So What's all this 'Modelling' Business About? The Third Strand of the National Curriculum for Information Technology

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Introduction

Modelling with a computer ranks as an unknown factor for many, but probably not all teachers who teach children in the 'middle years'. This rather outdated and un-National Curriculum like way of describing a range of children of different ages is used since for those children who are taught in 8–12 middle schools, the work which they undertake spans two key stages in the same school, or at least one key stage and the first year of the next. The description of modelling as an unknown factor may well be accurate for teachers in the other key stages too, but thoughts here are restricted to the 'middle years'.

As a strand of the National Curriculum for Information Technology, modelling was a surprising inclusion even to those primary teachers who had been doing precisely what the National Curriculum meant by modelling, or at least, nearly doing what the National Curriculum meant. According to the *Non-Statutory Guidance* (NSG) from the National Curriculum Council (NCC, 1990), and we have no reason to doubt it, computer models are 'representations of the real world, or abstract situations... and children should use, investigate, manipulate and later design' these models. Some practitioners were no further on after having read this description. The help available at the time was minimal, and depended upon the interpretation of the Orders and the NSG.

Modelling —What Does it Entail?

To enlarge upon the definition offered by the NSG, we can now look to other sources which include both centrally generated descriptions as well as contributions from other interested parties. We are also able to look to the wealth, though largely untapped, of available software types. We intend to examine one or two examples of 'good modelling practice' later.

To be told by the NCC that children should be using computer models which are representations of the real world or abstract situations is one thing, to actually get down to doing it in a progressive and developmental way, and to understand precisely what it means, is another. An extended, more detailed and enlightening definition is called for, one which can be put into the context of the types of activities teachers are planning for children in order to ensure coverage of and progression within the National Curriculum.

Modelling includes the use of computer simulations

A computer simulation is a program which simulates a situation, which may or may not relate to reality, by rigidly following a set, sometimes a very large set, of rules. There is also the possibility of including random elements with these rules.

Modelling includes the use of computer adventures games

A computer adventure is a simulation which has built into it a story and some sort of challenge which involves the solving of problems and the application of strategies.

Modelling includes the use of computer spreadsheets

A computer spreadsheet allows for rows and columns of information to be stored and manipulated. This manipulation can take the form of mathematical formulae, or more simply, it can be sorting or counting. The spreadsheet allows for changes to the whole **sheet** to be made automatically if one figure in one column or row changes and has an effect on other figures. A spreadsheet can be used to devise a model which has a mathematical basis.

Modelling includes the use of Logo and similar computer languages

Logo can, like all respectable content-free software, be put to use at a variety of levels. Using Logo-like instructions for controlling a floor robot is not necessarily modelling, but working in a Logo microworld, where certain rules apply and experiments can take place easily certainly is.

Modelling includes the use of 'custom' designed software

There are certain programs which have been designed and written with particular modelling needs in mind. In one way they are content-free, but in another they are tied to a narrower range of applications than other types of program. An example of this would be Numerator (1989), which is a system connecting boxes containing numbers to boxes containing mathematical operators. The system which is designed by the user is then put into 'motion'. Numbers travel around the system according to the designed structure, the operations cause changes in the values of the numbers which subsequently move around the system themselves, generating number

ElectBill

	A	B	C	D	E	F
1	Appliance	Power	Hours	p/Unit	Cost £	
2	Bar Fire	1000	10	6.1	0.610000	
3	Immersion heater	3000	10	6.1	--1.83	
4	Fridge	250	20	6.1	0.305000	
5	Lights	600	25	6.1	0.915	
6	Oven	2000	7.5	6.1	0.915	
7	Cooker	1000	8	6.1	0.488	
8	Television	150	15	6.1	0.13725	
9	Stereo	75	5	6.1	0.022875	
10	Immersion (E7)	7000	15	2.22	2.331	
11	Fridge (E7)	250	10	2.22	0.0555	
12						
13				Total	7.609625	
14			Standing	Charge	10.62	
15						
16			Total	Bill	109.5451	
17	Note: (E7) means					
18	Economy Seven					

Fig. 1.

sequences and allowing for hypotheses to be tested and patterns developed. There is scope for a great deal of advanced work with this particular program, as well as the investigation of simple patterns and sequences.

