Initiating CHANGE

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Introduction

When I started a new job in September 1997, one of the tasks I was required to do was to attempt to update some of the teaching methods used within the department. A major aim was to start using some of the available technology to provide different learning situations for the pupils within the school. In this article I will describe some of the ways I went about trying to introduce some change and the views of members of my department both before the process began and at the end of the first year. I will also give examples of some of the materials I used which may be of use to colleagues finding themselves in a similar situation.

Background

Position in September 1997.

Hardware: 2 sets of 16 Multimedia Networked PC's in Central Computer Room.

Software: Subject Specific: Nil.
Generic suitable for Mathematics:
Microsoft Excel.

Departmental Use as a Teaching Aid: Nil.

The school where I am working is an independent grammar school situated in the middle of a city and has a very good academic record. In Mathematics this was brought about by adopting a traditional approach to teaching. Coursework had only been introduced for Year 10 pupils the previous year; until then Ma1 had been tested using the London Board's "coursework by exam" option. However, as this had been abolished for Summer 1998 and as an HMC inspection was also scheduled for early in 1999, there was incentive for change in many areas.

According to NCET (1995) all pupils should experience six aspects of IT during their school mathematics course.

- *Learning from Feedback – the computer provides fast and reliable feedback which is non-judgmental and impartial. This can encourage students to make their own conjectures and to test out and modify their ideas.*
- *Observing Patterns – the speed of computers enables students to produce many examples when exploring mathematical problems. This supports their observation of patterns and the making and justifying of generalisations.*
- *Seeing Connections – the computer enables formulae, tables of numbers and graphs to be linked readily. Changing one representation and seeing changes in the others helps students to understand the connections between them.*
- *Working with Dynamic Images – students can use computers to manipulate diagrams dynamically. This encourages them to visualise the geometry as they generate their own mental images.*
- *Exploring Data – computers enable students to work with real data which can be represented in a variety of ways. This supports interpretation and analysis.*
- *'Teaching' the Computer – when students design an algorithm to make the computer achieve a particular result, they are compelled to express their commands*

unambiguously and in the correct order; they make their thinking explicit as they refine their ideas.

(NCET 1995)

Spreadsheets

While there are many different ways these six 'entitlements' can be achieved, the limited resources that were available lead me to focus on developing spreadsheet use. I felt that, by working initially with only a spreadsheet, we would begin to address most of the 'entitlements' to some extent.

A spreadsheet is one of the most common applications and may be found in most computer menus. It is ideal for mathematical application. Pupils in my school are taught the basic functions of a spreadsheet in IT lessons in Years 7 and 9. Once the initial operational problems of the package have been overcome, the ability to carry out a large number of repeated calculations makes a spreadsheet very suitable for classroom use. The option of having both numerical and graphical representations of the same data on the same page enables pupils to see links between variables more easily and allows experimentation with the data. Spreadsheets also employ a fairly straightforward method of coding which, according to Healy and Sutherland (1991), allows "pupils to express general mathematical relationships which are far more sophisticated than those which they can normally express in their pencil and paper work". This helps develop confidence in the algebraic processes that the spreadsheet formulae refer to.

One of the problems I met initially when trying to convince my department of the need for change, in their approach towards coursework and towards integrating IT into their teaching, was their very natural concern about lacking certainty in these areas. All are experienced teachers who have done things "their way" for a few years; the need to release more responsibility to the pupils when dealing with investigations and the lack of certainty about the direction a particular extended piece might take made them feel uneasy. This unease was magnified when they considered trying to use computers as part of their teaching. Not only did they all feel uncertain with both hardware and the particular software that I had suggested, but they also felt uncomfortable knowing that some (or even many) pupils were more familiar with the applications than them. They felt that they needed extended time with the computer to build their confidence that they could respond to every eventuality as they would in their usual classroom situation. With all the pressures of time due to short terms and general workload they felt they did not have this time to give. Despite my assurances that many computer "experts" (which I certainly did not claim to be) might sometimes be floored by a strange sequence of button pressing by an unwary pupil and that there was always the option of resetting the machine and having the pupil restart their application, they still felt uneasy. The in-school INSET sessions I had planned were therefore particularly important if I was to achieve my initial goal of every member of the department having taken at least one computer-based lesson in the current academic year.

