It IS Rocket Science you know...

Experiments to improve student understanding of the Scientific Method and Creativity

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Outline

Introduction

Increasingly we find problems with students' fundamental underpinnings in Science and Mathematics. They often come to us with relatively weak understanding of these disciplines, and poor motivation to master them.
Here we explore some of the issues, and a proposed solution we intend for our new Integrated Foundation Year (IFY).

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Richard Feynman

I have a friend who's an artist, and he sometimes takes a view which I don't agree with. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree. But then he'll say, "I, as an artist, can see how beautiful a flower is. But you, as a scientist, take it all apart and it becomes dull." I think he's kind of nutty. There are all kinds of interesting questions that come from a knowledge of science, which only adds to the excitement and mystery and awe of a flower. It only adds. I don't understand how it subtracts.

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- consequently, the word has a special level of stigma;
- but, when H&S considerations are removed, (in other words, we consider risks that do not sit in this arena), what positive things can be said?

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- It might create what could be cheekily be referred to as unintended learning.

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Health & Safety

Fears over the H&S types of risk mean that experimentation is less common, and less deep than in the past.

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3. teach the underpinning theory, and mathematical analysis in context.

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1. Introduction
2. Confidence and the Scientific Method
   - Risk Taking & Serendipity
   - Science in secondary education
3. Experiments as part of the solution
   - Water Rockets
   - Approximation, Modelling & Prediction
4. Conclusions
   - Acknowledgements

Water Rockets

As an example of how we plan to implement this in our IFY, using “water rockets”.

These use an old drinks bottle containing a little water, which is then filled with compressed air until it releases at a reproducible pressure. The air then forces the water out the back, and the mass of the water produced the reaction force to power the rocket.

Clearly here is a cheap, simple experiment that touches on Newton’s laws of motion, conservation of momentum, energy just for starters.

How will this integrate into the modules?

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3. undertake the experiment, recording the results and the conditions, and testing the reproducibility;
4. graph the results and explore them;
5. consider sources of error and put forward ideas to reduce them if we reran the experiment.

But not much meaning will be extracted, apart from looking at the hypothesis.

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You get the idea...

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Horizontal Motion

Once the idea of trigonometry, and resolution of vectors is dicussed, we can see the horizontal motion is quite simple if we make lots of simplifying assumptions.

$$\ddot{x} = 0$$

$$\dot{x} = u \cos\theta$$

$$\Rightarrow x = (u\cos\theta) \times t = ut\cos\theta$$

So, if we plot

$$u = \frac{x_F}{t_F \cos\theta}$$

We can start to explore initial velocity, using just constant speed logic.

Vertical Motion

Vertical motion is more complicated.

$$\ddot{y} = -g$$

$$\dot{y} = u \sin\theta - gt$$

$$y = ut \sin\theta - \frac{1}{2}gt^2$$

Theoretically we can use these equations to work out the height, and even g, but the model is really quite flawed.

Conclusions

- We need to find a way to introduce basic Science and Mathematics to our weakest students;
- We need to allow students to take risks;
- So we find cheap, fun, safe experiments that can be revisited to extract deeper meaning as we proceed through the module;
- Get students to understand what a hypothesis is, a theory, a model, and the limitations of models.
- We don't worry about "mistakes" provided students can reflect fully upon what happened and what should be refined;
- After all, things went wrong for us too!

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