

Catch them young: university meets primary school

Teaching science at primary school can be a challenge. At *La main à la pâte*, Samuel Lellouch and David Jasmin send university students to support primary-school teachers. Why not try two of their activities in your classroom?

Image courtesy of Fabrice Krot, La Maison des Sciences



Image courtesy of leby17 / iStockphoto



Guillermo is an engineering student at the prestigious Ecole Polytechnique in Saint Etienne, France. He is supporting Pascale, a teacher delivering a unit on electricity to six-year-olds (French CP level) in a local primary school. At the end of the class, they review the activities:

“Have you seen the diagrams the children made today? Their progress is amazing!” comments Pascale. “Next week we’ll learn about the switch. Can you come and help? It would be great if we could work together again.”

“Sure. I can provide diagrams, help you prepare the materials and guide the children’s ideas,” says Guillermo. “The switch is quite a difficult topic for six-year-olds. Perhaps we could

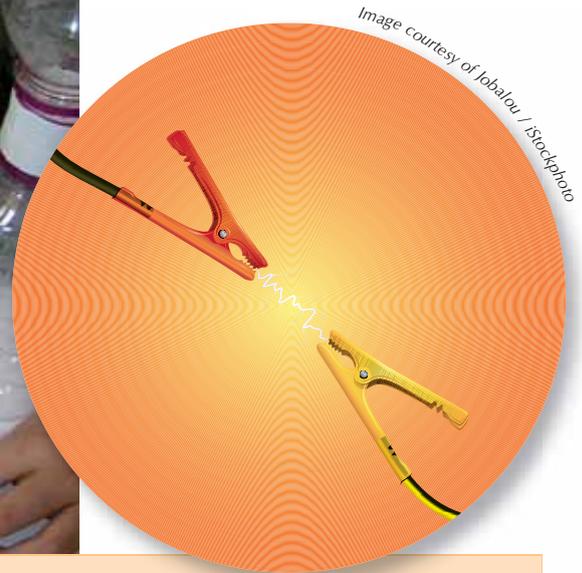
introduce it by asking them how they could turn off a light bulb without disconnecting the wires.”



As part of a project called *La main à la pâte*^{w1}, between 1500 and 2000 science or engineering students in France coach primary-school classes (children aged 3-11) during science lessons. The project was launched in 1996 by physics Nobel Prize winner Georges Charpak and the Académie des Sciences to promote investigation and inquiry-based science teaching in primary schools. Although it began in France, the project now runs in more than 20 partner countries. There are *La main à la pâte* mirror websites in German^{w2}, Spanish^{w3}, Serbian^{w4},



Pupils performing the sand timer activity



A win-win situation

Arabian^{w5} and Chinese^{w6}, as well as an international web portal, Teaching Science^{w7}. With versions in English, French and Spanish, this portal includes links to many of *La main à la pâte*'s partner projects in countries such as Belgium, Sweden, Turkey and Switzerland.

While an inquiry-based approach makes science more enjoyable for children, as well as helping them develop important skills and acquire scientific knowledge, it can be time-consuming. Particularly at first, preparing and running the sessions can be a lot of work: finding materials, organising experimental work, and guiding individual groups or children. Moreover, many primary-school teachers do not feel confident

The children learn about their own abilities to perform scientific experiments, and have the opportunity to compare their approach with that of a 'real' science student. In addition, the inquiry-based approach allows children to enjoy teamwork as well as the experimental activities themselves: this is a real source of motivation and shared joy.

The primary-school teachers may realise that science is not as difficult as they thought and, with the students' coaching, they can familiarise themselves with inquiry-based approaches similar to those used in scientific research. This is especially important because these teachers are more often trained in arts than in science – according to the French ministry of education, 80% of primary-school teachers do not have a scientific background. It is also satisfying for teachers to see how motivated and concentrated the children are in a concrete experimental situation.