To start the process I decided to run an INSET session one evening after school. This is not ideal at the end of a long day's teaching but it was the best we could manage at the time. I had previously spoken individually to each member of the department to assess their knowledge of spreadsheets: I had found one person who used a spreadsheet at home to store test marks, amongst other things; otherwise knowledge was almost nil. With this in mind, I prepared what I hoped would be a simple introduction to the package. (See the next page for an example of the documentation I prepared.) My aim was to enable them quickly to use the package for some useful mathematics, so there was little emphasis on the presentation of the spreadsheet, but time was devoted to some mathematical applications.

The initial feedback to this session was very positive with most staff saying that they could see how using the spreadsheet could be useful in certain areas and that if their initial responses had been enthusiastic then the pupils would also be motivated by the change in approach. Their enthusiasm was still tempered by their insecurity about their knowledge of the package, but most of them were starting to see that perhaps some small-scale work was possible.

Because of their inexperience, I felt that the best way to encourage them to start taking groups into the computer room was to provide them with some worksheets that they could just issue to their group. The aim of these sheets was to

Getting Started:

To enter data or a formula in a particular cell move around using either the arrow keys on the right hand side of your keyboard or use the mouse clicking the left button once when you reach the required cell.

Cells are labelled via their columns A, B, C, ... and their rows 1, 2, 3, ...
The top left hand cell is A1 etc.

Formulae: Enter any number in A1
move to cell A2 and type
= 3*A1
Now changing A1 will automatically change A2.

You are now ready to start using the spreadsheet to do some Maths.

