

4 Use of technology

New technology has had a profound influence on the world of work, and by implication on vocational education. Use of technology in numeracy tasks may include: a calculator, perhaps with graphics and statistical functions; a spreadsheet; a mobile phone, including GPS functions; specialist software applications; and programming languages such as Java for use in creating applications.

Researchers have investigated the effects that calculators may have on the development of students' numeracy skills. Electronic aids to calculation can be a great help to students and provide motivation in numeracy. Pomerantz (1997) comments:

Students' operational skills and problem-solving skills improved when calculators were an integral part of testing and instruction. Students using calculators had better attitudes toward mathematics than their non-calculator counterparts.

By reducing the time that, in the past, was spent on learning and performing tedious paper-and-pencil arithmetic and algebraic algorithms, calculator use today allows students and teachers to spend more time developing mathematical understanding, reasoning, number sense, and applications. Four-function, scientific, and graphing calculators, as well as calculators with computer symbolic algebra manipulation capability provide new pedagogical enhancement opportunities.

The question of whether calculators have a negative effect on mental arithmetic and written mathematical skills is addressed by Pomerantz:

It is very important that mental calculations as well as estimation and some paper-and-pencil skills continue to be taught in schools, when those are the most appropriate methods for solving problems. Such skills are necessary in the mathematical learning process. These skills will also come in handy when a calculator is not available and when it is necessary to determine the appropriateness of a calculator result.

Calculators, and other mathematical aids, should just be seen as tools to make work quicker and easier. Ultimately, an understanding of mathematical techniques is essential.

Pomerantz comments:

Despite all of their benefits and capabilities, calculators will never be able to replace the human mind when it comes to knowing how to read and understand a problem situation, writing an appropriate equation for the problem, choosing which operations to use to solve the problem, correctly interpreting the solution displayed on the calculator, and determining the appropriateness of the answer.

Being aware of the advantages and limitations of calculator and computer use, we can examine situations where they may be of genuine value to numeracy activities in vocational courses.

Calculators have the advantage of being easily portable and can be conveniently carried in a bag or coat pocket for use in project activities in the classroom, workshop or during fieldwork.

Basic arithmetic will be important in many situations, including for example, the calculation of percentages. Sometimes, however, more complex tasks may require the use of a calculator. We will give several examples from geography fieldwork where the easy availability of a calculator during data measurement is of particular value.

Tree height

During a vegetation survey, it may be necessary to estimate the heights of large trees. A convenient technique is to lay out a measured line horizontally from the base of the tree, then determine the angle to the tree top using a clinometer:

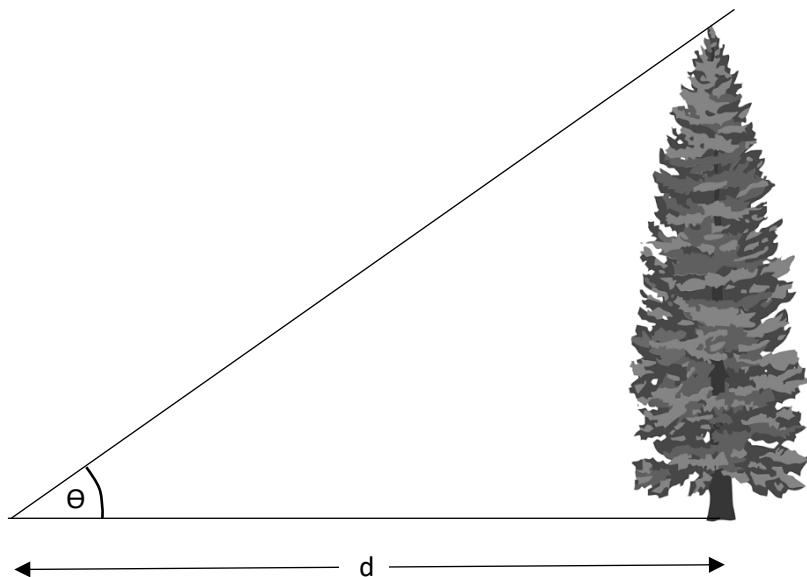


Figure 28: Calculation of the height of a tree using trigonometry

The height of the tree can be found by trigonometry:

$$\text{height} = d \tan \theta$$

Clinometers are readily available commercially, or can be easily constructed from a protractor and plumb line.

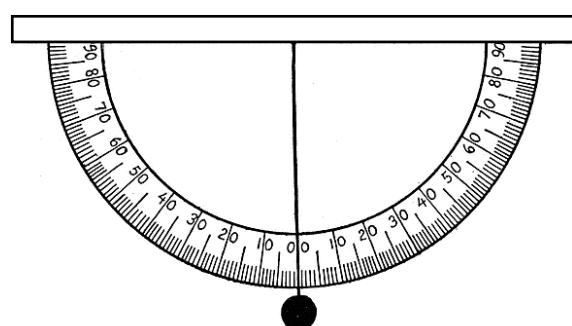


Figure 29: A home made clinometer

River width

A similar trigonometrical problem may occur during a river survey. Students may need to find the width of a river at a point where it is not possible to cross safely. A point is selected on the far bank. The closest corresponding point on the near bank is used as the start of a measured baseline laid out in a right angle:

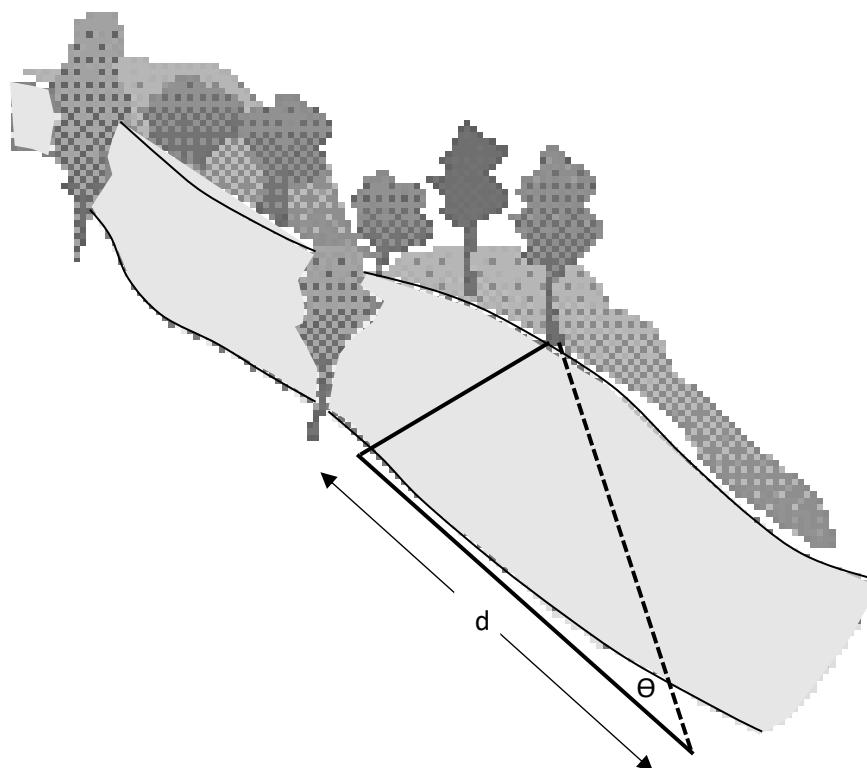


Figure 30: Calculation of the width of a river using trigonometry

The angle θ of the triangle can be found by taking compass bearings on the two ends of the line crossing the river, then finding the difference in bearing.

The width of the river can then be found by trigonometry:

$$\text{width} = d \tan \theta$$

Vehicle speed

In a road safety or traffic survey, students may need to estimate the speed of vehicles travelling along a section of road. This can be done by selecting two reference points, identified by prominent road markings or signs. The distance in metres between the points is found, either directly by tape or measuring wheel, or calculated from a large scale map.