The science and engineering students have the opportunity to give children a realistic idea of their job in particular and of science in general, while at the same time gaining an interesting insight into the world of teaching. Moreover, they face the sometimes difficult task of adapting their knowledge to a particular audience: children aged 3-11 can cause disconcerting situations, posing a real challenge to the students.

BACKGROUND



Pollen: scientific coaching at a European level

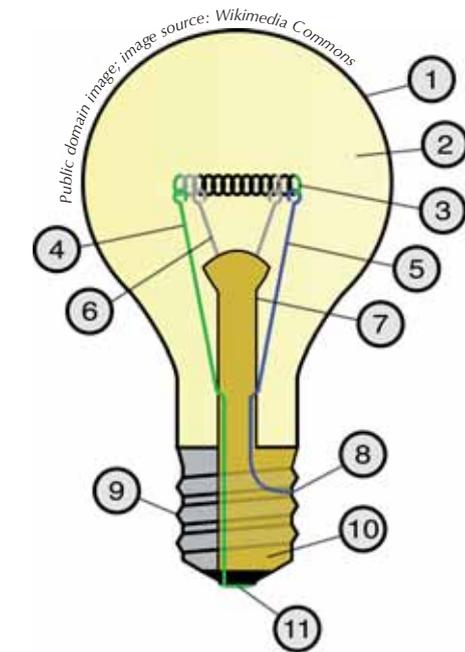
Pollen is a European project which aims to stimulate and support inquiry-based science education in European primary schools. Within the project, 12 seed cities for science in 12 EU countries have been selected to involve the whole community (including families, scientific partners, city halls, and cultural centres) in enhancing science teaching at primary-school level.

Teachers and scientists outside seed cities can get involved by forming local partnerships to become part of Pollen. They can also contribute to the online resources^{w9}, which are freely available.

BACKGROUND

enough to run scientific activities in lessons.

Students like Guillermo help overcome such difficulties. Coming from engineering schools, technical universities and university science departments all over France, they volunteer to help teachers use an inquiry-based approach in the classroom. For at least seven consecutive weeks, third-year students spend half a day per week at a primary school. Each student helps a teacher to prepare the lesson – finding materials, preparing handouts, and setting up the experiments, as well as helping with the sci-



1. Glass bulb
2. Inert gas
3. Tungsten filament
4. Contact wire (goes to foot)
5. Contact wire (goes to base)
6. Support wires
7. Glass mount/support
8. Base contact
9. Screw threads
10. Insulation
11. Electrical foot contact

entific concepts and knowledge. The teacher remains in charge of the lesson, and the student supports both the teacher and the children throughout the inquiry process. Once the lesson is over, the student and teacher analyse it together.

To allow more students and teachers to participate in such partnerships, as of 2009 the French ministry of education and ministry of research and higher education have joined this project, developing it into ASTEP^{w8}: supporting teachers through the involvement of scientists in primary education.

Furthermore, *La main à la pâte* is the French co-ordinator of the European Pollen project^{w9} (see box), which also promotes an inquiry-based approach, but with a stronger emphasis on community participation. Saint-Etienne, the French Pollen seed city, has concentrated on strengthening the links between primary schools and its university. Based on this experience, they have created a guide and a training unit for scientists and teachers, both of which are available online in French and English^{w10}.

Below are two teaching activities developed by teachers and students

involved in the *La main à la pâte* and Pollen projects. Details of many more activities are available on the *La main à la pâte*^{w1} and Pollen^{w9} websites.