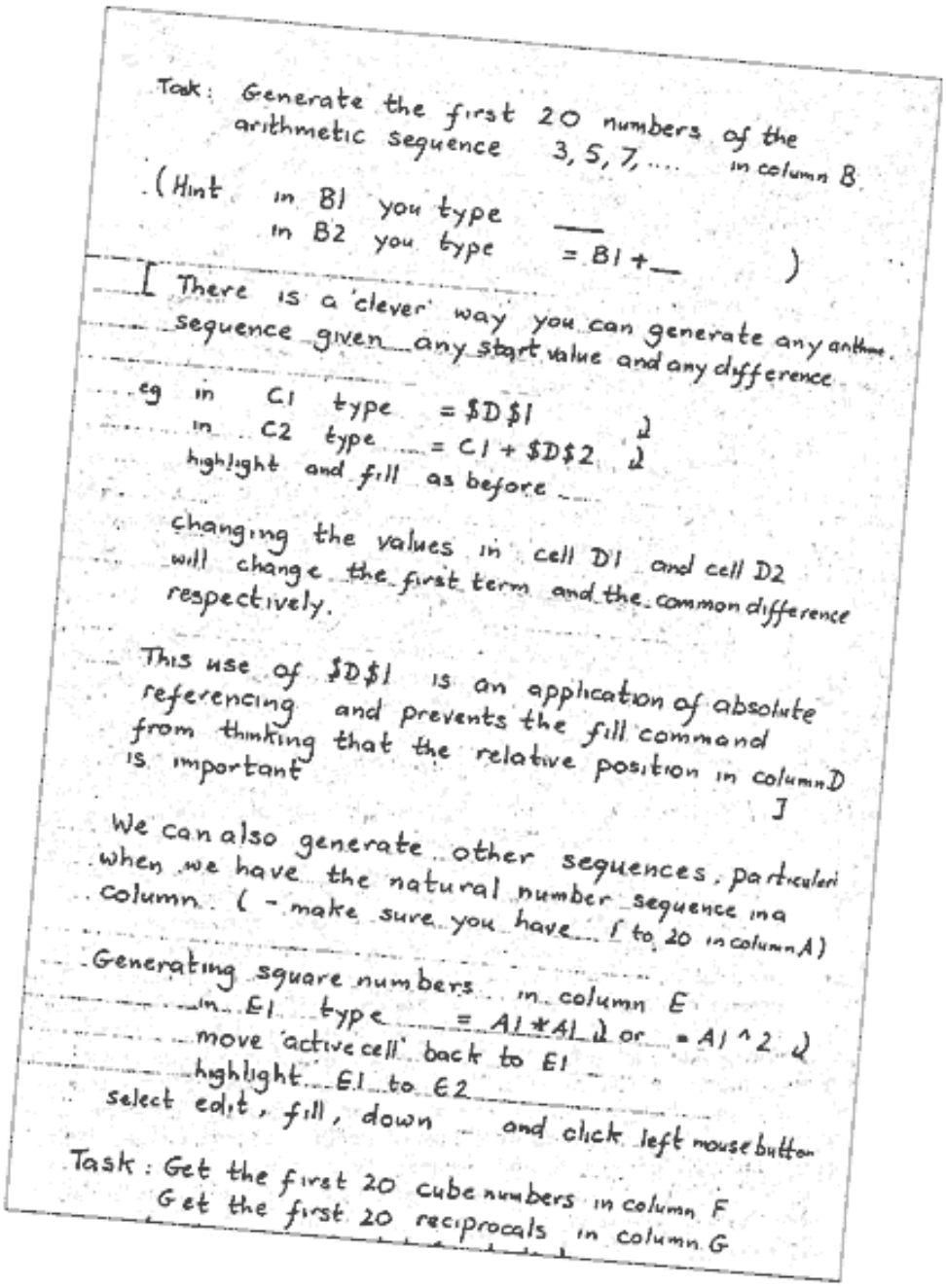
Generating number sequences

In A1 enter 1 ↵ ← means press enter key
In A2 enter =A1+1 ↵
move "active cell" back to A2, move mouse so "pointer" is on A2, hold down the left mouse button and move mouse pointer down column A (called "dragging" until A3 to A20 are all in black (highlighted).

Move mouse pointer to Edit (on the tool bar) select fill, down and click the left mouse button.
You should find the first 20 whole numbers in column A.

give step by step instructions for each stage of the exercise so, if the pupils followed them, the desired outcome would be achieved. So that I could be confident that these sheets were suitable for use, I first tested them on my own groups with varying success.

A sheet on straight lines designed for Year 8 pupils proved to be too wordy for some of my set 3 pupils. The more able pupils, and those who remembered their IT sessions on spreadsheets from the previous year, were able to get into the problem straight away and progressed more rapidly than I would have expected in a 'pencil and paper' lesson on the same ideas. Within 15 minutes they had grasped both that increasing the number in front of the "x" made the line steeper and the effect if that number was


Task: Generate the first 20 numbers of the arithmetic sequence 3, 5, 7, ... in column B.

(Hint in B1 you type ___
in B2 you type = B1 + ___)

[There is a 'clever' way you can generate any arithm. sequence given any start value and any difference.

eg in C1 type = D1 ↵
in C2 type = C1 + D2 ↵
highlight and fill as before

changing the values in cell D1 and cell D2 will change the first term and the common difference respectively.

This use of D1 is an application of absolute referencing and prevents the fill command from thinking that the relative position in column D is important]

We can also generate other sequences, particularly when we have the natural number sequence in a column. (- make sure you have 1 to 20 in column A)

Generating square numbers in column E
in E1 type = A1*A1 ↵ or = A1^2 ↵
move 'active cell' back to E1
highlight E1 to E2
select edit, fill, down and click left mouse button

Task: Get the first 20 cube numbers in column F
Get the first 20 reciprocals in column G

negative; moreover they could explain what would happen to the position of the graph if the constant term was increased or decreased. Those who experienced problems were struggling with the idea of substituting numbers into a formula and so had little appreciation of the ideas that the sheet was intended to develop. However, the general feeling amongst the group was, perhaps unsurprisingly, that it had been a 'good' lesson as "it was something different" and they were looking forward to another session on the computer. My own thoughts on the matter were that, while the sheet itself needed some screen dumps to cut the need for words, there had been a real improvement in learning and that this was a topic that was well suited to computer based teaching; using the spreadsheet eliminated the

need for accuracy in making numerical calculations and in the actual drawing, enabling pupils to concentrate on the outcome. By observing the differences between the lines and relating these changes to the alterations they had made in the formulae, pupils were able rapidly to develop their understanding.

