Building a Battery in Class

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Considerations when planning the activity

Battery-powered toys are common today. Children are accustomed to buying batteries, putting them in their toys and changing them. However, they do not know how batteries work. And yet, the advent of electricity—whether it comes from electric power plants or simply from batteries—has resulted in profound changes to the way we live.

The work of Volta was essential to technical developments involving electricity. Looking at Volta's life and work—especially the battery, which he invented—is particularly meaningful and appropriate to elementary school science curricula. The battery gave people a new, highly flexible source of energy that ultimately made it possible to develop the production of electricity.

While building a Volta battery—which is very simple and relatively economical—is possible in the classroom, the theory that underpins the activity is more complex. A concept for which students are lacking concrete knowledge—charged particles, or electrons—must be introduced before starting the activity.

Preparing for the activity in class

Volta's letter to the Royal Society

A possible starting point for the activity is Volta's description of his battery in his letter of 1800 to the president of the Royal Society, a reading that is simple and accessible:

> *I shall now give a more particular description of this apparatus and of others analogous to it, as well as one of the most remarkable experiments made with them. I provide a few dozens of small round plates or disks of copper, brass or rather silver, an inch in diameter more or less (pieces of coin for example), and an equal number of plates of tin, or, what is better, of zinc, nearly of the same size and figure. I make use of the term nearly, because great precision is not necessary, and the size in general, as well as the figure of the metallic pieces, is merely arbitrary: care only must be taken that they may be capable of being conveniently arranged one above the other, in the form of a column. I prepare also a pretty large number of circular pieces of pasteboard, or any other spongy matter capable of imbibing and retaining a great deal of water or moisture, with which they must be well impregnated in order to insure success to the experiments. These circular pieces of pasteboard, which I shall call moistened disks, I make a little smaller than the plates of metal, in order that, when interposed between them, as I shall hereafter describe, they may not project beyond them.*

This reading will encourage students to reproduce the stacked structure described by Volta.

How does a battery work?

The image we have of the object presented by Volta is a uniform stack of copper and zinc disks separated by card soaked with salt water. The copper and zinc disks are called 'electrodes' and the salt solution 'electrolyte'. The chemical reactions that occur between these components produce electricity—in other words, the circulation of electrons. These and many other electrochemical terms were introduced by British scientist Michael Faraday in 1834.

For Volta, the production of electricity was due mainly to contact between these three components, although he did understand the importance of the electrolyte solution to the flow of what he called 'charged particles'. When preparing the classroom activity, it is important to understand how a battery works while keeping in mind that this concept is beyond the reach of primary school students. Volta's battery has a copper electrode that is 'reduced' by the action of the electrolyte: it releases electrons that then bond with the H^+ ions in the electrolyte and flow to the zinc electrode, producing an electric current (if there is a closed circuit, meaning if the electrodes are linked by a series of conductors).

It can thus be said that the copper electrode 'loses' electrons. Hence, the copper electrode has a 'positive charge' (it becomes the positive pole). On the other hand, the zinc electrode dissolves partially in the electrolyte and ‘gains’ electrons. Hence, the zinc electrode has a ‘negative charge’ (it becomes the negative pole). This creates tension between the battery’s two poles.

The cathode (the copper) is constantly regenerated. This means that the copper that has reacted with the electrolyte is replenished by the electrons ‘picked up’ along the circuit. Only the zinc electrode (the anode) is consumed. The process continues until the anode is completely dissolved.

Materials

We recommend using coins. This is a relatively simple solution, especially since the introduction of the euro. Specifically, we recommend the 20 cent coin, which is made from a special copper alloy commonly known as ‘Nordic gold’ (89% copper, 5% zinc, 5% aluminium and 1% tin), and the 5 cent coin, which is made from copper-plated steel, an experimental material that is easy to find and that is also recyclable. The only problem is that these coins are small in size and stacking them up creates a fragile, unstable structure. In order to solve this problem, generally, students have built a base similar to the model described by Volta using a piece of polystyrene (drawings available on the CD-ROM).

A few recommendations

Upon completion of the activities, the students should be able to identify the two poles of the battery. And yet the ‘positive’ and ‘negative’ poles are determined by convention. In order to avoid misleading the students and to debunk misconceptions concerning the direction of the current, it is important for teachers to be able to answer this and other similar questions.

Batteries can be dangerous: E.U. safety standards stipulate that the human body must not be subjected to electrical currents of more than 24 V (which can be produced by a set of three 9 V batteries). It is important to remember this threshold when working with students).

Batteries can cause pollution: some batteries (button cells) contain mercury, which is harmful to our environment. This issue can be presented to students by encouraging them to collect and sort waste.