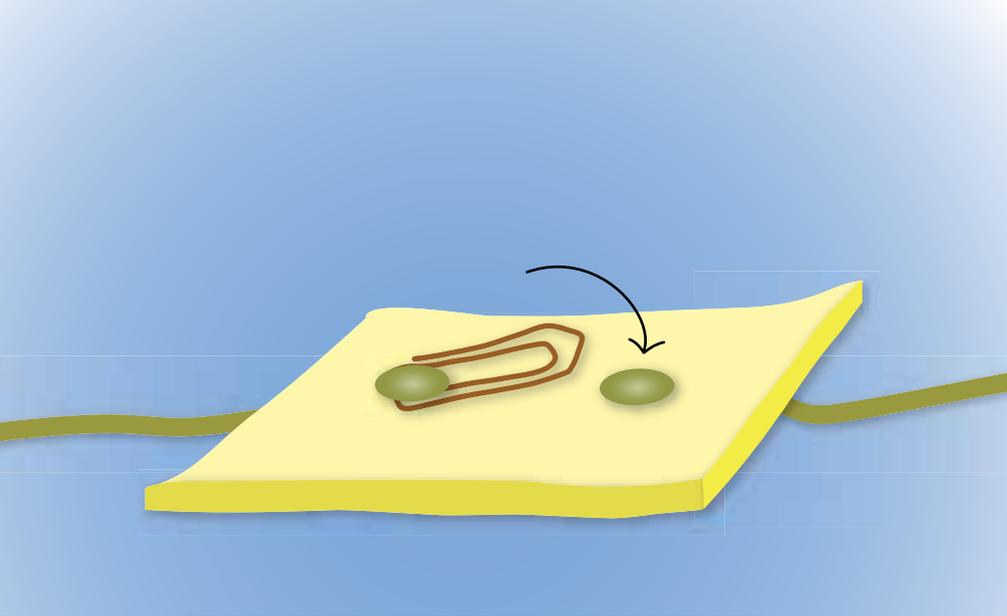
How can the bear's nose be switched on?

This activity, discussed by Pascale and Guillermo, is a teaching unit in six sessions to introduce the notion of the electric switch to children aged 3 – 6^{w11}. It can provide some ideas for teaching children about electricity, a topic that is often neglected in primary schools because teachers find it difficult to know how to approach it in class.

In the next section you will find the basic background knowledge required for the teacher and the class to work on this unit, while subsequent sections outline the activity itself. Further background information developed by *La main à la pâte* for teaching electricity at primary-school level can be downloaded from the *Science in School* website^{w12}.

Background knowledge for teacher and class

The key is to know what a simple electric circuit is. It consists of a con-



A switch made with a paperclip and two split pins

Image courtesy of Nicola Graf



Image courtesy of Jean Jannon / Pixello

A split pin

tinuous series of conductive objects, including a battery, electric cables and a light bulb. All these objects must be in contact with each other, one after the other, forming a closed loop – an uninterrupted circuit. Of course you can't see what's inside the battery, and it's dangerous to take it apart since it will generally contain harmful chemicals, but a functioning battery is built to ensure circuit continuity, allowing electricity to flow. If the circuit is cut at some point, the battery can no longer ensure the flow of electricity.

To understand that the circuit really forms a loop, the class can initially take a close look at a light bulb without a socket and with broken glass. They can see that it contains two different contacts (the base contact and the electrical foot contact; see image on page 46), and they can then trace the path followed by the electricity from one of the contacts through the filament to the other contact.

Unfortunately, at primary-school level there is no experiment to visualise which

direction the electricity flows in, since you'd have to be able to watch the tiny electrons. The important thing at this level is that electricity can move only if the circuit contains a working battery and forms a closed loop. How do you know if electricity is flowing through the circuit? At primary-school level, the only way is to see if a light bulb in this circuit is glowing or not.

If electricity is flowing through the circuit, the electrical current will travel through the filament; because of the filament's electrical resistance, it will become white-hot and generate light and heat. The filament is always inside a glass receptacle containing a vacuum or an inert (noble) gas, to prevent it from reacting with the oxygen in the air (i.e., burning).

When introducing the switch, the main thing is that pupils understand that it is a moveable element of an electric circuit which, depending on its position, can either ensure or interrupt the continuous flow of electricity. Once this concept has been

established, any item which fulfils this function is a valid switch, even if it's only a paperclip with two split pins (see images above), or – for smaller children – a crocodile clip (see image below) with which they can open and close the simple electric circuit they made.