The best use of modelling software has at its heart objectives which stand apart from the Information Technology Profile Component. It is important that the use of IT does not take place for its own sake. The use of IT must be seen as a tool which will better enable the fulfilment of other curricular aims and in this way be seen for what its real value is, namely a means to an end, and not an end in its own right. Some may argue with this, and there is of course scope for approaching the use of IT flexibly and certainly there will be times when a computer might just be used for the sheer enjoyment that it may bring, or for the motivation which it may well engender. In general, computer use in the context of the classroom, as it is in the wider world (with the possible exception of the realm of computer games), needs to be viewed as a way of tackling problems and finding answers more effectively than other ways of working might allow. This idea is central to the use of computers and other IT instruments. Before using a calculator, for example, to work out the cost of three rolls of wallpaper costing £2.00 each, one really ought to think hard and, at least, carry out the simple multiplication mentally. An IT solution is not always the most appropriate.

Modelling in Practice (1) Using a spreadsheet to model the use and cost of electricity

In the context of National Curriculum based work on electricity, in a cross-curricular topic entitled 'In the Home', children had been set the task of taking information from the labels found on most electrical appliances. The information given tends to be of the form:

Volts: 240
Watts: 7
Hertz: 50/60

From this information, armed with the knowledge that electricity is charged for in a certain way, it is possible to work out the cost of running any particular appliance for a given length of time. A model of this use of electricity can be produced on a spreadsheet (Fig.1). Once the model is complete, whether devised and built by the children, or perhaps set up by the teacher for younger or less experienced children, it is ripe for use in a problem-solving mode. For example, what would be the effect of electricity charges rising by half a penny? What ways can be found to save money? Would switching to Economy7 be a real saving (with Economy7, night time electricity is cheaper, but daytime electricity is slightly more expensive). With the spreadsheet model fully operational all of these questions and many others can be answered. The children are working in a sophisticated problem-solving way, with the aid of an even more sophisticated computer model which will carry out calculations and present answers for interpretation. The argument that the children should be carrying out the calculations themselves holds no water. Without the understanding of the requirements, in terms of arithmetic, to set up the spreadsheet, the children would not be able to operate at this level, and it is unlikely that they would be able to understand what was expected of them anyway. The drudge of carrying out repeated calculations in order to solve particular problems would certainly detract from any thrill of discovering a suitable solution. In any case children tackling this type of work would almost certainly have been through the process of working out one or two examples first

YEAR SIX NEWSPAPER					
ITEM	COST P	QUANT.	TOTAL P		
PAPER	0.02	500	10		
COPIER	3	500	1500		
PHOTOS	34	8	272		
SUNDRIES			500		
		TOTAL P	2282		
TOTAL PRINTED	250				
UNIT COST	9.128		SOLD AT	10	
SALES (ESTIMATES)	YEAR 4	YEAR 5	YEAR 6	YEAR 7	STAFF
	58	42	38	52	12
REVENUE (EST)	580	420	380	520	120
TOTAL SALES (EST)	202				
TOTAL REVENUE (P)	2020				
PROFIT/LOSS (P) AT TEN PENCE PER COPY	-262				

Fig. 2

anyway, with a calculator, on paper, in their heads or best of all, all three.

Modelling in Practice (2) Using a spreadsheet model to help children to run a newspaper mini enterprise

Work which has successfully been carried out in many schools can involve the setting up, from first news stories coming to light, to final production and sales of a newspaper. Ways of organising this type of work can vary enormously, from the deadline-driven model which gives children just one day to carry out the whole operation, to the more leisurely system whereby plans are made, news stories researched and written, pages laid out, pictures acquired, and printing undertaken over a longer time-scale. The different ways of working have their respective advantages and drawbacks, and this is not really the place to go into them. The production of newspapers in this way is necessarily an IT-intensive task, and to a large extent relies on the availability of hardware in plentiful supply. For this reason the use of a computer for running a spreadsheet at a time when hands-on time for word processing and desktop publishing is at a premium is not always practical, or possible. The use of a computer for a spreadsheet in the way which is about to be described, could in some cases be possible, or it could be used to equally good effect after the main event, perhaps as an evaluation tool or some other follow-up activity. If the computer time could be found during the hustle and bustle of the newspaper day, it would serve to illustrate that finance and planning are important parts of business operations.

The costs of producing the newspaper can be entered into spreadsheet cells and minor arithmetic can be carried out by the spreadsheet, giving figures which can then be used to form part of the decision-making process. The whole activity requires a little advanced work in the form of a market survey in order to establish very approximately how many copies of the newspaper are likely to be sold. The costing of materials and copying, as well as other items such as photographic processing and other expenses can easily be established. Any other income, for example, advertising revenue must become a part of the equation too.

