The Cycle of Physics Pedagogy

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"Energy is the capacity to perform work …" (Abbot A.F. 1963 p83), "Pressure is defined as the force acting normally per unit area." (Abbot A.F. 1963 p119); such was the language used in the early 60s text books. It is not surprising that the numbers of pupils choosing physics as an Ordinary (O) Level option was small and it was perceived as being difficult and for boys. In science education circles, notably the Science Masters' Association (which soon turned into the Association for Science Education), there was a move to change the way in which science was taught and consequently physics teaching was to come under the microscope. During that era the Nuffield Foundation dedicated well over £1m on curriculum innovation (equivalent to about £30m today) with science and mathematics being specific targets. As a result of these influences, the 60s was a decade of change in the approach to the teaching of science in secondary schools and the Nuffield dream had begun.

The City of Worcester Teacher Training College (renamed in 1965 to Worcester College of Education and now incorporated as part of the University of Worcester) played a significant part in this reform process in the area of physics. E.J. (Ted) Wenham, a talented physicist played a major role in the development of the Nuffield O Level Physics scheme. Central to the Nuffield physics science teaching ethos was the use of a modelling and concept approach; knowing that a gas expanded when heated and being able use the Gas Laws to calculate by how much was all that had been hitherto required. To be able to explain *why* was seen as much better physics and by modelling with ball bearings being vibrated in a clear plastic tube, the concept of thermal gas expansion was more easily understood. Such was Wenham's conviction in the approach that some years later he co-authored the comprehensive text *Physics - Concepts and Models* (Wenham et al., 1972) which was designed to provide pre-university students with a readable, coherent course of study in this fundamental science.

The name of Worcester was etched on the Nuffield physics teaching map by two notable pieces of physics teaching equipment; the *Worcester Circuit Board* and the *Worcester Current Balance*. Electrical circuits are conventionally drawn using symbols to represent components and a series of straight lines at right angles to represent the connecting wires. It is not surprising that if you give young secondary pupils some components and some flexible leads with plugs on the end and tell them to construct a circuit from a diagram they inevitably experience difficulties. The Nuffield solution was to give them a *Worcester Circuit Board* like the one in Figure 1; it is not difficult to see why this might be more successful, the components can be set out in a way that matches the diagram.

Figure 1

Another problematic area for pupils was an understanding of the use of ammeters and voltmeters as electrical measurers. I can vividly remember doing calculations on *shunts* and *multipliers* without really knowing what I was doing and what was going on inside the meter. Getting pupils to build a meter from a kit that included, among other things, a straw, a wooden throat spatula and a pin unlocked the mystery of the black box and gave an understanding of the concept of how to measure the strength of an electric current (Figure 2).

The Nuffield project had a relatively long lifetime but at pre 16 level the cost of equipment and the technician time to service practical work became prohibitive and the onset of the National Curriculum with its associated Standard Assessment Tests (SATs) and General Certificate of Secondary Education (GCSEs) saw regression to content rather than concept based science teaching despite the mantra of assessment which was what they (pupils) "know, understand and can do". The balance of assessment was weighted towards recall and there was a tendency for science teachers to use a content based approach and invent mnemonics and other memory aids to provide the results that were constantly being demanded by school leaders to maintain and improve their positions in league tables. A notable example was the plethora of memory aids to name and give the relative positions of the planets in the solar system.

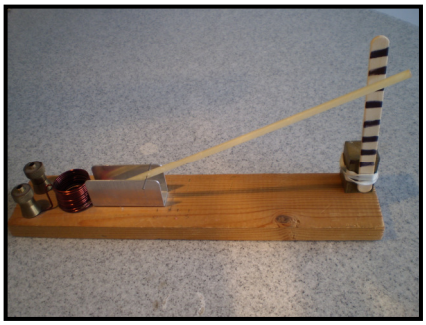

Figure 2

With the National Curriculum also came the idea of not only science for all but *balanced* science for all which meant the individual sciences losing some of their identity particularly at Key Stage 3. Within this balanced approach, the perception of the 60s still prevailed in that physics was the hardest aspect to master. This was reinforced by pupils consistently scoring significantly lower component grades in physics than the other two sciences of chemistry and biology.

In the 21st Century, National Curriculum reform moves have been made to reverse the content trend of the 80s and 90s to *how science works* at Key Stage 4 and to the *applications and implications* of science at Key Stage 3. There is also a trend towards greater access to triple science and hence the raising of the profile of the individual sciences. Have we gone full circle to the ideas of the early 60s and to the trend of appreciating the *how* not the *what*?

There is good news and bad news. The good news is the advent of computer technology and the resulting ability to model more easily; the ball bearings in the plastic tube can be replaced by a computer simulation using the technology available in most school laboratories. The bad news is that the Nuffield generation of teachers have come, or are coming, to the end of their teaching careers and the new entrants to teacher training are largely the product of the content driven era and thus only have the veneer of factual knowledge but not the necessary fundamental understanding of physics to teach in the Nuffield style with its associated understanding of the *why* as well as the *what*. This was highlighted in a comment made through the medium of the internet by a teacher who had found several unopened boxes of Worcester Current Balance kits in his science teaching prep room and was asking if anyone could tell him what they were and how to use them!

I fear that if the training of teachers of physics moves from institutions with a history of innovation to schools because the current Secretary of State for Education sees teaching as a craft to be learnt in the workplace, the decline in the standard of physics teaching will continue.

References

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