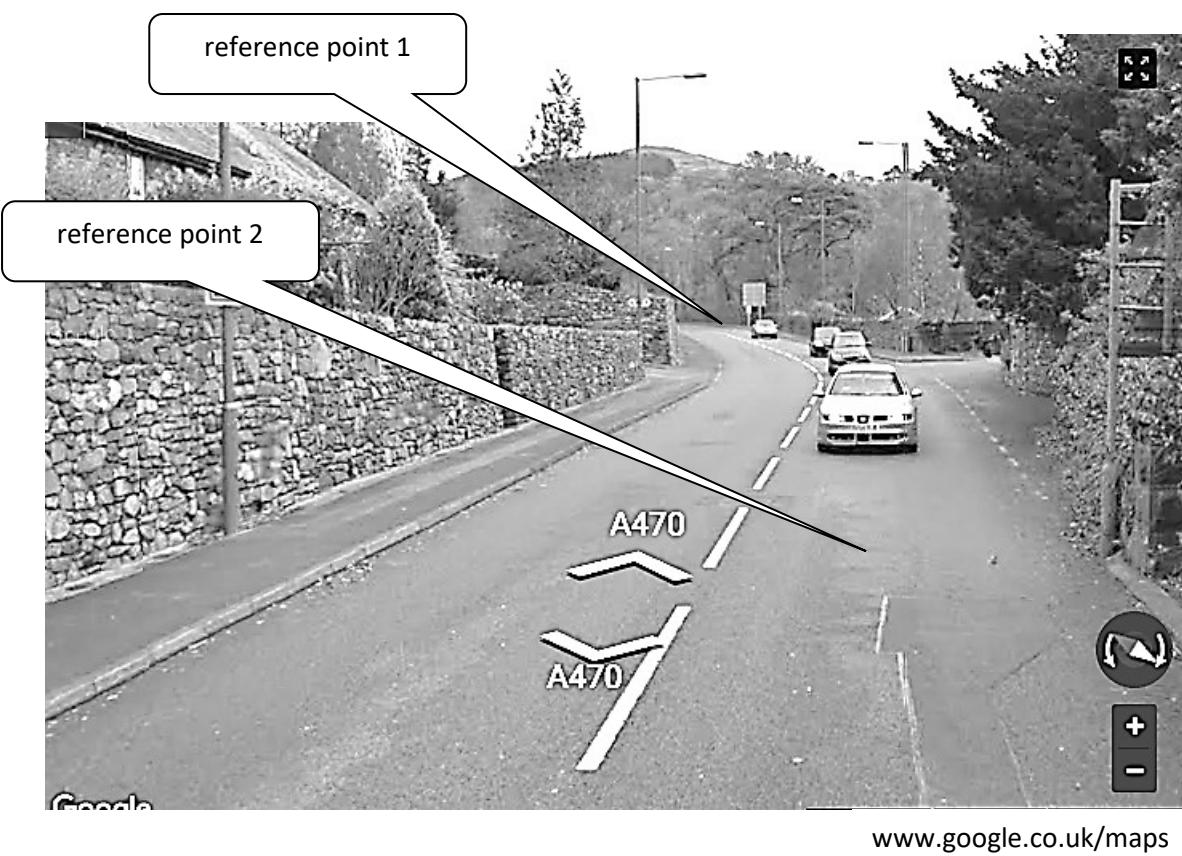


Figure 31: Calculation of vehicle speed between reference points

An observer records the time in seconds for a vehicle to travel between the reference points. The speed in miles per hour can then be obtained by the formula:

$$\text{speed mph} = \frac{\text{distance m}}{\text{time s}} \times \frac{3600}{1000} \times \frac{5}{8}$$

The factor 3600/1000 converts the speed from **metres per second** to **kilometres per hour**, then the factor 5/8 converts from **kilometres per hour** to **miles per hour**. The conversion factor from kilometres to miles will be sufficiently accurate in view of the likely approximation in the time measurements.

Modern calculators have powerful graphing and statistical functions, and are conveniently portable. However, when working on a large numeracy project we suggest that a computer spreadsheet provides a number of advantages:

- The spreadsheet can be saved as a permanent record of the calculation, then transferred if necessary to a word processed report or PowerPoint presentation.
- Graphs can easily be created from numerical data, often simply by highlighting a table of data and clicking an icon to select the required type of graph.
- Very flexible facilities are available for customising graphs to handle a wide variety of different formats of data.
- Functions are available for statistical processing of data, including the calculation of best fit lines through data sets in graphs.
- Formulae can be set up with named variables, to make expressions easier to understand.
- Data values can be easily changed, so that students can explore the behaviour of a mathematical model.
- It is easy to copy pages of a spreadsheet, so that variations of a model can be developed and compared.

A particular value of spreadsheets, and calculators, is in allowing experimentation with algebra. A difficulty in making connections between numeric and algebraic representations of data was identified during investigations with our own students. The Center for Algebraic Thinking (2016) makes a strong case for developing algebraic skills:

Employers often expect their employees to translate work-related problems into general mathematical models, from calculating discounts for merchandise to operating technology-based equipment and machinery. Many careers in the fields of science and technology demand high levels of mathematics competence to solve complex problems, such as chemical equations involved in the study of drug interactions. Algebra is also helpful in daily life, from applying formulas for calculating miles per gallon of gasoline to using functions to determine the profit of a business venture.

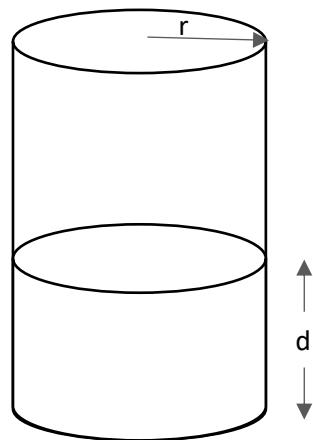
It is suggested by the Center for Algebraic Thinking that more emphasis should be placed on developing a flexible approach to problem solving by students:

Most word problems can be solved either through algebraic or arithmetic methods. To motivate appropriate use of algebraic and arithmetic solution strategies, students should be exposed to problems that are not easily solved with arithmetic solutions. Students should also be encouraged to develop flexibility in choosing whether an arithmetic or algebraic strategy is more appropriate for a given problem.

In the next section, we will look briefly at a couple of examples of the use of spreadsheets to tabulate numerical data, carry out calculations using formulae, and display results graphically. The mathematical techniques involved will be examined in more detail in later chapters of the book.

Liquid in a tank

Liquids are commonly stored in circular tanks. If the tank stands vertically on its circular base of radius r , it is a simple task to calculate the volume of liquid if the depth d is known:



$$\text{volume} = \pi r^2 \cdot d$$

Figure 32: Calculation of the volume of liquid in a vertical tank

However, if the tank is resting horizontally, the problem is a little more difficult:

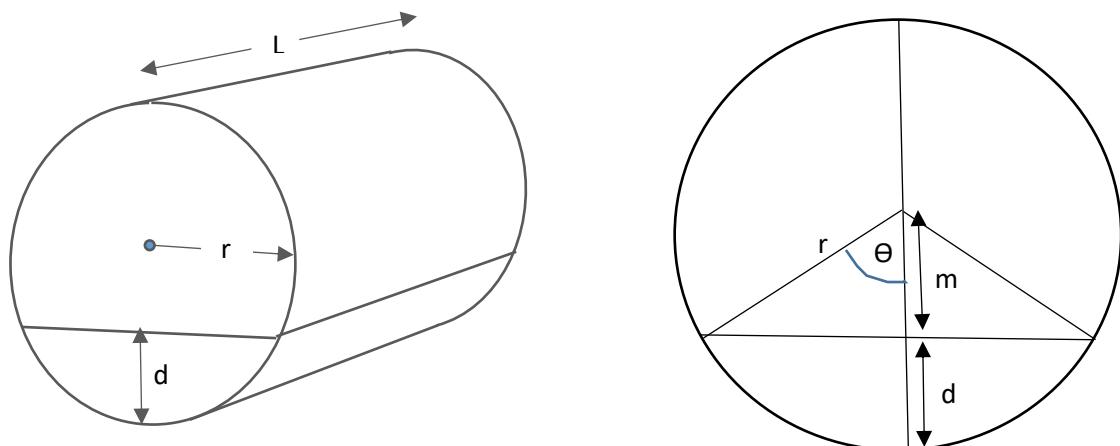


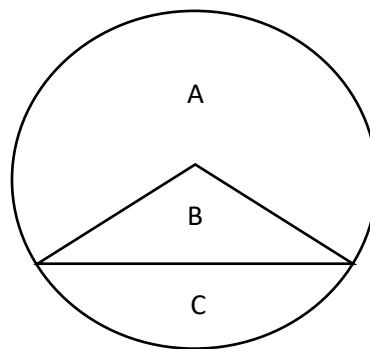
Figure 33: Calculation of the volume of liquid in a horizontal tank

A possible strategy for solving this problem is:

- Find the depth of liquid d in the tank, then use this to determine the liquid level m above or below the mid-point of the tank
- Use the cosine formula to find the angle θ from the length m and the radius r of the tank

$$\cos \theta = \frac{m}{r}$$

- Divide the circle into three areas:



Find the sector A using:

$$\text{area} = \pi r^2 \cdot \frac{(360 - 2\theta)}{360}$$

Find the triangle B using Pythagoras' theorem:

$$\text{length of the base} = 2 \sqrt{r^2 - m^2}$$

$$\text{triangle area} = \frac{1}{2} \text{base} \times m$$

Find the area C of the liquid by subtracting areas A and B from the area of the full circle.

- Complete the calculation of the liquid volume by multiplying area C by the length of the tank.

As an example, we will choose a tank of diameter 2 metres and a length of 4 metres. A spreadsheet can be used to produce a table showing the volumes of liquid for depths at intervals of 20cm.

Liquid volumes are calculated first in cubic metres, then converted to litres:

$$1 \text{ m}^3 = 1000 \text{ litres}$$

Stages of the calculation, as described above, are carried out in columns C to H of the spreadsheet.

An additional feature of the spreadsheet allows a depth of liquid, measured in metres, to be entered in cell B4. The corresponding volume of liquid will be calculated and displayed in cell B5.