Equipment and materials

- Light bulb screwed/ fixed into a base
- Connecting cables
- Battery
- Pocket torch
- Undecorated papier maché bear head with a light bulb as its nose (or similar inspiring setup)
- Materials to decorate the head (colours, etc.)

The electrical supplies can be purchased from local material companies, if they're not yet available at the school.

Procedure

Each step takes about 45 minutes. The following is just a proposed summary of the teaching unit. The pupils should focus on a familiar object to begin with, starting with a real-life

A crocodile clip



Public domain image; image source: Wikimedia Commons

use of battery and bulb, such as a pocket torch. After that, they can work in a more formal way with a battery and a bulb as a model for that object.

Step 1

- Switch on a pocket torch.
- Discuss with the pupils: Which elements are required to turn on a pocket torch?
The answer is: a battery, a switch, and a light bulb.

Step 2

- Discuss with the pupils: How can the bulb be switched on and off outside the torch?
- Take the bulb out of the torch.
- Light the bulb with a simple battery.
- Let the pupils draw the setup and try it out experimentally.
- Discuss with the pupils: What is/are the element(s) that generate light within the light bulb?
The answer is: the filament.

Step 3

Discuss with the pupils: How can we connect the bulb when the battery is far away?

The answer should involve connecting each pole of the battery to one of the bulb's contacts by adding two cables, which can be secured with crocodile clips, for example (see image below).

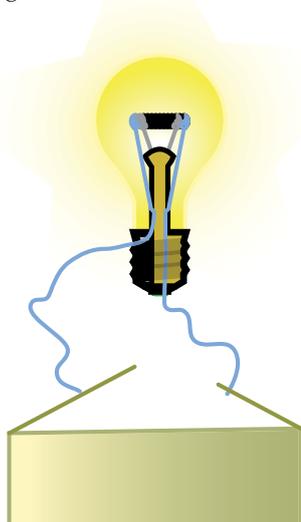


Image courtesy of Nicola Graf

Step 4

- Show pupils the papier maché bear with its light bulb nose.
- Let the pupils imagine the electrical circuit that would be necessary to switch on the bear's nose and ask them to draw it from scratch.

Step 5

- Gather all pupils and select several drawings of the electrical circuit.
- Discuss with the pupils: What changes would these circuits need in order to work?
To help pupils propose the changes, the teacher can compare the different diagrams and the class can select some diagrams to try out experimentally until they find the correct solution.



Images courtesy of Magali Courbin, La main à la pâte



Step 6

Decorate the bear head.

Step 7

Assemble the electric circuit inside the bear's head, and use the switch to light up the bear's nose!



Image courtesy of Magali Courbin, La main à la pâte

The decorated bear's head with its light bulb nose switched on

Sand timer races

Below is a selection of activities from one of the Pollen teaching units. This teaching unit for pupils aged 3-6 deals with two essential quantities in physics: time and speed (for a more complex notion of 'time', see Al-Khalili, 2009, pages 15-19 in this issue). It enables the children to familiarise themselves with ideas such as 'faster than', 'slower than' and 'at the same time as'. This teaching unit focuses on the inquiry-based method of experiment and discussion, and in it children study, use, produce and compare sand timers. They also learn to make the connection between the volume of sand (or in this case, semolina) in a sand timer and the timer's running time. To view the whole unit, visit the Pollen website^{w13}.

I – Preparing the sand timers (for the teacher)

Materials per sand timer

- Two plastic bottles, one with a screw cap and one without
- Semolina (flows more steadily than sand)
- An awl or similar sharp object
- Sticky tape

Procedure

1. Punch a hole into the screw cap using the awl. Make sure the hole is more or less the same size for each sand timer you make.
2. Take the bottle to which the screw cap belongs, and pour semolina into it (you will need different levels of semolina in different bottles – see part II).
3. Close the bottle with the pierced screw cap.
4. Turn the other bottle upside down and attach the two bottles at the neck, using sticky tape, to make a sand timer.