A second sheet on solving equations by trial and improvement, which I based on Rothery (1991, pp100-101) for Year 9 or 10 pupils, was more uniformly received by my top set 3rd Year pupils. They all seemed to make progress and to appreciate how much easier the computer was making their task. An interesting point that emerged in this session was the difference in response between the boys and the girls. The girls seemed uncertain and often needed to be reminded to make alterations when moving from one problem to another, while the boys were usually able accurately to continue unaided. This may have just been a phenomenon particular to this group, where I know many of the boys are computer enthusiasts, but it was interesting to observe some familiar gender stereotypes emerging and it made me think of the need to be careful that all pupils are receiving the same opportunities for development.

LOGO and FPLOT

At the start of the year, I had felt that restricting the computer training to spreadsheets would allow staff to become familiar with the package and give them confidence to try out some ideas with their classes. However this did not seem to be what the keener ones wanted to do. They wanted to try out all the different packages we possessed rather than focus on one. As I was conscious that I was in some way imposing the use of computers on them, I felt it best to follow their enthusiasm by running a session on other packages. The two I chose to deal with on this occasion were LOGO (which I had only just bought), a useful programme for developing some concepts of shape and space, and FPLOT, a limited graph plotting package that I had found unused in my office when I arrived.

Again I prepared some initial notes on the two programmes to help people get started at their own pace. As with the spreadsheet session, the response was very positive. On this occasion the atmosphere in the room seemed more relaxed as different people discovered particular aspects of the packages and then shared their findings with others in a way reminiscent of pupils put in a similar situation. There was also discussion about ways in which LOGO and FPLOT could be employed within the scheme of work to help increase understanding. However, I could still sense concern from some people that their lack of a total understanding of the software might lead them to lose control within a lesson. I thought this insecurity would never disappear until they had successfully started to integrate computers into their teaching strategy.

Teacher Feedback

One of my initial aims had been for all maths staff to take at least one class into the computer room during the year. While this has not been entirely realised at present, all the full-time teachers have tried one or more topics using different packages in the last few months with (mostly) great enthusiasm. One teacher even attended in her free time a series of IT lessons in which year 6 pupils used LOGO; she wanted to gain more understanding of the possible applications.

The most common general comment (apart from the fact that it was a long way up the stairs to the IT suite) was about the difficulty of carrying out a coherent mathematics lesson rather than a lesson on the particular software in only 35 minutes. This problem may be solved to some extent next year as timetable changes across the school will encourage more double periods; all subjects who want them will have at least one double per week. The maths staff said that extra time would allow them to introduce more discussion and use the machines in short bursts rather than pupils always working at their own pace on individual tasks. The hope was that the computers might become tools for learning and doing mathematics, integral to teaching and not just a 'special extra'.

Another general comment, which echoed what I had noticed in some of my own groups, was that boys seemed far more confident in computer based lessons, even when they did not really know what they were doing, while many girls appeared nervous. This, they said, was different to the usual attitude in class where the girls were equally confident answering questions and working on their own.

On specific packages, reactions were mixed; different teachers appreciated different aspects and encountered different problems. For example, one teacher experienced problems while using EXCEL to produce statistical diagrams with a Year 7 class; the programme would not allow individual bars in a bar chart to be labelled numerically starting at 0. (This does seem to be a problem with the version of EXCEL running in the school as no simple sequence exists to ensure that the required values are used as bar labels unlike previous versions.) She felt that the pupils had not really learnt much about the statistics involved but had tended to 'play' with the package, producing different types of diagrams whether they were relevant to their data or not. This frustration was contrasted by the experience of another teacher who, with the help of a student teacher, was tackling a statistical project with a top set Year 10 group. [It is always easier with two people to deal with something unfamiliar in a computer-room-based mathematics lesson.] She was very taken with all the built-in statistical functions and all the different ways the data could be examined for analysis and reported a high level of learning amongst her group.

Two teachers had used LOGO with junior classes in the school. Both found that the instant response and simple nature of the programme allowed all pupils to achieve something quickly whilst forcing them to think about their geometrical knowledge and be precise when drawing shapes. They thought that the programme was self-differentiating and could fulfil the needs of pupils at all levels, which would be particularly useful in a mixed ability Year 7 group. At present, neither teacher has gone any further into aspects of programming but, even at the basic level of just drawing shapes, both feel that there are sufficient applications of the package to make using it a worthwhile experience for the pupils.