Fig. 2 shows a possible sheet which includes information concerning costs, estimates of sales and a profit/loss calculation. You will see that the sale price of 10 pence results in a forecast loss of £2.62. Fig. 3 shows that a sale price of 15 pence switches the account to a profit of £7.48. This is an example of the model being used to answer the 'what if...?' question which can be used as a way of

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ITEM	COST P	QUANT.	TOTAL P		
PAPER	0.02	500	10		
COPIER	3	500	1500		
PHOTOS	34	8	272		
SUNDRIES			500		
		TOTAL P	2282		
TOTAL PRINTED	250				
UNIT COST	9.128		SOLD AT	15	
SALES (ESTIMATES)	YEAR 4	YEAR 5	YEAR 6	YEAR 7	STAFF
	58	42	38	52	12
REVENUE (EST)	870	630	570	780	180
TOTAL SALES (EST)	202				
TOTAL REVENUE (P)	3030				
PROFIT/LOSS (P) AT TEN 15p PER COPY	748				

Fig. 3

determining the most sensible asking price for the newspaper. Another use could be to attempt to establish the price at which sales would have dropped significantly, thus finding the optimum price for the newspaper, optimising profit in this case, or at least attempting to ensure that a loss isn't made.

Modelling in Practice (3) branching stories using Logo

Branching adventure stories in which choices and chance play an important part have, over the last 10 years or so, become very popular with a fairly large number of children. At first books were produced most notably by the authors Livingstone and Jackson, and then computer versions became available, some making use of text only and the more advanced (in terms of the sophistication of the actual programming, not necessarily the complexity of the story), making use of computer graphics.

A great many children understand the structure of these branching stories and are very well motivated to read and work them through. To develop stories of their own is in many cases only a small step further. There are custom-made programs which allow for the authoring of branching adventures, but the educational programming language Logo, which has many applications in all types of classrooms, lends itself well to this type of work.

This is certainly a modelling activity; children will be dealing with variables, by considering the choices which will be offered to the reader/user. They will be considering the range of possible outcomes which depend upon the choices made at each branch in the story. Rules governing the progress of the story can be included in a variety of ways and are always open to alteration by the designer as the work progresses. Having an overall picture of the story, and all of the options contained within, and developing the relationships between each part of the story is certainly modelling. Other children who work through the finished stories and take part in the excitement are also modelling, though necessarily at a lower level. This type of work, as with all modelling activity, can be firmly rooted in other compartments of the National Curriculum. There is a strong emphasis on IT naturally, but planning and context place the work in a much wider context than the IT Capability Profile Component.

