Sustainability Teaching Unit

Information for teachers

This teaching unit is based on a one-week research course for elementary school students, which is part of the Forscherwelt or Researchers' World education initiative.
The teaching concept and program were developed under the guidance of Prof. Dr. Katrin Sommer, Chair of Chemistry Didactics at Ruhr University Bochum, Germany, with the support of Henkel experts.
The experiments are suitable for third or fourth grade students.

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Suitable for approx. 9 double periods

Introduction

In the research world, elementary school students can become mini-researchers and conduct their first scientific experiments. The topics come from the “real” research carried out by Henkel and reflect on a small scale what adult researchers do when they develop new products. At Henkel, the issue of sustainability has traditionally been of paramount importance. The company therefore created a one-week summer program on this topic as part of Science Year 2012 “Project Earth: Our Future.”
This summer program was subsequently developed into a teaching unit for elementary school science lessons.

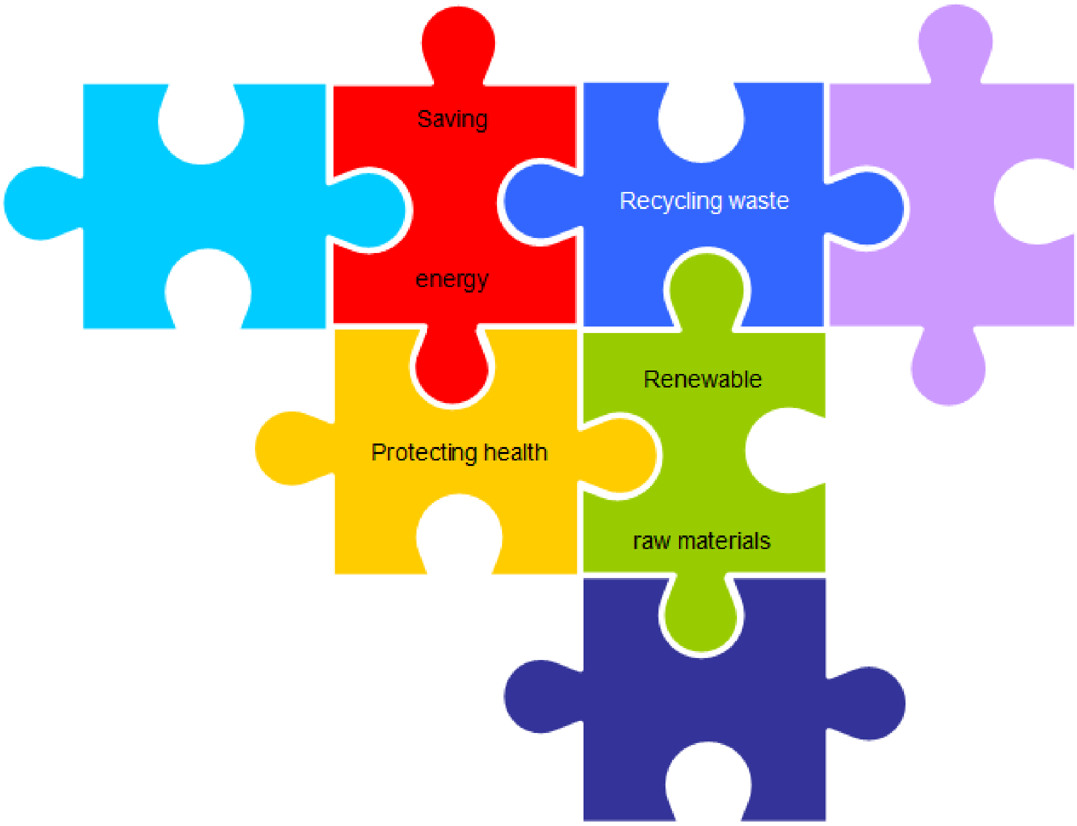
Many people, particularly children, are not sure exactly what “sustainability” means. The term tends to be associated with environmental issues, but it covers much more.
Based on a definition developed by the World Business Forum for Sustainable Development, Henkel has defined “sustainability” as follows:
The human race lives well, in harmony with the Earth’s limited resources.
For children, the following is easier to understand:

Sustainability means:

“All people on our earth living well and using only so much water, wood and other natural resources like our earth can re-build again.
To achieve this, three behavior patterns are very important:
reduce (meaning: no wasting),
reuse,
recycle.”