	A	B	C	D	E	F	G	H
1	radius (m)	2.0						
2	length (m)	4.0						
3								
4	liquid depth (m)	3	-1.0	120	4.18879	-1.73205	10.10963	40.43852487
5	volume (litres)	40438.5						
6								
7	liquid depth	volume (litres)	m	theta	area A	area B	area C	volume cu.m
8	0	0.0	2.0	0	12.56637	0	0	0
9	20	939.6	1.8	25.841933	10.76226	1.569204	0.234904	0.93961451
10	40	2616.0	1.6	36.869898	9.992366	1.92	0.654004	2.616017741
11	60	4728.0	1.4	45.572996	9.384775	1.9996	1.181995	4.727981443
12	80	7156.7	1.2	53.130102	8.85719	1.92	1.789181	7.156723488
13	100	9827.0	1.0	60	8.37758	1.732051	2.456739	9.826957589
14	120	12682.8	0.8	66.421822	7.929253	1.466424	3.170694	12.6827748
15	140	15678.8	0.6	72.542397	7.501956	1.144727	3.919688	15.6787506
16	160	18775.7	0.4	78.463041	7.088617	0.783837	4.693917	18.77566763
17	180	21938.1	0.2	84.26083	6.683855	0.397995	5.484521	21.93808259
18	200	25132.7	0.0	90	6.283185	0	6.283185	25.13274123
19	220	28327.4	-0.2	95.73917	5.882516	-0.39799	7.08185	28.32739987
20	240	31489.8	-0.4	101.53696	5.477754	-0.78384	7.872454	31.48981483
21	260	34586.7	-0.6	107.4576	5.064415	-1.14473	8.646683	34.58673186
22	280	37582.7	-0.8	113.57818	4.637118	-1.46642	9.395677	37.58270766
23	300	40438.5	-1.0	120	4.18879	-1.73205	10.10963	40.43852487
24	320	43108.8	-1.2	126.8699	3.709181	-1.92	10.77719	43.10875897
25	340	45537.5	-1.4	134.427	3.181595	-1.9996	11.38438	45.53750101
26	360	47649.5	-1.6	143.1301	2.574004	-1.92	11.91237	47.64946472
27	380	49325.9	-1.8	154.15807	1.804107	-1.5692	12.33147	49.32586795
28	400	50265.5	-2.0	180	0	0	12.56637	50.26548246
29								

A chart can be produced for conversion of liquid depth to volume, using the table of data in the spreadsheet:

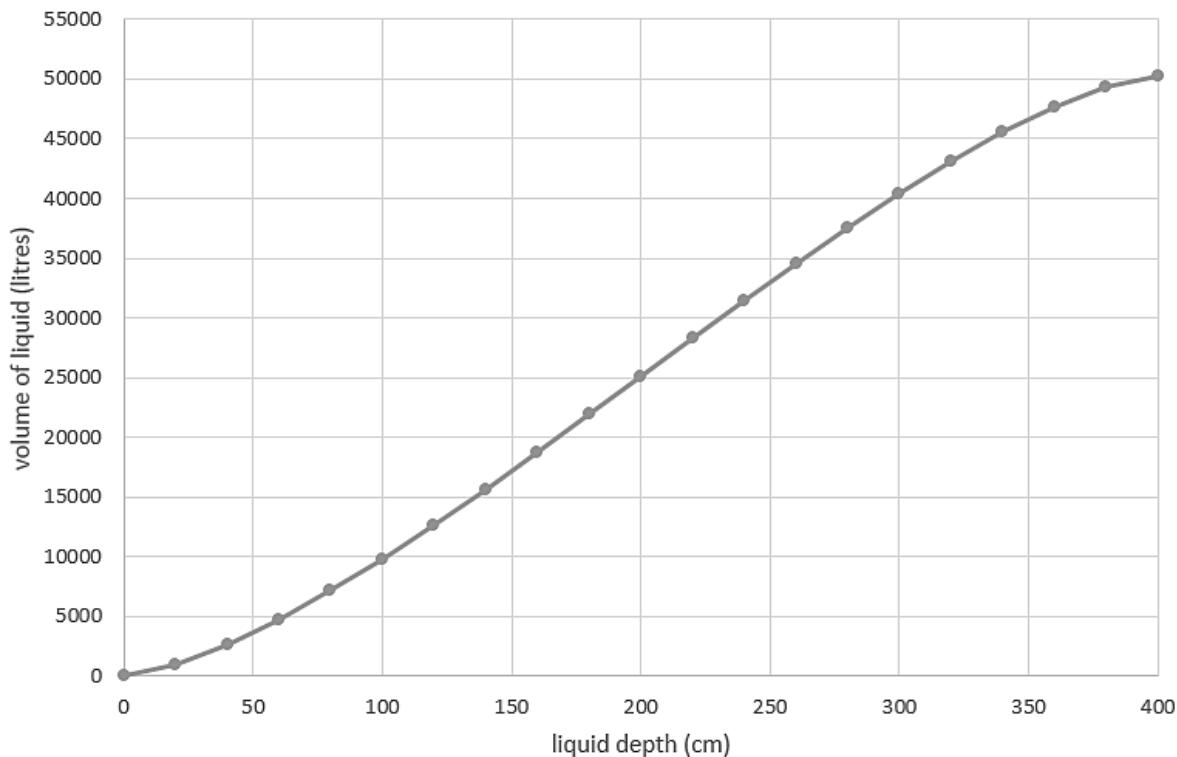


Figure 34: Graph of liquid volume against liquid depth in a horizontal tank

The objective of this work has been to help students appreciate the links between algebra and number, and to see how a formula can be used to generate look-up tables or graphs of numerical results. We have seen how a simple spreadsheet utility could be created to handle a routine calculation carried out in the workplace.

In our next example, we will carry out some analysis of data by spreadsheet.

Welsh speakers

Data has been obtained for the number of speakers of the Welsh language in Wales. We wish to examine the trend of the data, in order that future predictions of the numbers of Welsh speakers might be made.

year	Welsh speakers (thousand)
1901	929.8
1911	977.4
1921	922.1
1931	909.3
1951	714.7
1961	656.0
1971	542.4
1981	508.2
1991	500.0

We can enter these figures into a spreadsheet and produce an X-Y scatter graph. At first glance, the trend appears to be downwards, and it might be considered sensible to fit a straight line through the data points.

However, closer examination suggests that a better fit of curve to the data is a polynomial curve of the general form:

$$y = Ax^3 + Bx^2 + Cx + D$$

This curve appears to level out around the year 1990, and would be extrapolated to then give an upwards trend.

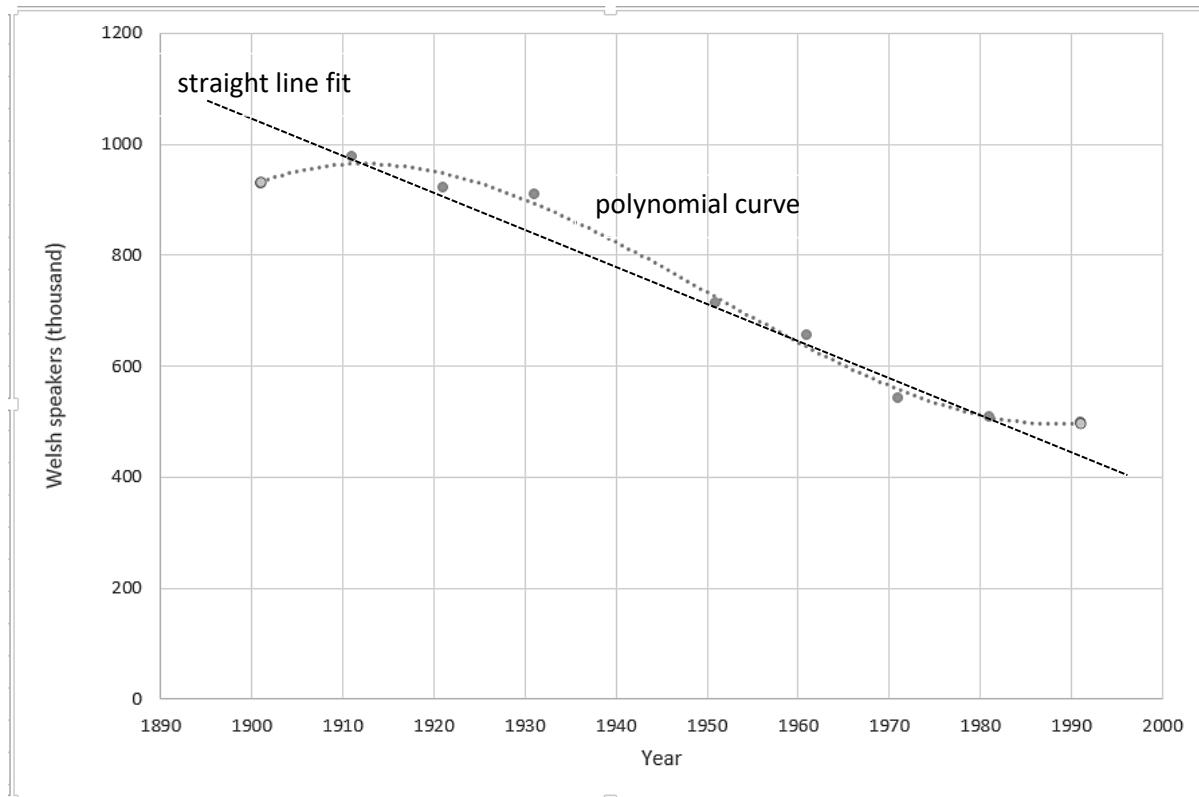


Figure 35: Census data for numbers of Welsh speakers, up to 1991

It is unsafe to simply fit a curve to data without being able to provide some justification for any trend which is identified. In the case of Welsh speakers, we might argue that a change in education policy in the past 30 years has led to more Welsh medium primary education and an increase in the number of children who speak Welsh.

