The pleasure of FINDING THINGS OUT

PETER LOXLEY DISCUSSES HOW WE CAN LEARN ABOUT REASONING FROM DISTINGUISHED ROLE MODELS SUCH AS RICHARD FEYNMAN

The pleasure of finding things out is a collection of short works by the Nobel Prize winning scientist Richard Feynman (Figure 1). The book provides insights into his infectious enthusiasm for science and his love of sharing ideas about the subject with anyone who wanted to listen. This article explores what primary science teachers can learn from such a distinguished role model.

Feynman has been widely acknowledged as one of the greatest physicists of the twentieth century. Born near New York in 1918, he grew up in a family with a keen interest in science. Although his father was a businessman, he was fascinated by science and loved talking to his son about how the natural world works. Often, Feynman would walk with his father in a local wood and they would talk about all the things around them. His father did not attempt to teach him the names of the animals and plants, but instead they discussed reasons for their behaviour. For example, on one occasion his father pointed to birds pecking at their feathers and asked his son why he thought they were doing it. Feynman suggested the birds' feathers must have got ruffled and they were rearranging them. '*OK, when would the feathers get ruffled?*' replied his father. '*When he flies*' responded Feynman. So, they looked at birds they saw landing, to check whether they pecked their feathers more than other birds. They did not, so they concluded that Feynman's answer was probably wrong. When Feynman ran out of ideas, his father revealed the answer. On their regular walks his father would tantalise him with different questions and wonderful visions of how nature works. The pleasure Feynman got from unveiling nature's secrets on his walks with his father remained with him for the rest of his life, and was his stated reason for becoming a scientist.

In his later life, Feynman became renowned not only for his pioneering work in nuclear physics, but also for his extra-ordinary ability to communicate science to audiences of all levels of knowledge. His enthusiasm for science and his ability to inspire

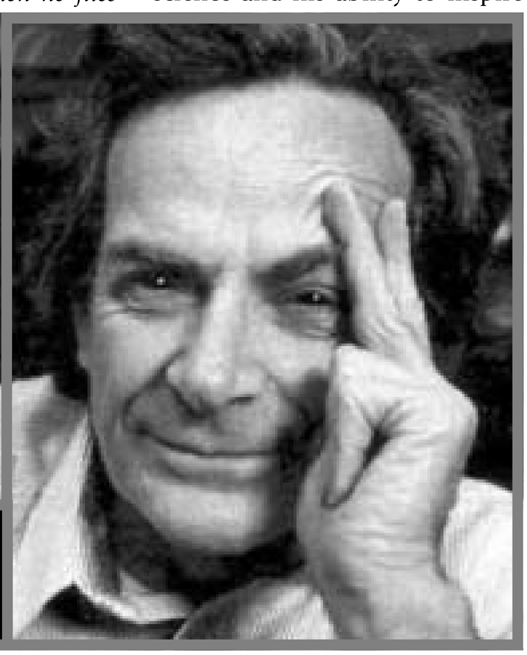

Figure 1
Richard Feynman

audiences stemmed from those early childhood experiences with his father, when he came to realise that the world looks very different when viewed through 'scientific eyes'. For Feynman, science provided inspiring and exciting visions of the world. He was an entertainer and storyteller who passed on his passion for science through his engaging sense of humour and the palpable pleasure he got from talking about the subject.

In a lecture to the American National Science Teachers' Association, Feynman spoke about the way science was taught in schools. He was very clear that although children need to be taught certain scientific words and definitions, the learning of these words and definitions does not mean that they are learning science. To illustrate the point, he described a picture of a wind-up toy dog he had seen in a science textbook with the question '*What makes it move?*' written underneath. The answer the author of the book was looking for was '*energy makes it move*'. Feynman berated this answer as non-scientific and meaningless for young people who are just starting to learn about the concept of energy. He suggested that it would be equally meaningful to them to say that '*God makes the toy move*' or '*spirits make it move*'. He then asked what the teacher would do if the children say they do not think energy makes it move; how would the teacher persuade them that the energy explanation is valid?

