

# DESIGNING AND MAKING EXHIBITS

Francis Evans



Francis Evans is a mixture of historian and amateur engineer. He wants to show people that engineering is not just applied science, but a creative activity. He suspects that we not only learn with our hands but think with them too.



*Spectators wisely keep their distance as Francis Evans demonstrates his water wheel exhibits.*

'I've a mind to . . .', whether it is a good mind or half a mind.

I am a plore maker and have been these 20 years. This essay is about my reflections on the process of initiating, designing and using models. I am not going to seek academic definitions.

Plore making is a creative activity and by that very fact it cannot be defined. Creativity dies when you let formulae and criteria do your thinking for you. It turns into the dead world of the expert.

Of course you know when you have a good plore. One day, at a conference, I showed my Wobbly Arch and Hanging Chain to a middle-class, middle-aged lady. She jumped up and down in delight, exclaiming, 'I've always wanted to understand how an arch works'. I saw the idea for the Wobbly in an old book, so it is fitting for me to praise it – it is fun, and yet it teaches profoundly. It is not limited to one action – you can do all sorts of tricks and experiments with the one model. Yet I had no idea how good it would be when I set about making the first one.

There is an unpredictability about the whole business, as if the rational business of design is underlaid by a sleepwalking, intuitive thought which is deeper and stronger.

My friend Albert helped me to make a Smeaton water-wheel out of Perspex. I merely wanted a working toy, but it turned out to be the most powerful teaching device I have ever used. Height of water – there was potential energy in tangible form; hold the shaft and feel the torque – a concept I had never really grasped; efficiency, kinetic energy, losses through water splashing against flat paddles; overshot wheel running badly because of its own back-water . . . it was all there. Probably my students will go on pointing out new things as the years roll by.

I am now strongly convinced that the best ideas grow out of something that we want to see ourselves. Never having studied science or engineering formally, I want to see how it works for myself. I don't just want to read it in a book. I am not satisfied by little arrows showing the thrust of an arch, or by some text book explaining about  $mv$  or  $\frac{1}{2}mv^2$  . . . I want to feel it and make it happen myself.

Just now I am playing with a model Pelton wheel. A high head of water turns into a powerful jet which hits the curved buckets on the rim of the wheel. Ideally the jet should be able to hit a stationary bucket, follow the curve around through  $180^\circ$  and come back the way it came. Not having done any work, it should come back at the same speed. A simple spoon won't do it – the curve is too flat – so I pushed an inch wide

plastic spoon into a  $\frac{7}{8}$ in groove and it bent to the right shape. Water from the tap shot up, all over the kitchen.

A Pelton bucket is double. I can only describe the shape as like the indentation made by buttocks in sand.

So I put two spoons side by side, with a knife edge between them to split the jet. That way the two streams of water come back each side of the entering jet, and there is no side thrust on the bearings. Now my wheel is made and I am trying out small variations to improve its behaviour: if the wheel is still, the water should come straight back; if the wheel turns at the same speed as the water, then the jet passes through it untouched; and if the wheel goes *half* the speed of the jet, then the water should just drop straight down, all its kinetic energy given up to the machine.

Let me reiterate the point: I want to see and *feel* it happening – and I guess other people would too. We are not

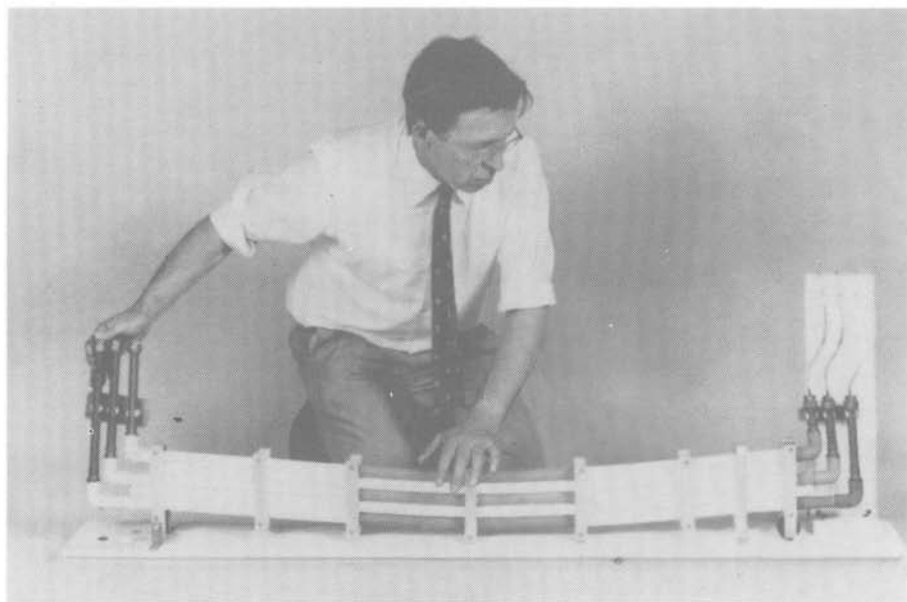


*Francis Evans' bridges are appearing in most of the emergent science centres in Britain. Here a group are busy with a selection of bridges at the Open University Open Day.*