Students can use the Internet to obtain additional data for the national censuses of 2001 and 2011 and add two further points to the graph to test the prediction. The result is shown in Figure 36 below.

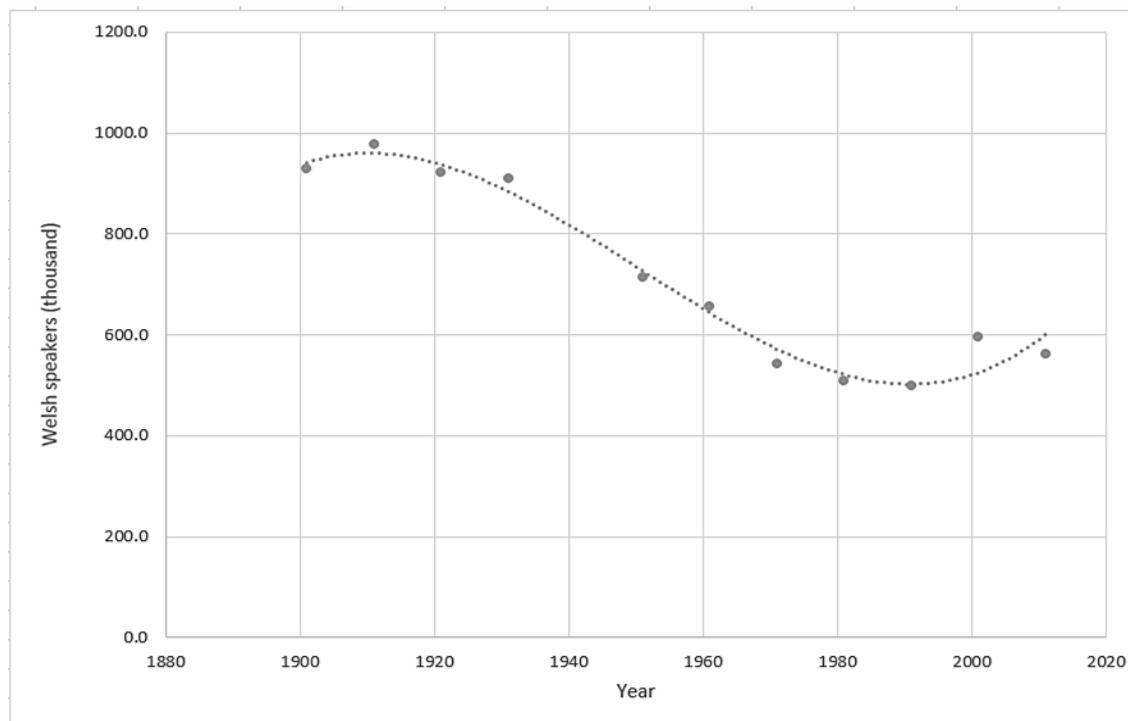


Figure 36: Census data for numbers of Welsh speakers, up to 2011

The graph does indeed continue the upwards trend which had been predicted by the polynomial curve. By carrying out this exercise, we hope to make students aware of the importance of interpreting data in relation to real world events, and to be cautious when making predictions.

So far in this chapter, we have looked at some uses of the general purpose numeracy functions of calculators and spreadsheets. Sometimes, however, more specialist applications are required in order to carry out tasks involving numeracy during vocational courses. We will examine some examples.

Room design

Students in various subject areas may need to carry out design tasks involving the layout of rooms in buildings. For example: business administration students may need to plan the efficient layout for an office.

Web based software is freely available for a range of building design tasks, from individual rooms to complete interiors of buildings with multiple floors. Actual furniture and fittings available from shops or the manufacturers may be listed, and can be realistically displayed in three-dimensional views. The web page may then display a shopping list of the selected items, including prices and the contact details of suppliers.



Figure 37: An example of office design

Building design systems generally allow the room walls to be laid out on a plan to exact dimensions. Windows and doors can be selected from menus, and added to the plan.

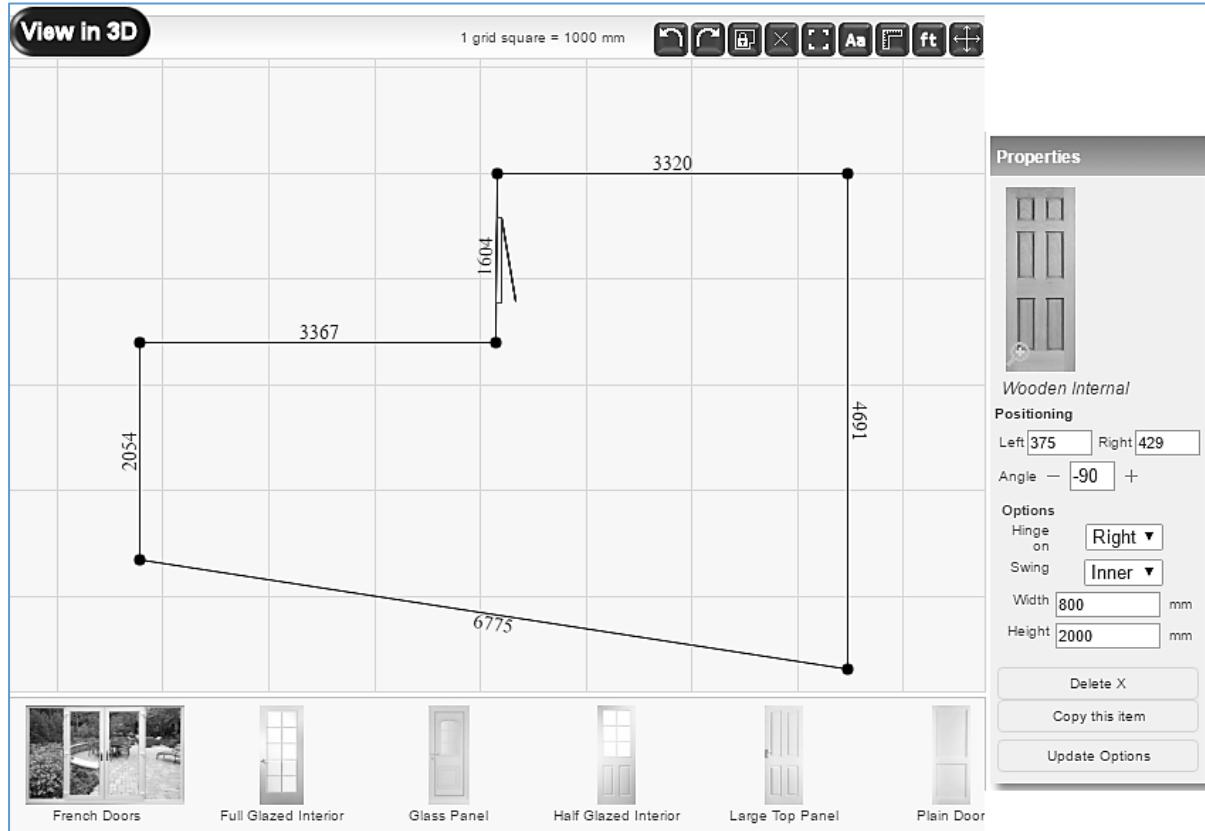
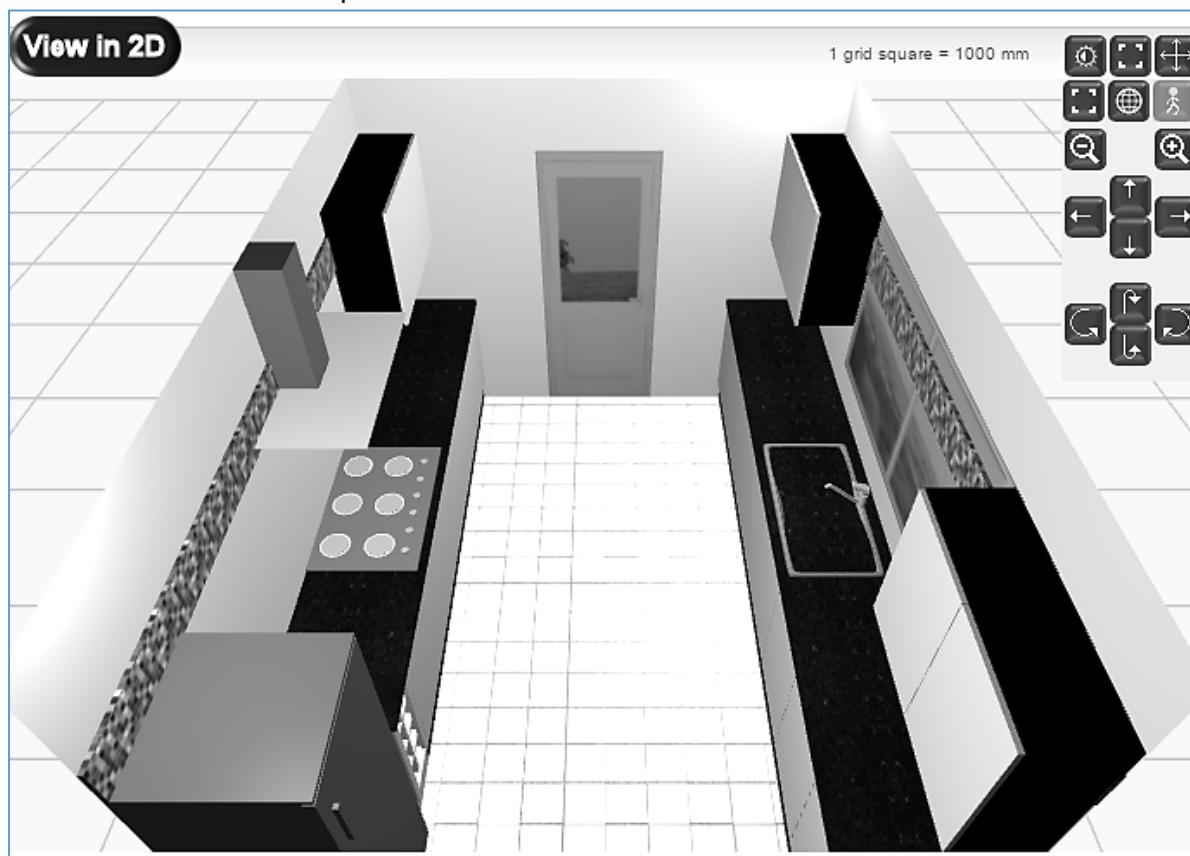