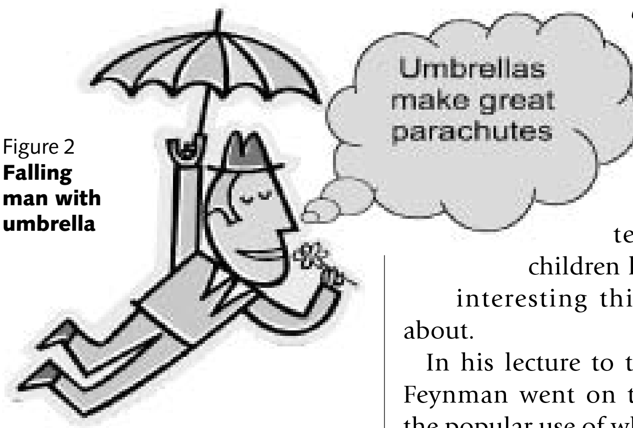

Figure 2 **Falling man with umbrella**

Reasoning versus 'mystic formula'

The point Feynman wanted to make to those teachers was that '*energy makes things move*' is only a definition, and only makes sense to children after they understand the concept of energy. He suggested that the children would learn more useful knowledge about how the toy dog works by pulling it apart to see how the spring is wound up and how it releases to make the wheels go around. Then perhaps later on in their science education they would learn how the Sun enables plants to grow and how eating the plants enables people to wind up the toy and make it move. So, for Feynman, the answer to the question was '*sunshine makes the dog move*'. Then, if children say that they do not believe it, teachers and children have a lot of interesting things to talk about.

In his lecture to the teachers, Feynman went on to condemn the popular use of what he called 'mystic formula' in science textbooks to answer questions. He criticised the practice of using definitions such as '*gravity makes it fall*' and '*soles of shoes wear out because of friction*' as explanatory models. In his own words: '*Shoe leather wears out because it rubs against the sidewalk and the little notches and bumps on the sidewalk grab pieces and pull them off. To simply say it is because of friction is sad, because it's not science*' (Feynman, 1999: 180).

Although Feynman gave this lecture in 1966, many of his criticisms apply equally to science teaching today. How often do we use definitions such as '*gravity makes it fall*' or '*shoes wear out because of friction*' as scientific explanations? How would we answer a child who said that they did not think that gravity made something fall? Now there's a challenge!

According to Feynman, there is one sure way of finding out whether children have a meaningful understanding of a scientific word, or just the definition. We need to ask the children to explain how something works without using the new scientific word. For example, ask them to explain how energy makes the toy dog move without using the word energy.

Explaining your reasoning

Influenced by Feynman, I carried out a small-scale experiment with some of our primary trainee teachers to see what they knew about air resistance. I gave them the picture of the man falling with the umbrella (Figure 2) and asked them to explain how the umbrella could slow his fall.

The automatic response was '*air resistance would slow him down*'. Was this a mystic formula or did they really understand how the umbrella crashes through the air? To find out, I then asked the trainees to explain how the umbrella works without using the term air resistance. Not surprisingly, their answers were mixed, but in the end they were able to describe how the umbrella would be slowed down because it had to push the air out of the way. Some thought the best way to explain was to demonstrate the effect by running with an open umbrella.

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To further challenge their understanding, I showed the trainees the picture of the boy