In this teaching unit, we would like to make “sustainability” tangible. For this reason, we will introduce the students to four areas in which they themselves can act in a sustainable way. We have also developed four key phrases for each of these areas: “Sustainable means …”

The four areas of sustainability in the teaching unit:



Sustainable means:

……using energy efficiently

…….avoiding, separating and recycling waste

…….using renewable raw materials

…….maintaining and protecting our health

Teaching unit modules

Lesson 1	A visit to the research world: introduction to the topic with film and discussion, laboratory permit
Lesson 2	Saving energy
Lesson 3	Avoiding and recycling waste
Lesson 4	Renewable raw materials 1 – using the example of a glue stick
Lesson 5	Renewable raw materials 2 – using the example of a glue stick
Lesson 6	Renewable raw materials 3 – using the example of a glue stick
Lesson 7	Protecting our health 1 – using the example of dental health
Lesson 8	Protecting our health 2 – using the example of dental health
Lesson 9	Protecting our health 3 – using the example of dental health

Lesson 1: Introduction to the topic

On their first visit, the students are given an initial overview of the topic by Henkel employees who have received training to become sustainability ambassadors. A short film shows the children how they can help the environment in their daily life. They are then given specially designed pictures to color in where they can indicate everyday situations in which, for example, electricity or water can be saved.

In the second part of the lesson, the students are introduced to laboratory rules and simple laboratory equipment.

Lesson 2: Saving electricity – saving energy

In the first lesson, the students discovered that saving energy or electricity is good for the environment. The actual meaning of the term “energy” was not discussed. This should therefore be looked at in the second lesson.
The term “energy” is one with which most elementary school students are familiar. They may even know everyday terms or phrases such as “solar energy,” “energy consumption,” “energy bar” and “it takes a lot of energy.” Most students also know that energy consumption, the emission of greenhouse gases/CO_2 and climate change are connected in some way. They associate “saving energy” with “environmental protection.” But what exactly is “energy”?

Introductory classroom discussion
Energy and electricity consumption are often used synonymously in everyday speech, although energy is sometimes also used to mean thermal or kinetic energy. From a scientific point of view, use of the term “energy” is therefore frequently regarded as vague. As a result, we will briefly discuss with the students where electricity from the outlet comes from and what it has to do with energy at the beginning of the lesson before moving on to the topic of saving electricity/energy.

► **For electricity to be generated, energy needs to be used.** When we “tap” electricity from the outlet, energy needs to be expended somewhere else in order to generate the electricity – in power plants, for example. The students should name examples of types of power plant that they know (hydroelectric power station, coal-fired power plant, nuclear power station, solar systems, wind turbines).
The power plants convert “energy sources” into electricity. We are talking about solar energy/wind power/hydroelectric power. But not every energy source is available indefinitely and can be used without problems.

► Coal-fired power plants and nuclear power stations are not very environmentally friendly and are associated with major risks.
► Greenhouse gases are emitted in conventional energy production (coal, gas).
► Greenhouse gases are blamed for climate change.
► Saving electricity means saving energy.
► Saving energy means reducing greenhouse gas emissions.
Electricity costs money ►saving electricity means saving money.

Transition to the second part:
Before starting the experiment, the students should think about what electricity is used for in the home – for cooking, for example. How can electricity be saved here?
“Pia’s father, for example, claims that the water you use for cooking pasta boils more quickly if you cover the pot with a lid. This means you use less electricity before the water starts to boil if the pot is covered with a lid than if it is uncovered.” ► Is this correct?
► **Question to be investigated:**
Is less energy needed to boil water with a lid than without a lid?

We now come to worksheet 1 for this lesson. The students are first given an open assignment in which they should think about how they can answer the question to be investigated with the help of an experiment using the materials available to them:

What experiment can you do to test the claim made by Pia's father?
Each research group has the following materials available for the experiment:

- 1 liter (34 fl. oz.) water in a measuring cup
- 1 large beaker
- 1 hotplate magnetic stirrer
- Aluminum foil
- 1 stopwatch
- 1 thermometer
- 8 boiling stones (which are put into the water to be boiled)

Discuss with your partners how you can work with the other groups to answer the question.

The students are given the following tip to help them:
When researchers want to compare something, they often conduct two experiments. The two experiments must be carried out in the same way, the only difference being the specific aspect you want to investigate.

First of all, the students should independently come up with suggestions about how to carry out the experiment. They should write down their ideas (worksheet 1) and then present them to the rest of the class. It is important to discuss with the students what they want to measure and how they can use the results to answer the question.