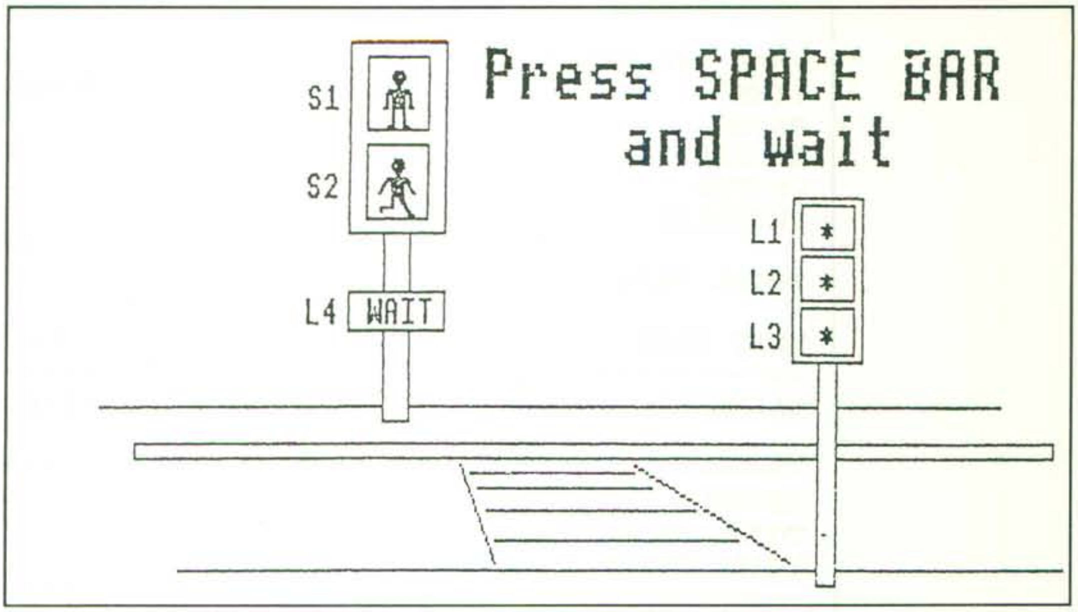

Fig. 4: A sample screen display from Montrol

Modelling in Practice (4)
Linking modelling with 'Measurement and Control'

In the best traditions of developing cross-curricular work, and making explicit the many links between the various parts of the whole curriculum, it is possible to forge a link between modelling in the National Curriculum and another of the strands of Information Technology. Measurement and control, the fourth strand of Information Technology, and often the one most ignored, lends itself well to links with models — this time in the sense of actual, physical models made from Lego, other construction materials, or from a combination of kits and other resistant materials. Combined with computer-controlled models, these allow for a high level of pupil involvement and interaction.

The operation of a set of traffic lights has been a standby design project from the time before computers showed themselves in schools, and children have spent valuable time wiring switches and coloured bulbs in both efficient and less efficient ways in order to demonstrate the logic of sequencing which they have mastered. With the advent of computer-control software this problem-solving task has taken on a new dimension. An example of this is the model of traffic lights which is built into the Montrol software. A clear line of progression can be seen with the use of this software. Using the model (which is ready made), children are allowed to sort out for themselves the logic and control sequences for the traffic signals and also for pelican crossings, using the same control language as they will be able to use when taking control of their own control problems at a later stage (Fig.4).

Montrol is a 'monitoring and control' program which operates through the usual interface mechanisms which are available to BBC and Archimedes computer users. Ready-made models, such as the traffic lights and greenhouses, as well as a granny flat, allow for manipulation and programming to be a part of the modelling/control/sensing project work undertaken. The screen representation of the model in use is an important aspect of the work, especially for those who are starting out with sensing and control, when a visual representation is extremely helpful. The screen representation can be left on one side as confidence and familiarity grow, but it can also be left in place.

Montrol is a good example of the way in which progression can be achieved in an area of Information Technology without necessarily looking for more complex or sophisticated software. Rather, the same software can be put to more complex and sophisticated uses. This is true of a good many examples of software commonly in use, and is perhaps an argument for using more advanced software for simple tasks. Some software producers have clearly recognised this and produced a means of using their product, which could be seen as difficult, or intimidating for learners in a 'cut-down' form. This involves allowing only a subset of the full range of functions to the beginner user, and quite often a simplified screen display is made available too. The full-blown spreadsheet Excel gives an example of this with Excel Starting Grid, a cut-down version of the

program which allows for a simplified range of operations.

Using a computer display and associated operations as a model, with links to sense and control in the way that Montrol and other software allows, is an ideal way of working towards covering the modelling and measurement and control strands of Information Technology Capability. There are clear ways of placing modelling and control work, carried out in this way, in the early stages of KS 2 — starting simply with the traffic lights, for example (controlling devices by commands with the help of a computer model). Work can also be developed through KS 3 — using both a screen model and a real model of a greenhouse, for example, in which information from temperature sensors is crucial to the success of the project. In KS 4 the scope is wider still, with possibilities for making proper use of feedback in the construction and modelling of conveyor belts, crossing barriers and so on.

■ Relevant Products

Non-Statutory Guidance —Information Technology Capability (1990) National Curriculum Council, Section C10.

Numerator (1989), Longman Logotron.

Montrol, available for BBC 'B' and Master; Archimedes version, Arc Montrol also available, from 'Keep I.T. Easy', KITE, PO Box 029, Nuneaton, Warwickshire CV11 4TT.

Excel from Microsoft and Excel Starting Grid from Research Machines plc, Mill Street, Oxford OX2 0BW.

Note: One unit of electricity is equal to having 1kW for 1 hour. Electricity bills show a charge per unit, 7.64p and less for Economy7 of course. The cost of running a 500W electric fire for half an hour, for example, can then be worked out: 500(W) ÷ 1000 (to change the Watts to Kilowatts) x 0.5 (h) x 7.64 (cost per unit) = 1.91 pence.