Mathematics and IT – a pupil's entitlement

A pupil's entitlement at Key Stages 3 and 4.

This is an on-line version of the booklet *Mathematics and IT.* It is designed to be used in conjunction with the *Review of IT in Mathematics* in framing your action plan and it is intended for use by the school mathematics department. It will also be helpful in discussions with the IT co-ordinator, the senior management team and school governors.

Mathematics and IT – opportunities for exploiting the power of IT

Listed below are six major ways in which IT can provide opportunities for students learning mathematics. These opportunities are expanded and exemplified in this leaflet.

Learning from feedback

The computer often provides fast and reliable feedback which is non-judgemental 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 and calculators 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.

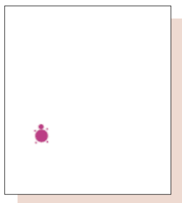
'Teaching' the computer

When students design an algorithm (a set of instructions) to make a 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.

Mathematics and IT – learning from feedback

The computer often provides fast and reliable feedback which is non-judgemental and impartial. This can encourage students to make their own conjectures and to test out and modify their ideas.

Students can use trial and improvement with the simplest of calculators to solve equations. Formal iterative searches have become common since new technologies have been available and feedback from the machine is an essential ingredient of these methods.



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repeat 6[fd 50 rt ?]
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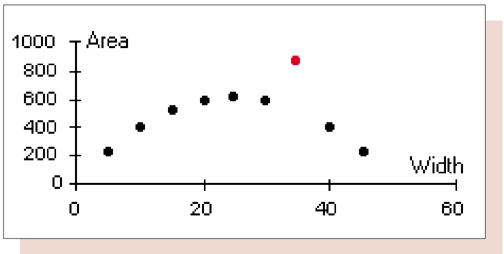
The computer's feedback will assist if a student is trying to draw a hexagon with *Logo*.

A simple *Logo* program will draw a hexagon. The drawing produced by the student's choice of angle will provide immediate feedback about whether the angle was correct. There is no need for a teacher's intervention and any mistake provides an opportunity to learn something new.

If a student is collecting data manually for the area of a rectangular field made from 100m of fencing, plotting a graph from the spreadsheet is likely to reveal any erroneous data.

Much good software offers continual feedback during students' activities, providing them with insight and encouraging explanation.



Mathematics and IT – observing patterns

The speed of computers and calculators enables students to produce many examples when exploring mathematical problems. This supports their observation of patterns and the making and justifying of generalisations.

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45

Choose a new multiple: ▼

Above is a simple grid as described (across). When using the computer choosing a multiple from the drop down list will redraw the grid with the correct squares highlighted.

Pupils might be asked to shade the multiples of 4 on a grid with 9 columns and then to find out which multiples form diagonal patterns on grids of different sizes. There are various software packages which allow many examples to be explored quickly so that pupils can observe patterns in their results. This process will help them to explain what is happening.

In this activity pupils may start by seeing that, on a grid with 9 columns, shading the multiples of 9 produces a column pattern. Watching the grid building up may then clarify why columns also occur when the multiples of 3 are shaded and this, in turn, may lead to a conjecture about factors.

In a similar way, when many examples are illustrated it may become clear why diagonal patterns occur when the number whose multiples are shaded is one more or one less than the number of columns – on a grid with 9 columns adding 9 gives the number immediately below and so adding 8 or 10 usually gives the number diagonally below.

Mathematics and IT – 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.

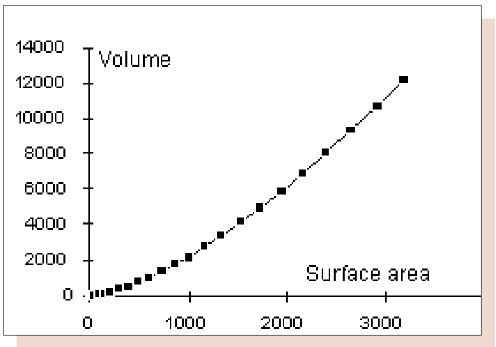
Why does a baby need to be wrapped up so well in cold weather?

After discussion about ways of modelling this problem mathematically, younger pupils might decide to explore the surface area and the volume of various cubes.

Cube Size	Area of Face	Surface Area	Volume
1	1	6	1
2	4	24	8
3	9	54	27

A simple start would be to tabulate results manually, on a spreadsheet, with the pupils calculating each entry in turn. When the spreadsheet is subsequently graphed, the need for more data becomes clear. This can be provided if the cube size, the surface area and the volume are connected through the use of formulae which are copied to many rows of the spreadsheet.

Indeed, calculating the surface area and the volume for particular cubes may have already suggested formulae to the pupils.



Within a spreadsheet an algebraic formula can be used to generate a table of numbers and this can then be graphed. Alternatively, a graphic calculator or graph-plotter allows the graph to be drawn directly from the formula and values can be traced. Working through a medium which enables pupils to switch effortlessly between these representations enhances their conceptual development.