conjurers inventing tricks. We are teachers confronting our own knowledge as if for the first time, and wondering what it really means.

Teaching is not just telling people things. You have to start off in tune with the ignorance, looking for the question which will interest them and lead them into wonderland. Always start from your audience, not from what you know. Far better that they learn something simple than they go to sleep and miss the secret of the universe. To do this you have to feel puzzlement and wonder yourself; you have to think the question out aloud in front of the audience. Simple ploys do the same sort of thing and there is a special kind of beauty in simplicity. Every time I run my little reaction turbine – no more than a seaside bucket and some drinking straws – I am entranced by the beautiful spirals formed by the drops as they fall.

I am led to believe that this is a correct view because it is paralleled in other fields. The worst aircraft are mostly designed by committees, especially if there is a ministry



*The liquid-filled tubes form a beam. When the centre of the beam is loaded, the levels of liquid indicate the strain. In the upper tube the level rises (indicating compression), while it falls in the lower tube and remains unchanged in the centre tube.*

specification to meet as well. The Spitfire and Mosquito were designed in the face of that sort of opposition. The real classics come when you understand the rules well enough to break them – very much as Nelson broke all the Admiralty instructions for naval warfare in his tactics at the Nile and Trafalgar. We're lucky to be part of the early days of interactive learning, before there are any experts and committees. The day will come when there are lectureships at the trendy universities and compulsory papers in BEd courses and Museumology degrees . . . the touch of death. There will be no place for Richard Gregory in that kind of world.

Richard Gregory's awful word 'plore' is so useful that we all



*Francis showing great faith in the flying buttress (note the weight above). Remove the buttress and the arch collapses. Visitors can press down on the top of the arch to load it and assess the contribution of the buttress.*

say it. The trouble is the other words that rhyme: sore, bore, gore, ignore and others you will doubtless think of. Even Bristol will run out of dreadful puns based on it one day. Couldn't we call an exhibit a Wonder instead? 'I wonder, it's a wonder' – etymologically speaking it is far closer to what we are trying to do. Then the inventors could call themselves a nicer name, 'Wondersmith' (German, *Wunderschmidt*) and we could have a Guild of Wondersmiths instead of being Ploremongers.

If you want to make good plores or wonders, think about Richard Gregory's most characteristic phrase, 'Wouldn't it be fun to . . .'. In the Gregorian canon, fun is not party hats and streamers. It is mental fireworks. It means that fun is not a formula for popularity, thinking of things kids would like, but a formula for intellectual quality. If we don't grasp that, then every amusement arcade and funfair in the country is offering us a hiding to nothing.

Exploratories should be leading the battle against the British heresy that intelligence is a bad thing and that the public want to be entertained, not to think. The TV companies and most newspapers treat us like Deltas out of Brave New World; but are they justified? Are we really, as a nation, as stupid as they think? My own experience says no; that most people, after an initial moment of astonishment, like to be treated as if they have a brain which still works.

Some of the classic plores smack a little of conjuring tricks. Bernouilli's balls are a good example – fascinating to play with, but I am not sure how much they teach. Also, in the rush to get a good collection of plore/wonders, I sometimes feel that there is a temptation to have lots of things in isolation from each other.