Depending on the strategies developed by the students themselves, a discussion can be held in which the students can more or less be steered toward forming two groups. The first group heats the water with a lid (aluminum foil). This group will be called the experimental group. The other group heats the water without a lid. This group forms the control group.
After the basic approach has been discussed, the students should go through worksheet 2 – which contains a specific solution proposal – and sketch the set-up of the experiment that they have planned. During the experiment, they should note down on worksheet 3 how long it takes for the water to reach 40°C (104°F), 60°C (140°F), 80°C (176°F) and 99°C (210°F). Comparing the figures measured with and without a lid shows that less time is needed to heat the water with a lid and the electric hotplate can be switched off sooner. This saves electricity.

N.B.: In order to be able to compare the measurements, each team must use the same equipment. If there are not enough materials available, the experiments can be carried out consecutively using the same apparatus.

Lesson 3: Avoiding and recycling waste

Example: cardboard/paper

Introductory classroom discussion:

Repeat the first key phrase: Sustainable means… using energy efficiently.

Question for the students: Can you think of any other situations in which you could act in a sustainable way? If the students do not come up with the topic of "waste" themselves, they should be steered toward it with appropriate questions. For example, they could think about whether they have created waste on that particular day and how much. They could also be asked whether their families separate waste and whether they know what happens to waste paper, for instance.

Using laminated sheets on the chalkboard and then the instructions for the experiment (worksheet 4), the paper cycle is gone through and the individual steps named. The industrial cycle and the experiment are compared, with the industrial steps that the students can reproduce in their experiment being highlighted. The students then work in pairs, following the instructions on worksheet 4.

Materials required for each team of students

- 15 g (0.5 oz.) of cardboard
- Measuring cup for water
- Water
- Large shallow plastic bowl
- Rolling pin
- Hand blender + tall container
- Fly screen for use as a flat sieve (approx. 30 x 40 cm / 12 x 15 inches)
- 1 kitchen towel or old T-shirt

Instructions

1. Weigh out 15 g (0.5 oz.) of cardboard. Tear the card into pieces the size of your thumbnail and put the pieces of card into a tall container.
2. Use the measuring cylinder to measure 200 ml (7 fl. oz.) of water and add the water to the pieces of card in the tall container.
3. Blend the card and water mixture until you have a gray pulp. You should not be able to see any large pieces of card in the pulp.
4. Put the pulp into a shallow dish and add 1 liter (34 fl. oz.) of water. Stir the card and water mixture vigorously by hand.
5. Use the fly screen as a sieve: Two of you stretch the fly screen across the sink and hold it tightly. Another one then pours the pulpy mixture onto the fly screen so that excess water can drip through. When the mixture stops dripping, put the fly screen containing the pulp onto the table, place a piece of fabric on top and turn both over.
6. Roll the rolling pin over the screen several times.
7. You can then put the piece of fabric with the "paper" onto the drying rack to dry.

Lesson 4: Renewable raw materials /1

The next three lessons cover renewable raw materials and introduce students to the topic using an everyday product they know well: the glue stick. Glue sticks can be produced from starch, a renewable raw material.
The lesson should with start with an explanation of what a “raw material” is and what “renewable” means in this context. The students are provided with a brief fact sheet:

What is a raw material?
Pens, paper, T-shirts, toys – virtually everything we come across in our daily lives is produced from a variety of raw materials. Wood is the raw material from which furniture or paper is made, for example, while cotton is the raw material generally used to make T-shirts. Plastic toys are produced from crude oil, another raw material. Raw materials are therefore substances from which all kinds of things can be made in one or more manufacturing steps.

What does renewable mean?
Plants grow relatively quickly and keep on growing when they are replanted. They are called “renewable raw materials.”
Crude oil, which can be used to produce a whole range of things from gasoline to plastic, does not grow back quickly. Once all the crude oil on Earth has been used, it cannot simply be “planted” again. Crude oil is **not** a renewable raw material. This means we should use it efficiently.

After the general introduction to renewable raw materials, starch is introduced as a raw material for glue sticks. But where does starch come from – from which plants? And how can we see which plants contain starch? To answer this question, in lesson 4 the students first learn about a method for detecting starch using a solution of iodine and potassium iodide (Lugol’s solution). These kinds of detection methods are part of the researcher’s toolkit – which is something that the students also need to learn about.

The students begin with a positive blank sample containing cornstarch (worksheet 5).
In the next step (worksheet 6), they are introduced to a range of different foods that might contain starch, such as potatoes, cucumber, milk, crushed grains of rice or corn kernels.
Before starting the experiment, the students should first think about which foods might contain starch. They then test their assumption using the detection method they just learned and document their results.