Note: For some of the exercises, the pupils themselves must fill the sand timers and glue the two bottles together (see parts III and IV).

Image courtesy of Fabrice Krot, La Maison des Sciences



II – Compare the time required for three sand timers to finish (20 minutes)

Materials for each group of four pupils:

Three plastic bottle sand timers filled with three different levels of semolina and marked in different colours: red for the emptiest, blue for the middle one, and black for the fullest.

Procedure

1. Divide the class into groups of four pupils each.
2. Three of the pupils have one sand timer each, and the fourth is the note-taker.
3. Instruct the pupils to turn the sand timers over, and rank them according to how fast they finish.
4. Repeat the experiment three times, with the pupils changing roles.
5. Discuss: Why didn't the sand timer with the least semolina (red) always finish first?
6. Conclude: The three sand timers have to be turned over at the same time.

1st	2nd	3rd
X	X	X
X	X	X
X	X	X

Table 1: Example of a written record by a group of four children. Column 1: sand timer that finishes first. Column 2: sand timer that finishes second. Column 3: sand timer that finishes third. The colour of the X represents the colour the sand timer was marked in

7. Decide to always use the same method to compare the sand timers:
 - One 'measuring' pupil with no sand timer counts to three.
 - On the count of three, the other pupils in the group turn over the sand timers.
 - When one sand timer has run out, the person who turned it over raises his or her hand and says the name of the sand timer colour, for instance: "Red!"

- The 'measurer' notes the order in which the sand timers finish.

8. Repeat the experiment three or four times.
9. Is the finishing order now always the same? Why/why not?

III – How can we adjust the time that a sand timer takes to finish? (20 minutes)

Materials for each child

- 3 empty sand timers marked in red, blue and black
- Semolina
- A sheet to record the finishing order

Procedure

1. Divide the class into small groups.
2. Hand out charts telling pupils the order in which the sand timers should finish (for instance red, then blue, then black).
3. Instruct the pupils: fill up the three sand timers to achieve the results provided in the chart.
4. Check and record the results.
5. The pupils should learn that the more semolina their sand timer has, the longer it will take to finish.

IV – Predicting the order in which the sand timers will finish according to semolina volumes (20 minutes)

Materials for each child

- 3 empty plastic bottle sand timers marked in different colours
- Semolina
- A funnel (can be made by rolling up paper)
- A small jar
- Filling level instructions (e.g. 1 jar of semolina for the red sand timer, 2 for the black and 3 for the blue)

OO > X	OOO > X	O > X
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Table 2: Example of filling level instructions for three sand timers. O = one jar of semolina

A worksheet with results tables (see below)

Procedure

1. Divide the class into small groups.
2. Instruct the pupils to fill the sand timers as indicated in the instructions.
3. Ask pupils: What order will the sand timers finish in? Write down the results you think you will achieve on the worksheet (see below).
Perform the experiment.
4. Write down the actual results (see example below).

Group: Chloé, Marion and Maureen

Fill all of the sand timers correctly and arrange them from the fastest to the slowest.

The results I expect

1 st	2 nd	3 rd
X	X	X
O	OO	OOO

The actual results

1 st	2 nd	3 rd
X	X	X

Table 3: Example of a worksheet to note down expected results for three sand timers and the results

6. Compare the expected results with the predictions.

V – Arrange three sand timers by comparing them in pairs (15 minutes)

Materials for each child

- 3 sand timers containing nearly identical semolina volumes
- A results table (see above)

Procedure

1. Instruct the pupils: You have three sand timers. You are allowed to turn over two at a time. Put them in order, from the fastest to the slowest!

Image courtesy of Fabrice Krot, La Maison des Sciences



Pupils performing the sand timer activity

2. Conclusion:

If the black hourglass runs out faster than the red one, and the blue one runs out faster than the black one, then the blue hourglass runs out faster than the red one.

