Does 'Voltless' Electronics help?

Bridget Elton

PGCE student, Manchester Metropolitan University

In the last issue of *Design & Technology Teaching*, Paul Jones put forward the idea of 'voltless' electronics to help pupils to grasp concepts such as resistance*. Here Bridget Elton suggests an alternative view

* As several sharp-eyed readers spotted (Paul Jones included) there was an error in Figures 5 and 6 in his article. The battery should have been shown connected between the buzzer and the emitter of the transistor, not between the variable resistor and the collector.

Analogies are useful in understanding and teaching electronics, but a bad analogy can add to confusion. This article suggests an alternative to the 'voltless' model, and points to the need for greater co-ordination with science faculties.

Many teachers of technology (and soon-to-be-teachers, such as myself) will have recognised the dilemma in teaching electronics which Paul Jones describes in 'Voltless Electronics at Key Stage 3'(Vol. 27 no. 2). Technology is supposed to be about designing and making, not a lot of electronic theory, but without some understanding of what is going on in a circuit how can pupils get beyond what he refers to as the 'prescriptive projects that give little experience of the nature of designing with electronics'?

Problems with the Waterfall

Unfortunately, in attempting to make things clearer, Paul Jones adds to the confusion, and not only in electronics. Under 'Simplifying the problem' Jones uses the analogy of a waterfall, but his description of what happens in the waterfall itself is inaccurate. He says 'If the height of the waterfall is constant, then the speed of the water hitting the ground varies *only* with the blockage at the top' (his italics).

In fact the blockage at the top is irrelevant to the speed of the water hitting the ground. The speed of the water at the top of the waterfall can be divided into a horizontal and a vertical component. The slope of a river is so small that we can regard the speed of the water at the top of the fall as equal to the horizontal component alone. The vertical component is effectively zero under all circumstances, and the speed of the water as it hits the bottom is therefore dependent only on the height of the waterfall (I am ignoring the friction of the air).

What the blockage does do, of course, is reduce the *rate* of flow, i.e. the quantity of water which falls in a given period. This is analogous with increasing electrical resistance which, for any given voltage, reduces the current (the rate of flow of electrons, i.e. the quantity of charge which flows).

The 'closed circuit with pump' analogy

I think a better analogy than the waterfall is a pump connected to pipes with constrictions or blockages in them (see Figure 1). The pump is the battery, the constrictions are the resistance and the water flow is the current flow. If you add a water wheel (more resistance), it becomes clear that this system is doing work, just as the simple circuits the pupils are familiar with do: lighting bulbs, sounding buzzers, turning motors. If you want to describe this circuit without reference to voltage, you can, although it may sometimes be useful to replace the pump with a more powerful one and discuss the effect on current.

This analogy has two further advantages. Firstly, you can turn the pump off to simulate disconnecting the battery, which is more difficult with a waterfall. Secondly, and more importantly, this analogy shows a closed system, and thus reinforces the idea of a *circuit*. Research[1] has shown that many children fail to grasp that a circuit is essential for current to flow, or that the current flows in the same direction all the way round. The waterfall analogy tends to encourage the (surprisingly common) 'one wire' view (see Figure 2).

Current gets 'used up'

When Paul Jones uses his model to explain a simple series circuit the problem gets worse. Many children have the 'common sense' idea that current is 'used up' as it flows through components which obviously need energy to make them work, such as light bulbs.

This 'common sense' idea is confirmed for them by the fact that batteries run out. What actually gets used up of course, is *energy*. We need to help pupils distinguish between energy (or power — power equals energy per second), and current. If children think that current is used up, they will have tremendous difficulty designing even the simplest circuits.

Again, the 'closed circuit with pump model' helps to make things clearer. It will be obvious to children that the flow of water is the same in all parts of the circuit and current is not used up (otherwise there would be gaps in the water!). They also see clearly that the power output increases and decreases when current does. The change in current in the model can be attributed either to a reduction in blockages (resistance) or to an increase in pump output (voltage).