Figure 38: Entering the plan of a room

Designs can usually be displayed in perspective or isometric views, and can be rotated. The user can zoom in to view particular areas in detail.



www.easyplanner3d.com

Figure 39: Designing a kitchen

Design projects can be carried out in a variety of course contexts without the need for detailed computer knowledge. For example, students might work on the design of a Health Centre:

Familiarise yourself with the way the architectural design program works.

Use the program to design a small health centre for a rural area. The building will be used by a doctor, a nurse and a receptionist. There should be:

- an office and store for medical records
- a waiting area for patients
- a doctor's consulting room
- a treatment room where the nurse can carry out minor procedures such as changing dressings and giving injections.

Also required are toilets and a staff rest room.

Print out the plan and elevations for your design, and briefly discuss the features which you have included to make the building convenient for the staff and patients who use it.



Figure 40: Beginning the design of a Health Centre

This type of design project can be enjoyable and motivating for students, and provides images of a professional standard for display in a PowerPoint presentation or written report.

A building design project can provide a focus for discussing important issues related to a student's vocational course. For example, Health and Social Care students might consider the access needs of wheelchair users:

You are working in a residential home for young people with mobility difficulties. The home has a unit consisting of four single bedrooms, along with shared kitchen and bathroom facilities.

You have been asked by the manager to help refurbish the unit. You have been given a floor plan, along with a budget for each room and a list of furniture and other items needed.

Create a design which will provide a pleasant living environment, allowing easy wheelchair access to rooms and in the use of furniture, bathroom and kitchen functions.

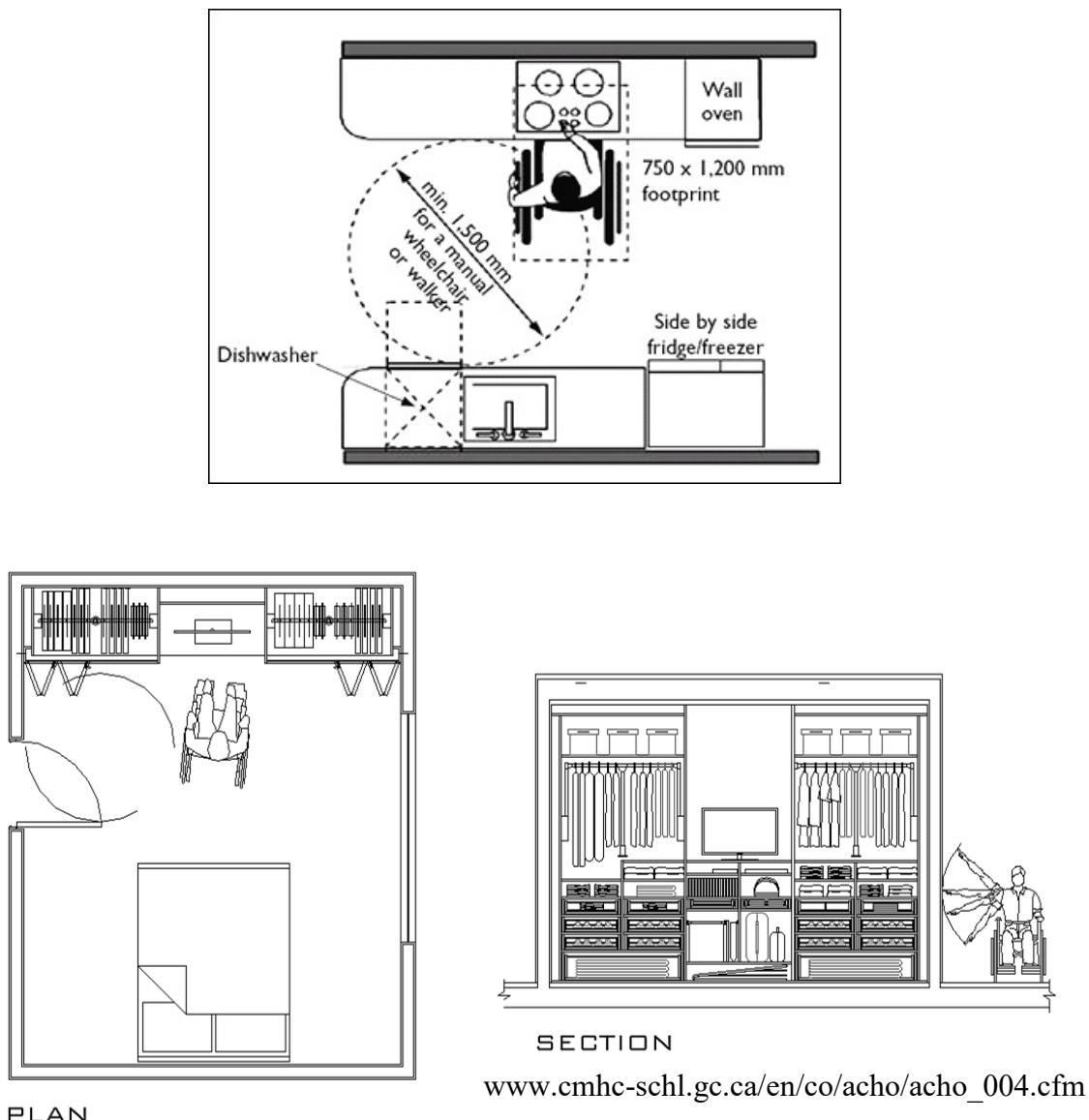


Figure 41: Design considerations for accessible kitchens and bedrooms

Students are able to research the requirements for convenient access, including the most suitable sizes and heights of furniture and fittings.

Accounting software

Another vocational area in which specialised software can be of value is accounting. It is important that students are introduced to industry standard software packages of the type which they are likely to meet when they enter employment. Systems such as Sage Accounting provide a range of standard book keeping facilities, including: nominal accounts for recording different categories of business expenditure, entry of customer and supplier records, bank transactions, and recording the issue and payment of customer and supplier invoices.

Accounting systems use double-entry book keeping method. Each transaction is recorded in two separate accounts, once as a credit and once as an equivalent debit.

Money or goods entering the business is treated as a credit, whilst money or goods leaving the business is a debit. For example, money spent in purchasing a vehicle would be recorded as a **debit** in the Motor Vehicles nominal account. Under the double entry system, this would be balanced by an equivalent **credit** in the bank current account ledger. This is because the bank is considered external to the business, and supplies money to the business for purchase of the vehicle.

Bank current account											
Debit				Credit							
Date	Details	£	p	Date	Details	£	p				
				01 Jan	vehicle purchase	13,500.00					

Motor Vehicles											
Debit				Credit							
Date	Details	£	p	Date	Details	£	p				
01 Jan	vehicle purchase	13,500.00									

Figure 42: Double entry for a business purchase

The double entry book keeping system can appear confusing, but fortunately all the necessary entries are handled automatically by the accounting software to make the recording of business transactions simpler.

The screenshot shows a software interface for 'Bank Payments'. At the top, there are fields for 'Bank' (Bank Current Account) and 'N/C' (Nominal Ledger). The 'N/C' field is set to 'Motor Vehicles'. Below these, a table lists a transaction: Date 01/01/2005, N/C 0050, Details 'vehicle purchase', Net 13500.00, T/C T1, and Tax 2362.50. To the right of the table is a 'Nominal Ledger' dropdown menu showing a list of accounts, with 'Motor Vehicles' selected. At the bottom of the screen are buttons for Save, Discard, Calc. Net, Print, Search, New, OK, Cancel, and Close.