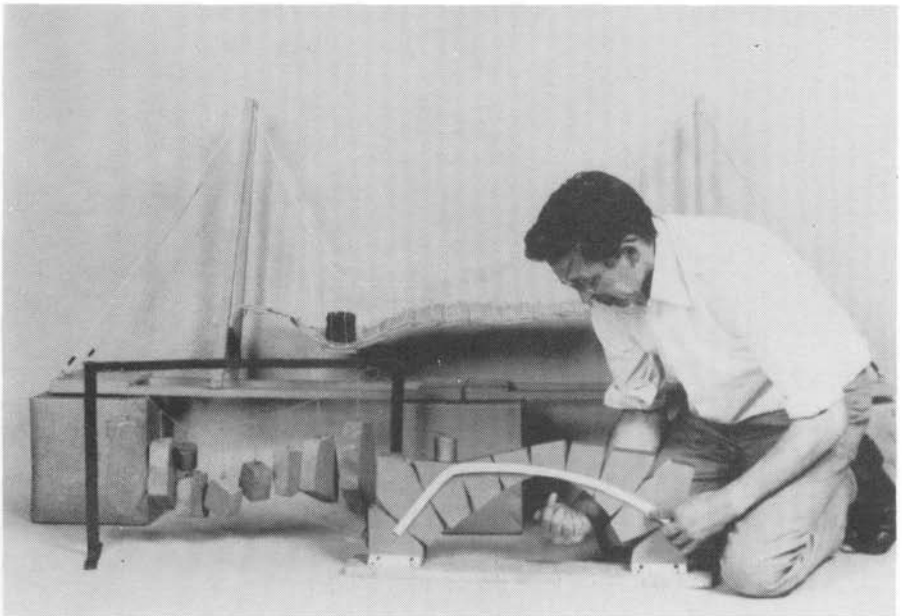
Perhaps the answer to the second problem is to have groups of exhibits which lead on, one from another. People need not understand them at one go – one hopes they will come back. In any case, some subjects need an accumulation of previous experience before they make sense. I don't think that arches and suspension bridges make much sense until there is some conception of the behaviour of brittle and tensile materials and the differences between cast and wrought iron. I think that people have to be taken step by step into the idea of energy, starting with the ideas of potential and kinetic before they can begin to understand the structure, and we cannot impose it on them; but I believe that it should be available for those who are interested enough to want to go at things systematically.

Successfully conveying a point is a two stage business.

Stage one is to interest the visitor, to get him to ask the question himself. Stage two is to help him to answer it. For there is no use in offering information people do not want; equally, there is no worth in titillating but not satisfying curiosity. We must do both.

Take the example of Bernouilli's balls. It is puzzling and in the best Exploratory tradition *counter-intuitive* to see balls pulled together when a vacuum cleaner blows air between them. But so what? To elucidate the point, a 'Trombone', a new model based on a suggestion by Dr James Stangroom, would serve nicely – the visitor sees the air pressure varying as he moves the trombone slide back and forth in an air flow in a venturi. We ought to consider this double barrelled approach when we have an elegant, simple plote which may not stand on its own. There is always a temptation to go for the elegant idea which will appeal to fellow wondersmiths, but we should remember the public.

Like sleepwalkers, we should be walking in the strange half



*Suspension bridge and 'Wobbly Arch' exhibits. The blocks of the arch are rounded so that their points of contact reveal the thrust line through the structure. The chain takes up the shape of the thrust line when similarly loaded. When the line of thrust goes outside the arch, the bridge collapses.*



world of phenomena sharpening our perception of what we already know, so as to bring out a conscious awareness of the meaning of what we see. Everybody knows that a kettle takes five minutes to boil but half an hour to boil dry . . . let's give them James Watt's flash of inspiration, that there is latent heat in steam; again, lots of people burn their hands on hot brake drums or metal heated by grinding, without ever knowing that heat and work can interchange.

We would not have interactive science and technology centres if we were happy with the way physics and the other sciences are taught in schools, but don't let us over-react to that. If we go overboard on phenomena then we are selling short the great creative intellectual steps. We probably need to take a double step ourselves. The double step entails, first of all finding out how to show mathematical operations more easily, and secondly, to integrate that kind of mathematical explanation with demonstrations of phenomena. Many of us are chary, rightly, of computer simulations but this may be a suitable area to use them. I have in mind, for instance, the idea of a real pendulum alongside a computer simulated one, so that one can vary parameters on both – length, amplitude, mass etc. But we should also show the equations and the mathematics going on as well, so as to bring out the parallelism between them. Let the visitors do this so that they can explore the magical, mysterious way that mathematical physics echoes the phenomena of the real world. What would Plato have said if he could have seen it!

I will end on a sad note. As they stand, science centres can be seen as a reflection of failure – failure to teach science well in schools, despair at a popular descent into barbarism. Bread, circuses and no mathematics was the Roman formula; most Romans were barbaric long before the Barbarians arrived – they had lost their intellectual roots. It will be hard graft but we must grow again upon our roots. There is nothing wrong with being popular, colourful and exciting; but popularity without intellectual foundations; colour without underlying structure; excitement without deep purpose – all these are marks of the Barbarian. I want no part in science centres merely being such a postscript to the most brilliant civilisation this world has yet produced.