Materials required per pair of students

- Lugol's solution (iodine/potassium iodide solution)
- Disposable pipette
- Several test tubes or other small glass containers in which the substances to be tested can be mixed well with Lugol's solution
- Cornstarch and confectioners' sugar for the blank samples
- Starchy foods, such as potatoes, soaked rice grains and canned corn
- Non-starchy foods, such as cucumber

To test for the presence of starch, put the powder substances into a test tube with a little water and add a few drops of Lugol's solution. If starch is present, the substance will turn dark blue/purple or black.
If you use potatoes, cucumber or rice grains, it is advisable to have the students grate or crush the food beforehand and to put drops of Lugol's solution directly onto the food.

Lesson 5: Renewable raw materials /2

Obtaining starch from food

Once the students have found a starchy raw material (potatoes or corn), they move on to the next step of isolating the starch from this raw material. The students should work in pairs. The class can be started with a discussion about how the students could get the starch out of the food. The observation that water becomes cloudy if a starchy food is left to soak in it for several hours can be a helpful starting point. This phenomenon is particularly noticeable when grains of rice are soaked in water. The cloudiness means that something has "migrated" from the food into the water. It is useful to prepare a sample beforehand illustrating this effect.

Once the students have realized that you can use water to obtain the starch from the food, they can start the actual experiment (worksheet 7):

Materials required for each pair of students

- 3-6 potatoes, depending on size
- Or 150 g (5 oz.) cornmeal
- An old dish towel
- 2 medium sized plastic bowls
- Vegetable grater
- 1 china dish or heat-resistant crystallizing dish
- Measuring cup
- Water

Instructions

1. Choose one of the foods (3-6 potatoes or 150 g (5 oz.) of cornmeal) and grate if necessary (into a plastic bowl).
2. Add 300 ml (10 fl. oz.) of water to the grated food in the plastic bowl and stir with a glass rod.
3. Put a dish towel above a second plastic bowl, pour in the mixture and squeeze out the water (liquid). Collect this liquid in a bowl and wait until some sediment settles at the bottom.
4. Put the remaining mixture back into the first bowl and repeat steps two and three, but using only 200 ml (7 fl. oz.) of water. Wait five minutes and then carefully strain off the liquid. Leave the white residue at the bottom in the bowl.
5. Put the residue into a dish and place the dish in the oven at 180°C (350°F) for 20 minutes.

After the drying step, a hard whitish substance remains in the dishes: the starch.

Lesson 6: Renewable raw materials /3

Having managed to obtain starch from potatoes in the previous double period, in this lesson the students will be introduced to a formulation and instructions for making a simple adhesive substance. As an introduction, they will watch a short TV film showing how Pritt Stick is made. The students learn from the film that the adhesive stick contains two key ingredients, starch and soap, and also that a watery mixture of raw materials has to be heated to over 75°C (167°F).
The assignment (worksheet 8) involves systematically varying a basic formulation in order to determine the quantities of raw materials needed to produce an adhesive substance most similar to the glue stick. This gives the students an insight into the systematic way in which researchers work.

Materials required for each pair of students

- 10 g (1 tablespoon) cornstarch
- 10 g (1 tablespoon) soap powder – or a piece of soap, unfragranced if possible
- Water
- Measuring cylinder
- Thermometer
- Beaker (approx. 150 ml/5 fl. oz. capacity) or other container suitable for heating
- Hotplate
- Glass rod
- Vegetable grater

Instructions

1. Use a vegetable grater to grate the piece of soap until you have enough soap powder.
2. In a beaker (150 ml/5 fl. oz. capacity), dissolve 1 g (¼ teaspoon) of the grated soap in 14 ml (1 tablespoon) of water as thoroughly as possible; this will produce a lather.
3. Add 4 g (1 teaspoon) of starch to the lather mixture produced and mix well with the glass rod.
4. Heat the mixture on a hotplate to a temperature of about 75°C (167°F), stirring occasionally with the glass rod.
5. Repeat steps 1. to 4. using 2 g (½ teaspoon) and 4 g (1 teaspoon) of soap.

Lesson 7: Protecting our health /1

The final three lessons cover an aspect that is not linked quite as obviously to sustainability: health protection. The class should start with a discussion about why sustainability also includes health protection. Reference should then be made to the example of dental health. This is an area where the students themselves are able to protect their health – and thus act in a sustainable way.

Initial conclusion: Sustainability also includes health protection ► Good dental hygiene protects our health because bad teeth may cause other diseases. ► What's more: Healthy teeth are attractive ☺ ► Dental hygiene protects your health – and gives you a dazzling smile!