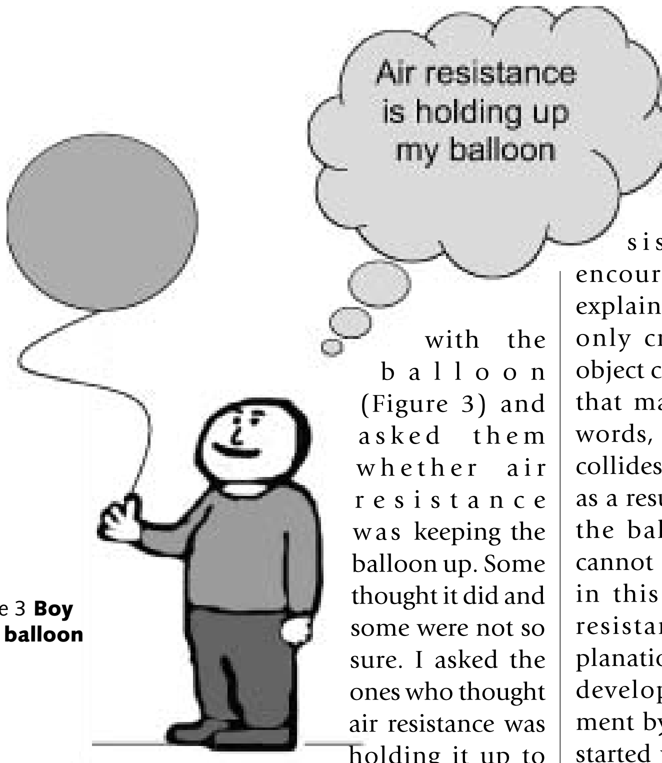

Figure 3 **Boy with balloon**

with the balloon (Figure 3) and asked them whether air resistance was keeping the balloon up. Some thought it did and some were not so sure. I asked the ones who thought air resistance was holding it up to persuade the others that they were right. This they found very difficult, because of course they were wrong. Air resistance does not cause a balloon to float in mid-air. If they had thought about how air resistance works they could have figured out that it was impossible for it to cause something to float. As it was, they hypothesised quite correctly that air must be pushing up on the balloon to hold it up, but could not explain how the air was doing the pushing without citing the mystic, and in this case misleading, formula *'air resistance holds it up'*.

I next asked the trainees who thought it was not air resistance to persuade the others that they were right. Their intuitive response was to provide an alternative explanation, rather than try to discredit the air resistance idea. With encouragement, the trainees explained that air resistance is only created when a moving object collides with the materials that make up the air. In other words, as the umbrella falls it collides with the air particles and as a result is slowed down. Since the balloon is not moving it cannot be colliding with the air in this way and therefore air resistance cannot be the explanation. This is an example of developing a persuasive argument by deduction. The trainees started with their understanding of how air resistance works and logically reasoned why it could not be responsible for causing the balloon to float in the air. Having established air resistance was not supporting the balloon, the trainees were keen to find out the real answer. Feynman would have been proud of us.

Things are not what they seem

The message Feynman was trying to get over to the teachers was that the pleasure of learning science comes from the wonder and awe of finding out that the world is not as we first perceive it to be. Children cannot discover nature's secrets for themselves; they need to unveil them with the help of an inspiring teacher. If we follow Feynman's example when teaching science, we will start by setting up situations that ignite children's desire to find out about some aspect of nature whose behaviour they can observe. Then, through rational and persuasive dialogue with their teacher, they can share the amazing visions of the world that science has discovered. Of course, finding out answers to questions is already an important part of primary science. However, often answers are sought through the procedural processes set out in the National Curriculum and not through the kind of persuasive dialogue that developed between Feynman and his father. In order to share with children science's evocative visions of nature, teachers need to become accomplished storytellers with a passion for talking about how the natural world works. We need to remember that children find little pleasure in learning definitions; and, as Feynman points out, learning a mystic formula is not learning science.

Feynman died in 1988, but I cannot help wondering what he would have to say about the way we teach science in our primary schools today. According to his colleague Freeman Dyson, Feynman's starting point for developing scientific ideas was his own imagination (Feynman, 1999). Typically, he would spend many hours drawing diagrams and pictures that helped him visualise and talk about the phenomenon he was trying to explain. Drawing and talking were Feynman's ways of making initial sense of the ideas forming in his mind. I am sure he would encourage our children to do the same when trying to make sense of scientific ideas. In fact, if Feynman had his way I imagine we would spend a lot more time planning tantalising sequences of dialogue, designed to help children discover the pleasure of finding things out.

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Reference

Feynman, Richard P. (1999) *The pleasure of finding things out.* London: Penguin.

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