Figure 43: Simplified entry of a business purchase

The accounting software stores all the necessary data and can readily extract information to produce reports, such as a trial balance which indicates the totals for each ledger. Under the double entry system every transaction will be recorded in two ledgers, as both a credit and an equivalent debit, so that the overall total of all credit and debit items for the whole business will balance exactly.

Date:	06/03/2006	Town and Country Gardens Ltd	Page:	1
Time:	16:17:49			
Period Trial Balance				
To Period: Month 12, December 2005				
N/C	Name	Debit	Credit	
0050	Motor Vehicles	13,500.00		
1100	Debtors Control Account	7,802.00		
1200	Bank Current Account	142,765.69		
1205	Cash Account	40,000.00		
2100	Creditors Control Account		852.65	
2200	Sales Tax Control Account		1,162.00	
2201	Purchase Tax Control Account	2,693.81		
3000	Capital	200,000.00		
4110	Sales - plants	2,690.00		
4112	Sales - construction materials	980.00		
4113	Sales - garden furniture	640.00		
4115	Sales - power tools	1,000.00		
4116	Sales - buildings	1,330.00		

Figure 44: Trial balance showing ledger totals

When a sales invoice is issued, the accounting software will record this in the sales ledger as a **credit**, and in the customer's account as a **debit**:

Sales					
Debit			Credit		
Date	Details	£ p	Date	Details	£ p
			10 Sep	sale to J.Smith	5,000.00
J. Smith customer account					
Debit			Credit		
Date	Details	£ p	Date	Details	£ p
05 Sep	goods supplied	5,000.00			

Figure 45: Double entry for a sale of goods or services

Payment of the invoice by the customer will be recorded as a **credit** in the customer's account, and as an equivalent **debit** in the bank current account.

Bank current account					
Debit			Credit		
Date	Details	£ p	Date	Details	£ p
02 Sep	money received from sales	5,000.00			
J. Smith customer account					
Debit					
Date	Details	£ p	Date	Details	£ p
05 Sep	goods supplied	5,000.00	10 Sep	payment	5,000.00

Figure 46: Double entry for a sale of goods or services

The treatment of bank current account items as credits or debits seems counter-intuitive, but it must be remembered that this account records money going out of the business (**debit**) to be stored in the bank, or being taken out of the bank to give back to the business (**credit**).

Students can benefit from working through realistic sequences of business transactions, as might occur in a real office. For example, a series of transactions for the company Town and Country Gardens, an example company providing landscape gardening services:

- On 25 January the following cash transactions occurred:

Vehicle expenses	£620.80
Office expenses	£344.20
Cleaning materials	£106.94
- Golden Sands Caravan Park (Account no C301) have returned some stone slabs which were surplus to requirements. A sales credit note, reference CN1 and dated 26 January has been sent to Golden Sands Caravan Park, representing a net cost of £80.00 plus tax of £14.00
- Town and Country Gardens paid the following cheques on 30 January:

Cheque No 00566 to Norfolk Nurseries (Account P101)	£121.26
Cheque No 00567 for £75.20 to Powys Builders' Supplies (Account P102) in settlement of invoice no. 1044	
- Town and Country Gardens received the following cheques on 30 January:

Golden Sands Caravan Park (Account no. C301) Cheque No. 17235	£763.75
Llanberis Village Council (Account No. C302) Cheque No. 67441	£2,103.25

After entering transactions and updating records, students may be asked to produce the accounts summary documents which might be required by the managers of the business:

- Obtain the following printouts (hard copy):
 - a) Sales Ledger Report(s), to include customer name, account reference number, each transaction and account balance.
 - b) Purchase Ledger Report(s), to include supplier name, address, account reference number, each transaction and account balance.
 - c) Current Account and Cash Account Analysis, to include each transaction and the account balances.
 - d) A Trial Balance.

Working in this way with industry standard software packages will be good preparation for students entering the workplace. Employees are required to be competent in the use of Information Technology systems, but also need a good understanding of the underlying numeracy task so that they are able to check that results and can quickly identify errors.

The term Techno-mathematical Literacy has been proposed by Bakker, Hoyles, Kent and Noss (2004). This represents the use of computers and new technology in combination with mathematics, as required during workplace activities. We will examine a number of further examples of Techno-mathematical Literacy in this book.

The authors outline the aims and structure of Techno-mathematical Literacy as:

Making the invisible visible

- Posing a problem
- Identifying key variables
- Appreciating the need to quantify
- Systematic measurement and sampling
- Representing data
- Combining and coordinating different data sources to assess relative effects of key variables

Coming to a decision and identifying an action

- Interpreting, conjecturing and communicating with data
- Making a decision based on information
- Judging implications of possible decisions and deciding action.

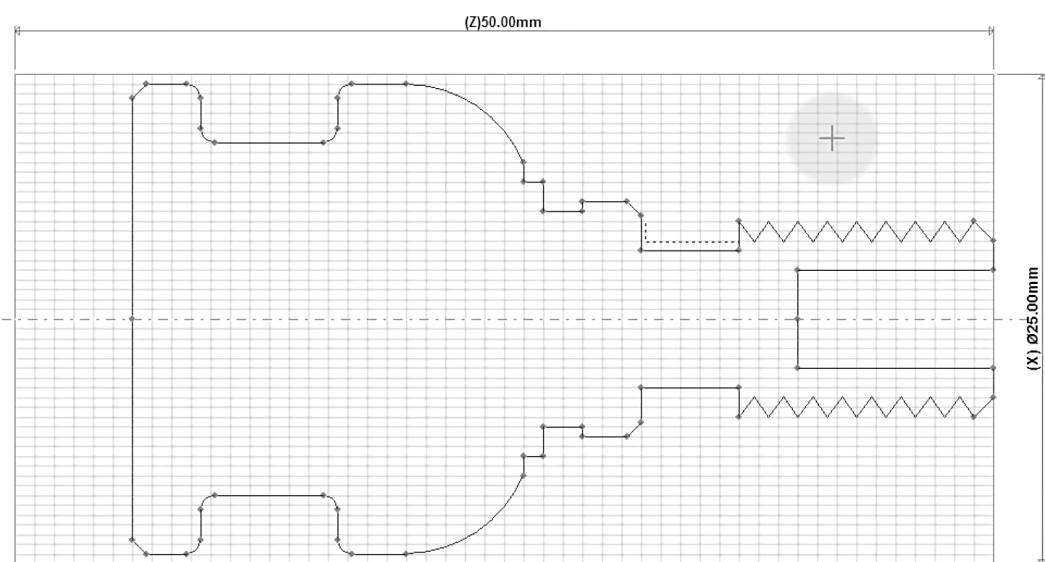
Engineering CAD CAM

The use of computer technology is now essential to the design and manufacturing processes in many sectors of industry. It can be motivating for students to use modern Computer Aided Design and Computer Aided Manufacturing systems, and experience in using these systems can help to prepare students for careers in modern industry.

The primary purpose of Computer Aided Design is to produce accurate 2-dimensional and 3-dimensional engineering drawings. However, modern CAD software may also provide functions to help in checking that a design will perform satisfactorily before manufacturing begins. Kinematic Analysis allows components to be animated, so that the paths of moving parts can be checked for potential collisions. Finite Element Analysis can check the strength of the designed components and identify possible points of weakness, and investigate the conduction of heat through components to check that working temperatures will be satisfactory.

Computer Aided Manufacturing is used in planning and implementing the different manufacturing operations to create a product. A program will be generated, composed of operation codes, which is then sent to a machine tool to control the manufacturing sequence. Prior to actual manufacturing, the CAM software may run a computer simulation of the tool selection and cutting sequence, so that any potential problems can be identified and corrected. CAM is mainly used to control milling, drilling and turning operations on lathes and milling machines, but may also be used in cutting shapes by gas torch or laser. A recent advance in computer aided manufacturing has been the development of three-dimensional printers.

Computer aided design and manufacturing systems suitable for use in colleges are available from various engineering suppliers. The Boxford company, for example, provides systems with different levels of help available to students as they are progressively introduced to CAD-CAM techniques.



www.boxford.co.uk/software/lathe/

Figure 47: Input of the cross section for a turned component

At an initial level, students can design a component on screen which will be produced by turning on a lathe. The diameter of the material is specified, and a cross section of the component is built up. This may include drilled holes, screw threads, and convex or concave curves.

At any stage during the design process, the component can be displayed in a three dimensional view. This will help the student to check the solid shape and confirm that there will be no manufacturing problems.

