing the cup in the electronic balance.
5. Using another polystyrene cup, take a little water (without any ice) from the ice bucket and pour it into the polystyrene cup of water at room temperature.
6. Record the mass of the cup to find out the mass of the ice water added to it.
7. Measure the temperature of the water once it has reached thermal equilibrium.
8. Calculate the relative heat capacity of the cold water that was added using this equation: (temperature of original water x mass of original water) / temperature of ice water x mass of ice water).
9. Find specific heat of the water using formula: $q = cm\Delta T$. If your answer is close to 1.0, you are doing the procedure correctly.

Task

Read the instructions carefully.

A. Discuss each step and explain its purpose.
B. Design an experiment to compare the Specific Heat Capacity of three rock samples: granite, limestone and marble.
C. Write a detailed plan for the investigation, include a prediction, equipment, method and safety.

4 Energy
Investigating wind turbines

KS4 National Curriculum WS link

2. *Experimental skills and strategies*
   c. applying a knowledge to a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments
   d. carry out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
   g. evaluating methods and suggesting possible improvements and further investigations

Resources:
Task sheet 4: 1 each

Time:
Activity: 20 minutes
Discussion: 10 minutes

Notes

- **Suitable for:** Main or Homework activity
- **Key words/concepts:** efficiency, wind turbines, planning

Suggested answers

A. Suggest how the method could be improved.
- Repeat the experiment for each turbine.
- Improve details: particularly with controlling variables. i.e. distance from the fan; mass of the mass; units of the equations; length of the string.
- Any other reasonable suggestions.

B. Write a risk assessment for the investigation.
- Standard laboratory safety.
- Keep electric fan cables clear of being a trip hazard.
- Depending on mass, make sure the mass falls into a box or onto a table where there are no hands or feet in the way.
- Possibly goggles in case blades fly off.

Extension suggestion

Draw a table for the results.

Energy

Investigating wind turbines

4

A simple turbine can be made using a cork with plastic blades attached to an axle. When the turbine is placed in front of an electric fan, the turbine will turn. If a small mass is attached to the cork by string, the string winds around the cork, raising the mass above the desk.

Task

Read the text below which outlines a simple method for investigating the efficiency of wind turbines.

A. Suggest how the method could be improved.
B. Write a risk assessment for the investigation.

Method:

1. We investigated three turbines. We varied the number of blades on the cork to make turbines with 2 blades, 3 blades and 5 blades. We wanted to see which was the most efficient.

2. We took the 2-blade turbine and placed it in front of the electric fan.

3. We turned the electric fan on for 60 seconds exactly. After 60 seconds we switched off the fan and measured how far the mass was above the desk.

4. We could work out how much work was done using the equation:

   Work done (Joules) = force (N) x distance (m)

5. We worked out how much energy was input by using the equation:

   Energy (J) = power (W) / time (s)

6. We then worked out the efficiency of the turbine.

7. This method was repeated for the 3-blade and 5-blade turbines.

5 Energy
Appliances data analysis

KS4 National Curriculum WS link

3. *Analysis and evaluation*
   c. carrying out and representing mathematical and statistical analysis
   e. interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions
   f. presenting reasoned explanations, including relating data to hypotheses

Resources:
Task sheet 5: 1 each or 1 between 2

Time:
Activity: 10 minutes
Discussion: 5 minutes

Notes

- **Suitable for:** Starter, Main activity, or Plenary
- Teachers may need to read through the text with less able readers before they attempt the task.
- **Key words/concepts:** energy, efficiency, environmental issues surrounding use of energy and water

Suggested answers

1. Supported, generally. Lecky is an exception.
2. Supported, generally. Lecky is an exception.
3. Supported. It has the largest capacity (they will produce lots of washing) and it is A+AA.
4. Difficult to say. It uses more water than the others; En-R-G uses less water and is still AAA.
5. Not supported. The opposite is true.

Extension suggestion

What further information would you require before deciding on which washing-machine to buy?

Energy

Appliances data analysis

5

Washing-machines have their energy efficiency rated and displayed to help customers make a decision when buying one. Energy ratings go from A–G, with A being the highest energy efficiency.

Model	Energy Efficiency Class A–G	Energy Washing	Spin Drying	Max spin speed RPM	Load Capacity Kg	Energy used per wash kWh	Water used per wash litres	Cost £
Washo	A	B	C	1000	5.0	0.95	49	170
Spinner	A	B	B	1200	5.0	0.95	49	200
Lecky	A	A	B	1500	7.5	1.33	65	280
Po-Wer	A+	A	A	1400	8.0	1.22	75	250
En-R-G	A	A	A	1600	6.0	1.02	54	300

Task

Discuss the following statements and decide whether they are supported by the information in this table. Make sure you can justify your decisions.

1. More energy-efficient washing-machines are more expensive.

2. The larger the load capacity, the more energy is used by each wash.

3. An environmentally-friendly family with two parents and four children under seven years old should choose to buy the Po-Wer washing-machine.

4. The most environmentally-friendly machine is the Po-Wer model.

5. The faster the maximum spin speed, the lower its spin-drying rating.