Jones's diagram of a series circuit (his Figure 3) on the other hand, with its large arrow going into the large resistance and small one coming

Fig. 1

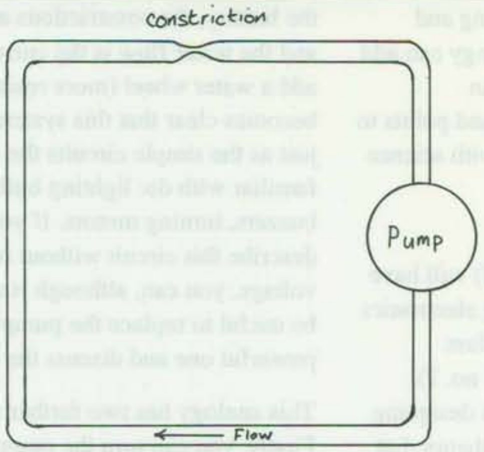


Fig. 2

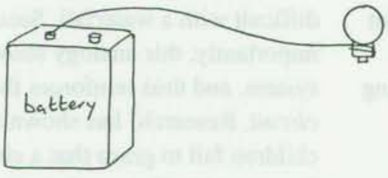
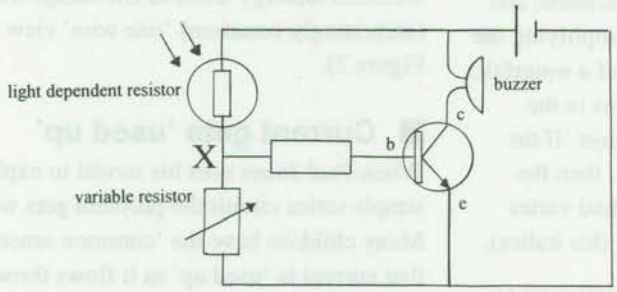


Fig.3



out, reinforces the notion that current is used up. Indeed, Jones advocates deliberately confusing the concepts of power and current. Since in science they will probably be taught to distinguish them, this can only result in confused pupils.

■ Errors in the transistor circuits

In the section on light and dark detecting circuits, there is an error in both diagrams. I suspect that this is merely a drawing mistake since, as drawn, the circuits (his Figures 5 and 6) will not do anything at all. The corrected circuit is shown in Figure 3. This is a rather unusual way of drawing it, but on the basis of the original diagrams I think this is what was intended. With the battery in the original position the collector and emitter are at the same potential, so, voltless model or not, no current will flow.

■ Is there a better way to teach electronics?

Paul Jones has attempted to deal with a problem created for technology teachers by the National Curriculum. Despite rationalisation in the new orders, application of electronics is taught in technology, while knowledge and understanding of electricity is taught in another faculty. I know that cross-curricular co-ordination is easier said than done, but could we not at least agree a common set of terms? Maybe there is a case for not teaching electronics until say Year 8, by which time it can be hoped that the children will have covered at least basic electric circuits in science.

Maybe we should concentrate on digital electronics which lends itself to the building blocks approach — I would be very interested to hear about any good digital projects. Or maybe the electricity part of science and the electronics part of technology could be taught by the same teacher — perhaps even in the same series of lessons? The National Curriculum says what has to be taught, not which faculty it has to be taught in.

My impression is that electronics is one of the least successful parts of the technology curriculum. As a PGCE student I don't claim to have the solutions, only that I would like to be part of finding some of them. I hope there will be more articles which address the problems which Paul Jones tackles, and particularly articles from teachers who have run successful and imaginative projects in electronics. I would also welcome correspondence on the issues I have raised, and I can be contacted at 11 Desford Avenue, Manchester, M21 OTG.

■ References

See, for example:

Driver, R., *The Pupil as Scientist?*, Open University Press, 1983

Driver, R., *et al., Making Sense of Secondary Science*, Routledge, 1994

Osborne, R. and Freyberg, P., *Learning in Science*, Heinemann, 1985