We then look in detail at the cause of caries. The students generally have a misconception here. Most children think that sugar is directly responsible for caries. Strictly speaking, however, this is not the case.

It is explained to the students that bacteria "eat", process the sugar and a new substance is produced: lactic acid. This is called "metabolism." Humans are similar: They eat food, digest it and excrete the unusable leftovers. These bacteria cannot be seen with the naked eye, but tablets are available that stain the areas where bacteria are found (plaque). (This may be demonstrated.)

The bacteria in the mouth are called "lactic acid bacteria." This name comes from the substance they produce. The lactic acid from bacteria in the mouth damages the teeth and causes caries.

What is an acid?

The first few experiments focus at phenomenological level on what an acid is. The students are introduced to indicator paper/indicator strips that they can use to test whether or not a liquid is acidic. The concept of acids and bases is deliberately not addressed at this point. The students' assignment is to use an indicator to investigate the following liquids: tap water, household vinegar, lemon juice, lemonade and lactic acid (worksheet 9). For this experiment, each group needs a set of test tubes and, ideally, simple indicator paper. The results are subsequently compiled on the chalkboard.

Lesson 8: Protecting our health /2

In the previous lesson, the students learned how to detect the presence of acids. The next step is to examine more closely the effect of acids on substances that contain calcium – because teeth contain acid-soluble calcium. The class should start by defining the term “calcium.” Calcium is contained, for example, in lime (calcium carbonate) as well as in other substances. To illustrate this, the students are shown a number of objects that contain calcium: marble, chalk, eggshells.
Eggshells are used below as a model substance for teeth. The term “model substance” should therefore also be explained in the introductory discussion: Model substances are substances or materials used as a substitute in investigations if experiments on the actual object under investigation are not possible. To relate this to the current situation: In the following experiment, you cannot remove your own teeth and examine them in a test tube. ;)

The question for the students to investigate is as follows (worksheet 10):
What effect does acid have on the eggshell?

Materials required for each pair of students

- Piece of an eggshell
- Approx. 100 ml (3.5 fl. oz.) household vinegar
- Test tube
- Scales that are as accurate as possible

Instructions

1. Weigh your eggshell and make a note of its weight.
2. Put your piece of eggshell into a beaker and add enough vinegar to cover the eggshell completely. Wait for 15 minutes.
3. Weigh the eggshell again.
4. Calculate the difference between the first and second times that you weighed the eggshell. TIP: To find the difference, you need to subtract one number from another.
5. Write down what the acid does to the eggshell.

We also use a simple digital microscope connected to a computer by USB cable. This is used to produce a highly magnified image of an eggshell before and after it was placed in vinegar.

Lesson 9: Protecting our health /3

The students have seen that acid attacks the calcium-containing eggshells. In a classroom discussion, the results of the model experiment should now be linked to the effect of acids on calcium-containing teeth. The model experiment suggests that acids attack teeth and cause cavities (caries).
The students know that caries can be prevented by regularly cleaning your teeth with toothpaste. But how exactly does toothpaste work?
Toothpaste contains two important components that are responsible for protecting our teeth: firstly fluoride, which inhibits the development of caries, and secondly abrasive particles that help the toothbrush to remove food and plaque from the teeth and thus deprive the bacteria of their “food source.” In this lesson, the students will conduct an experiment on both components.

First question to be investigated:
How can you show that toothpaste protects your teeth from acid?

Before being given the instructions for the experiment, the students should suggest how the question could be answered.

Materials required for each pair of students

- 1 egg
- Toothpaste
- Beaker/container for the egg
- Household vinegar

Instructions

1. Divide your egg into two halves by drawing a line in the center.
2. Rub toothpaste into one side.
3. Put approx. 100 ml (3.5 fl. oz.) of vinegar into a beaker and place the egg in the vinegar.
4. What do you observe? Record your observations:

Second question to be investigated:

Which substances in toothpaste help to remove food and plaque from your teeth? To answer the question, test whether you can clean a coin using toothpaste, table salt, lime or detergent.

Materials required for each group of four

- 4 coins
- Thin cleaning cloths
- Toothpaste
- Detergent
- Table salt
- Lime (calcium carbonate)

Instructions

Work in a group of four. Each student receives a different “cleaning agent.”

Put a small amount of your cleaning agent onto a cloth and rub the coin for 10 minutes. Compare your coin with the coins cleaned by your neighbors.

The cleaning agents that contain abrasives clean most effectively.