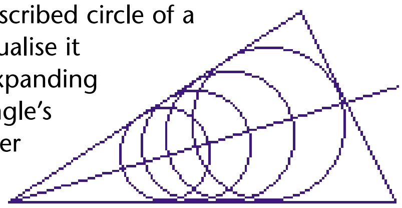
Mathematics and IT – working with dynamic images

Students can use computers to manipulate diagrams dynamically. This encourages them to visualise the geometry as they generate their own mental images.

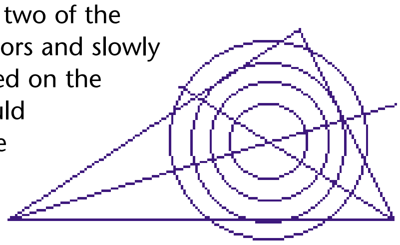
Deforming a figure produced by geometric construction generates many examples and the dynamic link between them enables conjectures to be formulated and tested.

Transformation geometry is concerned with movement and so it is helpful to work with geometry software which is dynamic. This enables students to drag an object around the screen with the mouse and see the reflection, or some other transformation, moving simultaneously.

The dynamic nature of the software also stimulates mental images of other geometric ideas. For instance, if a pupil familiar with the software is asked about the inscribed circle of a triangle, she may visualise it shrinking into and expanding from one of the triangle's vertices. This, together with the symmetry, might suggest that the centre of the circle lies on the angle bisector.



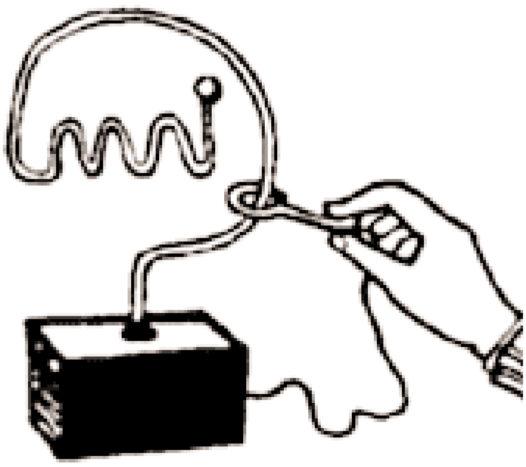
The pupil might then decide to use the software to construct two of the triangle's angle bisectors and slowly enlarge a circle centred on the intersection. This would confirm that the circle touching all three sides of the triangle does indeed lie on the angle bisectors.



Mathematics and IT – exploring data

Computers enable students to work with real data which can be represented in a variety of ways. This supports interpretation and analysis.

Some Year 7 children had recently made a few gadgets to use at the school fair and they were discussing which was the most difficult. After much debate, the pupils decided that every child in the class should have three attempts with each gadget and that each time they should record how many times the alarm bell sounded. In addition, the tests would be timed and the initial distance traversed without touching the wire would be measured.



The data was fed into a spreadsheet:

Gadget	Bells 1	Bells 2	Bells 3	Time 1	Time 2	Time 3	Dist 1	Dist 2	Dist 3
A									

The pupils then had to decide how best to use all this data to achieve a reasonable single measure. They talked about averages and added further columns to incorporate them. They graphed the various columns of the spreadsheet to detect any connections. They then worked at different formulae, also using the spreadsheet and its graphs.

These children were engaged in the process of mathematical modelling while they were handling data. They decided what experiment to do, which data to record and how to use the data.

Work of this nature can be directly linked to other curriculum areas. For example, testing the distance travelled when cars roll down slopes or finding the time for a pendulum to swing are activities which contribute to the science curriculum, and geographers may want to learn about the rate of flow of a river at various distances from the banks. Using real data with computers means that a cross-curricular approach is feasible. Pupils can also use existing databases to gain access to much larger sets of data.

Mathematics and IT – 'teaching' the computer

When students design an algorithm (a set of instructions) to make a 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.

Many younger pupils have an intuitive idea about percentage. They know that it means a penny in the pound and they can use this fact to evaluate simple quantities – 1% of £6 is 6p and so 5% must be 30p. However, a problem not involving money and with more awkward numbers presents difficulties because the children do not have a general method which always works. When they attempt to teach a computer to evaluate percentages, using a language such as *Logo*, they must reflect on what they know in order to find a single method for calculating the answer.

```
to percent
:a   :b
print :a  *  :b  /  100
end
```

On typing percent 20 75, the computer now prints 15 (20% of 75).

The opportunity to teach a computer arises whenever pupils use formulae in a spreadsheet. Teaching a spreadsheet to display the volume of a box, for example, assists understanding of symbolic expressions. Dynamic geometry software provides another environment in which students can teach the computer. Constructing a square, say, means that pupils have to clarify their understanding of its properties.

> *The computer is an ideal medium for students to generate algorithms: it always does precisely what it has been told to do, it waits patiently for its commands, it has no expectations of its teacher and it is uncritical of failure in the way human beings might be.*

A Pupil's Entitlement – acknowledgements

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