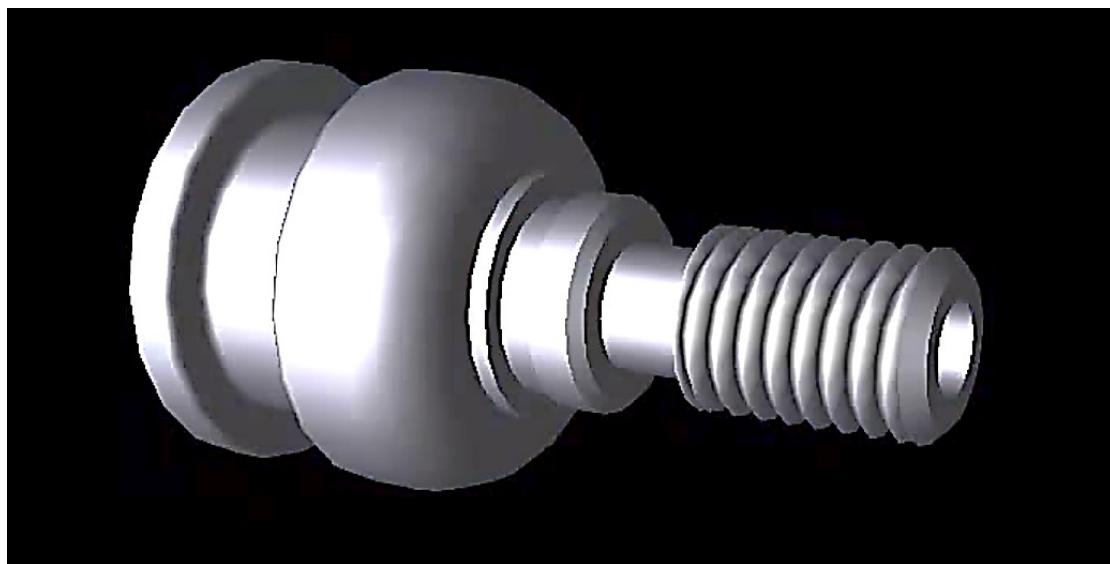


Figure 48: Three dimensional view of the component

When the design is completed, a simulation of the manufacturing process can then be run on screen. Lathe tools will be selected and moved into position to make cuts. Each operation is defined by a set of numeric codes representing the tool and the required cutting path. The sets of codes are displayed for each stage of the simulation, and together make up a program which can be sent to the lathe to manufacture the component.

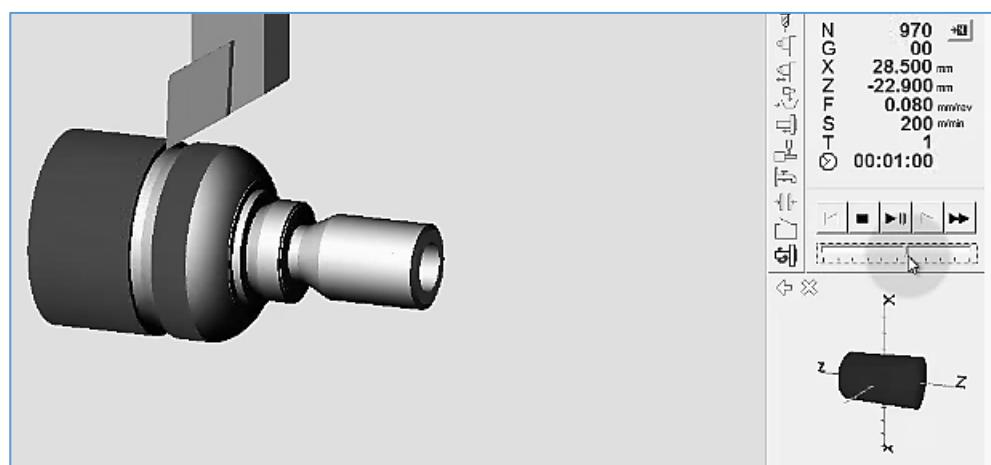


Figure 49: Simulation of manufacturing the component

When students are familiar with the capabilities of the CAD-CAM system, they can gain a greater understanding of the manufacturing process by directly writing the control program. The Boxford software provides an intermediate level of training in which tool operations can be selected and specified through a series of menus, and the corresponding numeric codes will be added to the control program.

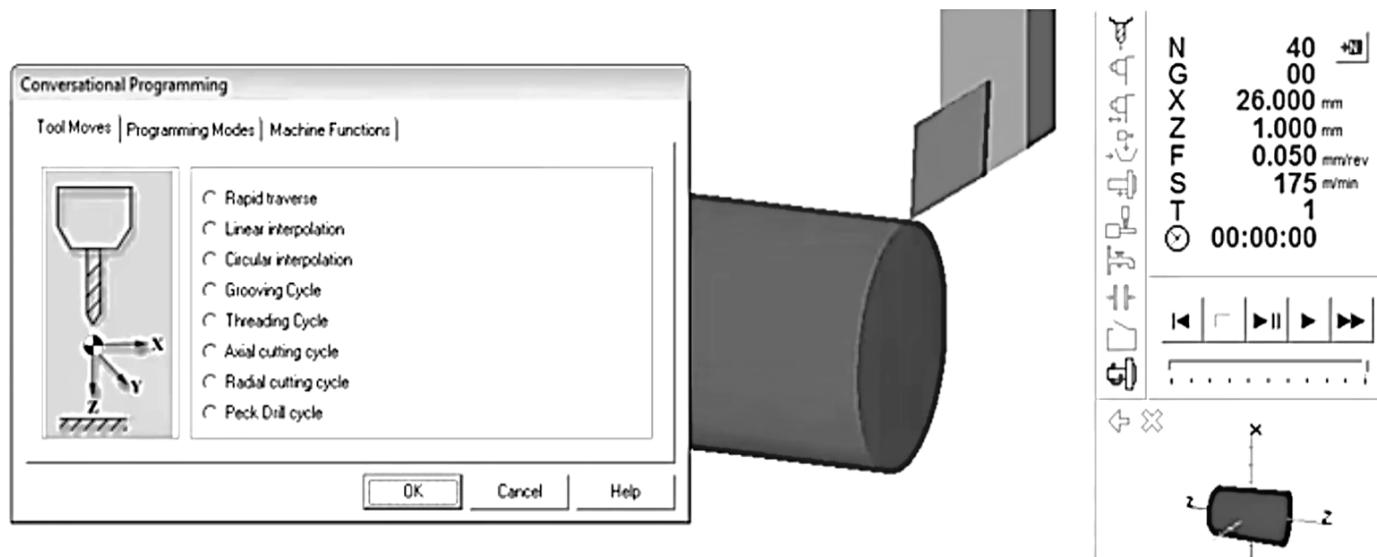


Figure 50: Selection and specification of tool operations from menus

As students gain confidence in the operation of the CAD CAM system, they can work through design and manufacturing exercises, using work sheets to record the control codes for each tool operation.

U26 TAFLEN GWEITHREDIADAU OPERATIONS SHEET				Cymru Meirion Dwyfor	
MANYLION BILED BILLET DETAILS		DEFNYDD / MATERIAL:	BRASS	TYPE NO. _____	
20mm		O/DIA	I/DIA	36mm	
DISGRIFIAD O'R GWEITHREDIAD DESCRIPTION OF OPERATIONS		CYFLYMDER SPEED	PORTHANT FEED	TOOL NO.	
1	Tool park position		Rapid		
2	Tool change position				
3	Tool change			1	
4	Start position				
5	Face off to 35mm long using G94 with 0.5mm cuts				
6	Tool change position	Rapid		2	
7	Tool change				
8	Centre drill 5mm deep *				
9	Tool change position				
10	Tool change			3	
11	Drill Ø7 hole x 15mm deep *				
12	Tool change position	Rapid			
13	Tool change				
14	Start position			1	
15	Turn Ø10 x 10mm using G90 with 1.5mm cuts				
16	Tool change position	Rapid			
17	Tool change				
18	Start position				
19	Part off to length (1.6 parting tool) *			4	
20	Tool park position	Rapid			
21	End program				
DIAGRAMAU DIAGRAMS				RHESTR ARFAU TOOL LIST	
				1 Left hand turning 2 Centre drill 3 Drill 7mm 1 Left hand turning 4 Parting tool	

Tasg 1: Rhaglen brawf Task 1: Test Program																
Copiwrch y raglen hon a sylwch beth sy'n digwydd ymhob llinell. Copy the following program																
Drg No.		PROGRAMMING SHEET									MATERIAL: PLASTIC					
		TITLE: TUT6-2			WRITTEN BY						SHEET No. 1 OF 1					
Description		Prep Code	Misc Code	Axis Coordinates		I	K	F	S	Spindle Speed	(x)	(z)	U	W	Tool No.	
	N	G	M	X	Z						U	W	P	Q	R	T
Metric Units	10	21														
Centre Drill	20														01	
Move to Start - CSS Off	30	97	03	0	2					2500						
Drill Centre	40	01			-5			0.06								
Rapid Clear	50	00			2											
Park Position	60		05	30	10											
5mm Ø Drill	70														02	
Drilling Speed	80		03							2000						
Peck Drill Cycle	90	83		0	-10			0.04					10000	2		
Park position	100	00	05	30												
End Program	110		30													

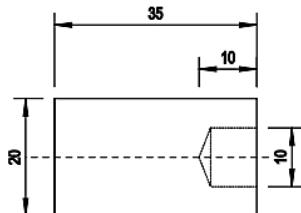


Figure 51: Student worksheets for CAD CAM exercises

Components often do not have the rotational symmetry necessary for manufacture on a lathe, so are produced instead on a milling machine. A solid block of material can be shaped by rotating cutting tools. Computer Aided Manufacturing software will in this case have to specify the three-dimensional paths which the cutting tools will follow, relative to the work piece. Boboulos (2010) gives an example of a solid component produced in a CAD CAM system by milling. This consists of a rectangular base with an upwards extension containing curved recesses. A series of holes are drilled into or through the component.