FPLOT is a very cheap curve drawing package that the previous Head of Department had bought but never had installed on the network. It has some major drawbacks, as I found when I took a Year 11 class in to use it. The software tended to default to strange scales on the axes when plotting curves; the axes are rarely annotated in the way one would do it when drawing the graph by hand. However, the package can serve a useful purpose, at least until another graph plotting package can be bought. Other staff who used it, while recognising some of the problems, felt that it would be much more useful than EXCEL for aiding understanding of curves (graphical calculators are definitely a thing of the future for us!). One teacher, who took a bottom set Year 10 group into the computer room to examine simple transformations of the curve $y = x^2$, such as $y = x^2 + c$ and $y = ax^2$, was convinced that the package had helped understanding. The facility to draw multiple curves quickly was very helpful for less able pupils, who would otherwise struggle to calculate values and plot curves. She reported very positive feedback from the pupils; one very weak girl, who has found almost every aspect of the course difficult, said this was the first time in ages that she had achieved something in a maths lesson.

Review and Future Planning

Introducing new technology into teaching can be difficult because of the time required to understand the technology. However, if teachers are willing to learn by experience and do not expect to have complete mastery of the software before using it, then much useful learning can take place. Fortunately this seems to be the case with the majority of my department.

Looking back over the course of the year I feel that a great deal of progress has been made. I have not accomplished all my aims as not all department staff have yet attempted computer based lessons but some have tried more than I had hoped for in the first year. The purchase of software has continued. Besides EXCEL, LOGO and FPLOT, for which some training has been carried out, the department now has more software available to use on the network. We have DISCUS, a statistical *teaching* package using Excel for use at A-level and GCSE; I hope to encourage pupils to use this in their own time. There is also a GCSE revision package (Maths Connections) which I hope might encourage teachers who prefer a traditional approach to come to the computer room and experience working in a different environment from the usual classroom. Along with these, we have just bought a selection of concept-based small "games" suitable for the junior end of the school. I think I still have a great deal to do, in training other staff and myself, and in preparing suitable

Mathematics Department Policy Statements. IT Development Plan

At present the level of IT use within Mathematics teaching is limited. The aim of this plan is to help in a way towards increased use in the future.

1997 – 1999

- Increase staff familiarity with the various packages possessed (EXCEL, LOGO, FPLOT, DISCUS, STEPS) through a series of in-house INSET sessions and (if possible) external courses.
- Produce/purchase sets of comprehensive worksheets showing how the different packages can be used in different situations to increase pupil understanding and to stimulate interest.
- All staff to trial different packages with different forms so that experience is gained and confidence increased.

1999 – 2001

- Purchase a departmental stand-alone computer complete with OHP attachment and with its own trolley for ease of movement about the departmental teaching rooms and a cupboard for safe storage.
- Install all the packages possessed and Cabri (or Geometer's Sketchpad) for displaying dynamic images and DERIVE for symbolic manipulation.
- Start to integrate computer use into everyday teaching rather than requiring a special visit to the computer room.
- Purchase a set of Graphical calculators for use with classes and obtain training for staff in their use.
- Begin to utilise the Internet and the different resources available there either as an integral part of class teaching or by encouraging pupils to research topics on it.

While these aims are in no way meant as a complete list of developments that may occur, it is hoped that with some definite aims in mind progress will be made towards the integration of computers into mathematics teaching.

Position in July 1998.

Hardware: Unchanged

Software: Subject Specific: FPLOT, DISCUS, Maths Connections, 13 x DLK Modules, 5 x STEPS Modules

Generic suitable for Mathematics: Microsoft Excel, LOGO

Departmental Use: examples included in departmental schemes of work for years 7 to 11; almost all staff have tried at least 1 lesson and aim to build on experience gained next year.

worksheets and support material to make the integration of technology as smooth as possible. As computer use in maths lessons becomes more widespread and regular, I hope that pupils will be less 'excited' by the novelty of the experience and less distracted by the technical features of the packages. This would free them to concentrate on using their skills to achieve the desired goals.

I still have some longer term aims to integrate the technology into mathematics teaching (see the IT development plan, above, which I wrote at the start of the year while attending the ATM Course "Implementing IT in Mathematics"). However, many of these are dependent upon financial support so I must wait to see which are possible and in what time scale.

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