For Teachers

Which is the Best Fuel?

Teacher's Guide

This activity is related to

a) appreciating that fuels have different heats of combustion;

b) the meaning of ‘best’ can change depending on the context, and that different factors can be considered in determining the best fuel;

c) planning and carrying out an experiment.

The scenario has been described in such a way as to allow the students an opportunity to design the experiment. Variables to control, such as the amount of water to be used, the apparatus required and the precautions needed, are not mentioned. It is, however, possible to simplify the procedure by giving the actual experimental instructions and allowing the students to carry out the experiment. Time can then be spent discussing the meaning of 'best' as a group activity.

Learning Outcomes per lesson

Lesson 1

At the end of the lesson, students are expected to be able to:

1. understand the issue
2. suggest suitable fuels to use in an investigation
3. plan an experiment to determine the best fuel

Lesson 2

At the end of the lesson, students are expected to be able to:

1. obtain a workable plan for carrying out the experiment by discussing their experimental plan with colleagues in a group and modifying their plan as appropriate.
2. find out how to determine the calorific value of fuels and also undertake calculations on the head of combustion.

Lesson 3

At the end of the lesson, students are expected to be able to:

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1. Carry out the experiment in a group, each member of the group using a different fuel. Repeat the experiment as appropriate
2. Record the data obtained in a suitable format, calculate both calorific value and heat of combustion. Compare results with the data from others in the group.
3. Discuss the procedures used in the experiment, the steps taken to determine accuracy (including the number of repeats of the experiment) and the limitations of the set-up to give accurate results.

Lesson 4

At the end of the lesson, students are expected to be able to:

1. Write a report of the experiment, giving details of accuracy, calculation performed and how data is presented.
2. Determine the best fuel and the reason for indicating this.

Suggested Teaching Strategy

1. The lessons can begin by a revision of the meaning of a fuel. This can be undertaken by each student writing down their interpretation. This can be followed by the teacher soliciting responses from members of the class and build up a description of a fuel on the blackboard.
2. By means of a brainstorming session, the teacher can solicit examples of fuels and where they are used. [At this stage the idea is to get suggestions rather than any attempt to confine this to fuels that might be possibilities for the experiment. Thus examples such as nuclear fuel, or electricity are just as acceptable as petrol, diesel, natural gas or kerosene].
3. Following this, the teacher could raise the question - which fuel is best ? The students can discuss the meaning of best as a group discussion. To ensure the discussion can begin, the teacher can give each group a handout on possible meanings of 'best' related to fuels. [At this stage the teacher will need to limit the fuels under consideration, by suggesting, for example, that the students only consider liquid fuels]. Various ideas could be solicited from the class.
4. This can then be followed up with the question 'can you suggest how we could find out? It is suggested that students tackle this question in groups. The teacher will need to guide the students in the planning part of the experiment (as he/she goes around the various groups), by trying to get the students to suggest the following
    * something (water) is heated by burning each fuel in turn;
    * this something needs to be constant for each experiment;
    * the something could be a fixed mass of water;
    * the amount of fuel used needs to be measurable;
    * a measure of the heat given out can be taken from the rise in temperature of the water;

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* by measuring the amount of fuel before and after the experiment will indicate the amount of fuel used;
* by measuring the time taken for the fuel to burn, it is possible to determine which fuel heats the water the fastest.
* by knowing the cost of the fuel per given quantity, it is possible to determine the most economical fuel.

5. The teacher encourages students to put forward other points that may or may not be utilised, such as the water needs to be at the same temperature at the beginning of each experiment, heat losses need to be minimised/measured and the vessel in which the fuel is contained needs to be identical in each case.

6. The students, in their groups, write out an experimental procedure, suggesting apparatus that might be suitable.

   [The experiment can be conducted using apparatus as close to the students suggestions as is practicable. The main components are a spirit lamp (which is a small container with a wick), about 200g water in a conducting container (something like a 'coke' can), a thermometer (this can also act as a stirrer), balance and a stop clock. A clamp to hold the 'coke' can and draught shields to minimise heat loses by the movement of air can be extra considerations].

   In their procedure the students need to determine

   * initial mass of fuel + container
   * final mass of fuel + container
   * hence the mass of fuel used in the experiment
   * initial temperature of the water (room temperature)
   * final temperature of the water (suggested about 50 Celsius)
   * hence the temperature rise of the water
   * time for which the fuel was burning
   * cost of fuel used

   [Possible fuels to use may be - paraffin, methylated spirits (ethanol), methanol, candle wax (spirit burner not required in this case)]

7. After the planning exercise, the teacher can discuss the procedure with the class, making sure unsafe practices are not suggested. Then, to ensure each group is able to carrying out the experiments, the teacher can give a handout to each student group, detailing the experimental procedures (this can be modified to more closely follow the students' suggestions)

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Achieving the Objectives

OBJECTIVE	This is achieved by
1. to appreciate that 'best' can have more than one interpretation and to suggest the most appropriate meaning in this context	the students discussing their suggestions given for the 'best' fuel. They need to give reasons for their suggestion from a social and scientific point of view.
2. planning an investigation, interpreting experimental instructions and carrying out an experimental procedure	the students discussing how to measure the heating ability of a fuel and then carrying out the actual experiment in small groups by following experimental procedures which are an adaptation of those put forward by the students.
3. undertaking calculations to determine the link between amount of fuel, temperature changes and time taken	by the students calculating the calorific value and heat of combustion from the readings taken during the experiment
4. cooperating as a member of a group	the students working as a group in carrying out the experiment and in the results from the whole class being pooled to obtain a set of results from which the 'best' fuel can be determined
5. Communicating orally and by means of a written interpretation	discussing within a group the meaning of 'best fuel' and in developing the working procedures for the experiment. The written interpretation is undertaken by each individual student
6. Explaining the meaning of fuel and introducing the heat of combustion	the individual classwork in which students give their ideas in writing, followed by the blackboard summary. Heat of combustion is introduced as the conclusion of the experiment, based on parameters used in the experiment. (An extension could be for students to base the heat of combustion on standard parameters e.g. 1 mole of water heated 1^{o}C rise).

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