Finally, it is important for students to be able to see what the inside of a battery looks like, but opening a battery must be left to the teacher. Flat batteries are more appropriate for this demonstration due to the fact that cylindrical batteries often have a tough casing and are impossible to open!

Building a battery in class

Encourage students to think about the topic

To begin with, the teacher can ask students to bring to class different batteries found at home. The batteries can then be grouped by type: flat, cylindrical, saline and alkaline. The teacher can then ask students what they know about the origin and uses of each type of battery. The teacher may also want to base the observation on a battery-powered toy, asking students what they think makes the toy work. The discussion that ensues will result in a list of battery functions and uses. If necessary, the teacher can remove the battery from the toy to show that it no longer works. Whatever option is chosen, we recommend encouraging students to think about the origin of the battery and having them read Volta's letter in order to build their own battery.

Which materials should be used?

Based on a list of materials used by Volta, students can imagine which everyday objects could be used to replace them (opposite, top).

Determine the steps

The steps in building the battery must then be explained:

– Take the polystyrene base and attach the skewers, ensuring that they are perfectly straight: the resulting structure will keep the stack of disks from falling over.

– Make ‘sandwiches’ out of 20 and 5 cent coins, placing a small disk of cotton soaked in lemon juice (or salt water) in the centre of each.

– Slide the ‘sandwiches’ onto the base, stacking them up in the centre of the support structure.

When building their battery, students will notice that they need to watch out for several things:

– When the cotton disks are compressed (especially those at the bottom of the stack), they lose some of their lemon juice, which reduces the effectiveness of the battery (students will then learn about the role played by the electrolyte: if the juice dries up, it can no longer perform its function). In order to minimise

this, cotton may be placed between all of the coins. Volta did not understand the importance of the electrolyte. He believed that electricity was generated by the contact between two different metals!
– Remember that the cotton disks must be smaller than the coins in order to keep two pieces of cotton from touching (Volta is clear about this in his letter).

The class can also use a test meter to see if their battery works and to compare it with a store-bought battery. One child stated during this exercise: ‘I can’t believe it. My battery says 195 [mV] and the battery I bought says 1,590!’ Following a discussion of their observations, students decided that, in order to obtain the same reading as for a store-bought battery, they would need eight interconnected stacks.

Volta used	We can use
20 copper disks 4 cm in diameter	20 20-euro-cent coins
20 zinc discs 4 cm in diameter	20 5-euro-cent coins
20 stiff card (pasteboard) disks	20 small cotton disks the size of 5-euro-cent coins
A salt-water solution to soak the card disks	The juice of one lemon to soak the cotton disks
Three vertical rods attached to a wood base	A polystyrene base and three small skewers (or plastic straws) to support the stack

Building the stack

If the students complete their structure correctly, they will see that the surface of the coins has changed, especially the 5-cent coins. One student exclaimed, ‘Our coins are going to get used up. I won’t have any money left!’

We also attempted to conduct the same experiment with fewer ‘sandwiches’, but the students found that the test meter registered lower readings. In one class, a group of students tried to build a mini battery. They said: ‘We still get a reading’. During the activity, it is important to allow the students to experiment with all of their ideas while ensuring that they do not change more than one variable at a time. This is necessary if students are to understand where differences in the results come from.

One group got tired of having their stack fall over. They then decided to build a ‘horizontal’ battery. ‘We managed to use more coins, but our battery didn’t look like Volta’s anymore!’ They then looked for other historical documents. This led them to Volta’s ‘crown of cups’ battery. During the experiment, the students discovered that a half of an orange was a much more ‘natural' battery than Volta's. ‘We tried to build a different kind of battery. We stuck copper and zinc electrodes in oranges. It took 12 oranges to light a small lamp’. Students can also use other kinds of fruit and even other electrolytes (even water). They will thus see that most electrolytes work. In one class, students even tried to use kiwis and two glasses of water.

Extending the activity

One possible way of extending the activity is to give students flat batteries and light bulbs in order to explore electrical circuits. In groups of four or five, students can be given a light bulb, electrical wire and a battery with the task of lighting the light bulb. Let the students experiment, using trial-and-error to explore the way in which the Volta battery they made during the first part of the activity is used. They can test the battery with a light bulb, which will introduce them to the concept of the closed circuit. With a limited number of ‘sandwiches’, it will be difficult to light the bulb. However, some students will come up with the idea of connecting several batteries together to see what happens.

Students may then try to identify the characteristics of a light bulb by examining the boxes and caps. This will provide an opportunity to discuss the measurements given and the units used to express them. This is a good time to introduce the unit used to measure voltage—the volt—the origin of which students will now have no trouble at all understanding!