Web references

- w1 – To find out more about *La main à la pâte*, see: www.lamap.fr
- w2 – For the German mirror website of *La main à la pâte*, see: www.sonnentaler.net/info
- w3 – The Spanish version of *La main à la pâte* can be found here: www.indagala.org
- w4 – To find out more about *La main à la pâte* in Serbian, see: <http://rukautestu.vin.bg.ac.yu>
- w5 – For the Arabic website of *La main à la pâte*, see: <http://lamap.bibalex.org>
- w6 – The Chinese version of *La main à la pâte* can be found here: <http://lamap.handsbrain.com>

- w7 – The Teaching Science web portal, a joint project between the International Council for Science (ICSU) and the Inter-Academy Panel for international affairs (IAP), in collaboration with *La main à la pâte*, with links to international partner projects, can be found here: www.icsu.org/1_icsuinscience/CAPA_TeachSci_1.html
- w8 – For more information on the French ASTEP programme (supporting teachers through the involvement of scientists in primary education), see: www.astep.fr
- w9 – For more information about Pollen, including many more learning units, see the Pollen project website: www.pollen-europa.net
- w10 – For a guide and training unit for scientists and teachers in French and English, see: www.astep.fr or www.pollen-europa.net



REVIEW

Inspectors aside, outside visitors are welcome in school science lessons – in addition to being a fresh face, they can bring another kind of expertise to bear. Undergraduate science students have a good chance of relating to schoolchildren simply by virtue of not being the regular class teacher. University students can also be a powerful antidote to the ‘boffin’ stereotype, at a time when formative attitudes to science in general and scientists in particular are being developed. A visiting university student would be welcomed too by the teacher, who in primary schools is unlikely to have a science background him/herself. The visitor will be someone who can probably make the experiments work, and has a better chance of dealing adequately with the awkward science questions pupils are likely to supply!

Numerous organisations are keen to involve schoolchildren under their understanding of science mandate. Hopefully this article will encourage you to make contact so that soon you will also be welcoming these visitors into your classrooms, through initiatives such

as the European-wide Pollen project or their national equivalent, for example the ‘Researchers in Residence’ scheme or ‘Student Associates’ scheme in the UK.

The article details two hands-on investigative activities suitable for most primary-school science classrooms. One is about electricity, often not covered in primary schools using practical work; the other is about fair testing and good experimental technique. The first may include apparatus less commonly found as class sets in primary schools. The sand timer activity makes good use of a simple homemade piece of apparatus, enabling a variety of questions to be asked and predictions tested. Both activities are highly suitable for ‘how and why’ discussions with school pupils. They have been tried and tested with the help of university students in the classroom, and their successful deployment should encourage primary-school teachers to try a more investigative hands-on approach to science lessons – either with or without visiting help.

Ian Francis, UK

w11 – The French-language version of the teaching activity ‘How can the bear’s nose be switched on?’ (‘Le nez de l’ours – Réaliser un montage qui permette d’allumer une ampoule’) can be found on the *La main à la pâte* website (www.lamap.fr) or here <http://tinyurl.com/lenezdelours>

w12 – Further information about teaching electricity at primary school can be downloaded here: www.scienceinschool.org/2009/issue11/pollen

w13 – The sand timer teaching unit is available in English on the Pollen website (www.pollen-europa.net) or here: <http://tinyurl.com/hourglassrace>. Additionally, there are a number of examples based on the sand timer activity in the Pollen methodological guide: www.pollen-europa.net or <http://tinyurl.com/guideforteachers>

David Jasmin has a PhD in physics and has been working in science education and science popularization since 1995. He has contributed as a research engineer to *La main à la pâte* since 1997 and is head of this programme since 2005. Besides, he is the scientific coordinator of the Pollen project. He is also the author and editor of various books on primary school science education.

Samuel Lellouch is a second-year engineering student at the Ecole Polytechnique in Saint Etienne, one of the most prestigious engineering ‘Grande Ecoles’ in France. In 2007/2008, he spent six months supporting primary school teachers in class in a low-income suburb in Paris.

