50 Years of Teaching Modelling – Experience in England

Hugh Burkhardt, Shell Centre, University of Nottingham, United Kingdom

The paper reviews the central role that applications have played in English mathematics and mathematics education, and how the explicit teaching of modelling in schools and universities has developed over the last half century. Starting with the still-present influence of Isaac Newton, it goes on to the stimulus that the launch of Sputnik gave to innovation in mathematics curricula and the emergence of modelling as an element in curricula. The exciting developments of the first 30 years are outlined, as are the adverse effects of the introduction of the National Curriculum in 1989. This personal account concludes with some comments on current issues – both challenges and opportunities.

1 Mathematics in England

1.1 Newton and afterwards – a little history

The British have long had a view of mathematics primarily as a toolkit for modelling. Though there have been many distinguished pure mathematicians, the applied tradition has been strong in both mathematics research and in mathematics education. Even after 350 years, the dominant influence remains that of Isaac Newton. A towering figure, he invented calculus\(^1\) for a purpose – to prove that the observed elliptical motion of planets followed from the model combining his new laws of motion and his new theory of gravity. A useful few years’ work\(^2\)!

The concept of the „applied mathematician“ was established and applied in Britain\(^3\) to those who worked on problems in other fields, first mainly physics but more recently expanding into biology, economics and many other fields. Applied mathematicians do roughly half the mathematics teaching in British universities, so there are theoretical physicists in both mathematics and physics departments.

The influence on school mathematics is also strong. Real situations are used to exemplify mathematical concepts, not only in the early years but throughout. Models from applications in various fields are a regular part of mathematics teaching and learning, albeit in formalised version that suppresses the empirical aspects. Newton’s influence is most direct in the last two years of high school, where students from age 16 to 18 traditionally\(^4\) spend half their mathematics time on applications of Newtonian mechanics to a dozen standard problem situations – examples include motion in a circle, projectiles, ladders leaning against walls, and collisions between balls. It is mostly about learning models but the variations in the problems involve some active modelling by students. This half of the curriculum is often taught by mathematics teachers who are not strong in physics (sometimes as a point of principle!); it is more challenging to most students than the calculus and algebra it complements.

\(^{1}\) At around the same time as Leibniz, who developed a better notation – close to that we use today.

\(^{2}\) He later translated the proof into purely geometric terms so that it could be understood by colleagues!

\(^{3}\) In the US and some other countries, applied mathematicians are „purer“, working on mathematics that can be applied, rather than the applications themselves.

\(^{4}\) There is now some variation, with statistics sometimes an alternative to the mechanics.
1.2 Modelling – we’ve all always done it

In Moliere’s play, *Le Bourgeois Gentilhomme*, the character of the title, Monsieur Jourdain, was amazed to find that he had been talking in „prose“ all his life. So it is with modelling. Everyone at some time, when faced with a practical problem in planning or design has used some of the mathematics they have acquired to help them to make progress towards a reasonable solution.

Young children use counting in their playground games, as do teachers making sure all the students are on the coach before returning from a school trip. Most children reason about money. The bar graph, based on a survey of students in his class, was a seven-year old’s pitch to get more pocket money. It worked.

All adults make some money calculations, if only to make sure that they will not pass the limit on their credit card. Do-it-yourself work around the home involves measuring and calculating. All this is mathematical modelling – the use of mathematics to help understand and solve practical problems. Many will use spreadsheets for family budgeting.

Unfortunately, most people see this „home maths“ as quite separate from „school maths“. This applies to teachers, students and the adults they become. Most adults use none of the mathematics they are first taught after age 11 in their everyday lives. This is the challenge that makes the inclusion of modelling in school mathematics so important. This paper gives a brief overview of what has happened in England over the last half century.

1.3 The real world in the maths classroom – a not-always-welcome guest

In considering the teaching and learning of modelling skills, we should begin with the mathematics classroom itself and, particularly, the teacher. Within the teaching profession, mathematics teaching has high status – with, perhaps, even a little mystery about it. This reflects the non-specialists’ view of the subject – as abstract, difficult and disconnected from the rest of learning and the world outside school. Some teachers of mathematics enjoy this detached status, seeing themselves as priests in a temple of exact higher-level learning. The result is an inward-looking approach to mathematics and its teaching, which is reinforced in teachers’ minds by their own experience and training in the subject.

Some mathematicians regard such activities as „trivial“, unworthy of the word „modelling“. However, learning to model with such problem develops all the processes of modelling.