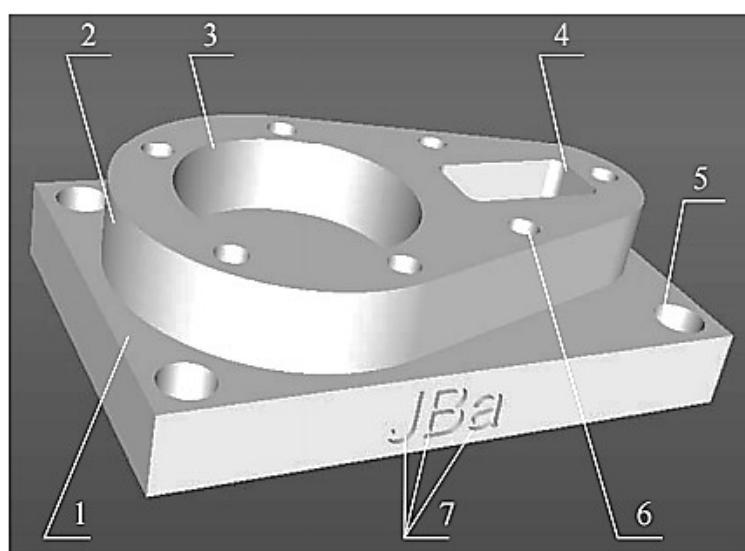


Figure 52: Component produced by milling

As in the case of the turned component described earlier, the design can be accurately created on screen using a CAD program. The design is then analysed by CAM software, the necessary sequence of machining operations determined, and a control program written.

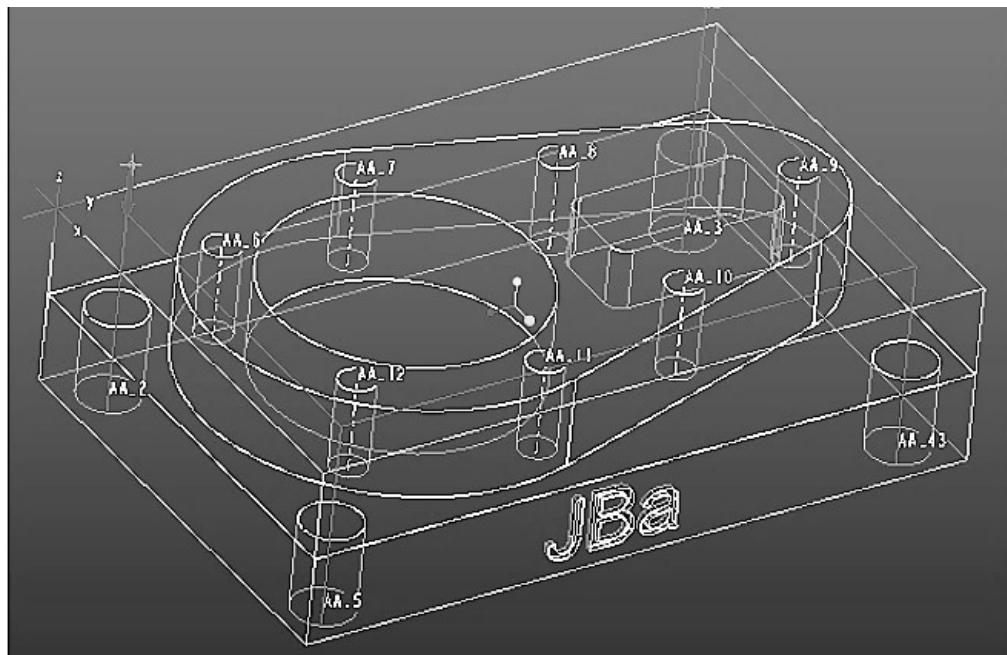


Figure 53: Computer aided design of the milled component

The sequence of milling and drilling operations can be simulated on screen, to check for problems which might occur during manufacture.

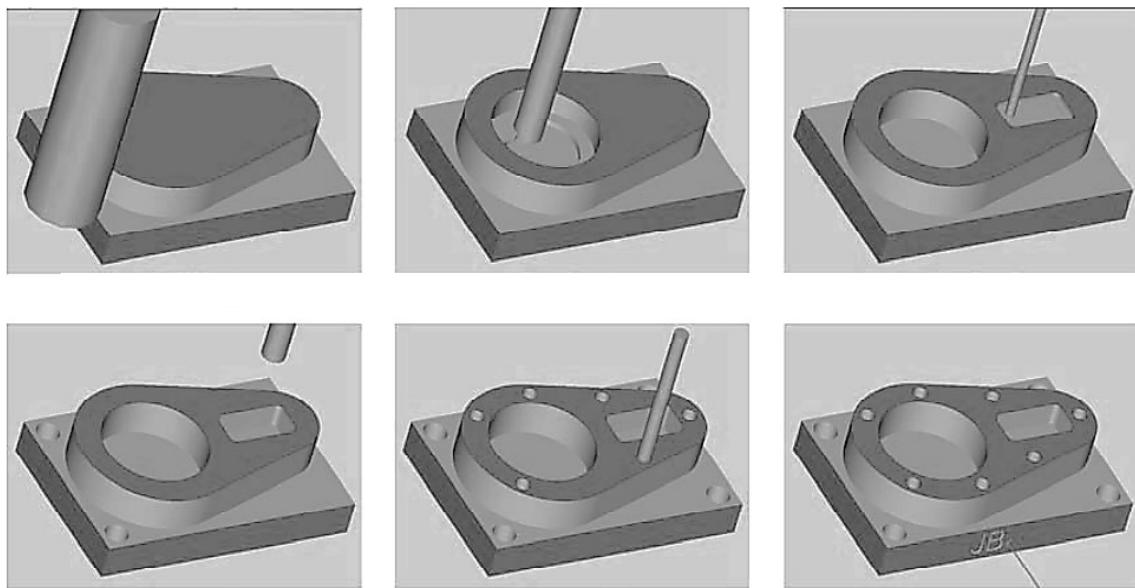


Figure 54: Stages in manufacture of the milled component

Overall, computer aided design and manufacturing can provide valuable opportunities for students to develop a range of broader numeracy skills:

- the ability to visualise components in two- and three-dimensions
- problem solving, in creating designs which will meet the requirements of the client
- accuracy in the use of computer software when producing designs to specified measurements
- spatial awareness in developing and checking a sequence of manufacturing operations which involve the selection, positioning and movement of different tools

Computer aided design and manufacturing systems clearly involve very specialised and expensive equipment, but we will look next at a technology which is readily available to most students and has interesting applications in numeracy...

Mobile electronic devices with GPS

Nearly all cell phones now include some sort of GPS capability. Some smart phones may even include free navigation applications. Maps may be used on-line as you travel, or may be downloaded beforehand for the area which will be visited.

We look here at a case study by a student which describes the use of a particular GPS application:

Using the My Tracks app to record exercise

I have been using a simple smartphone app called My Tracks to record times and distances while out walking or cycling. The app uses the phone's GPS to track your route and display it on a map. All the time and distance data is saved at the end of the walk and if you wish it can be exported in various formats, including CSV. This means it can be used in other applications if required.

The app doesn't need internet connection, so it can be used even if there is no mobile phone signal. This makes it really useful for walking in the countryside.

There are three display screens. As you're recording a journey, the first screen displays your route as a red line on the map in real time. The second screen shows a graph of your speed and elevation. The third screen displays various stats. Once you have stopped recording and the data has been saved, these can be accessed by returning to the walk in the list and then selecting the appropriate tab.



Figure 55: The My Tracks app recording a walking route in London

Total distance

The app records the total distance travelled in kilometres. There is a pause button, so if you only want to record time spent walking, the app can be paused during the parts of the journey that are done by car or public transport. The total distance walked is the information I find most useful. Before I had the app, I had to measure distances on the map which was not easy to do and therefore not always accurate, especially if the journey involved lots of twists and turns!

Calories used

If you input your weight, by selecting the relevant type of exercise, the app will give an approximate figure for how many calories have been used during the exercise period. I don't personally use this, but it is of use to anyone who needs to count calories as part of their diet plan.

Total time

The actual time spent exercising is also recorded. Using total time and total distance, the app calculates the average speed. As I am just walking to maintain fitness, I don't record any speed data, but if anyone is training for an event or trying to improve fitness, this is useful data to have.

Moving time

This enables you to see how much of the time spent exercising was actually spent moving. I often pause to take photos or you may stop for a rest. Without the app, it's easy enough to note how long a walk or cycle ride took and you can measure the distance and thus calculate an average speed. However, the app is able to show whether you moved at a steady pace throughout the exercise period or whether you moved faster at certain times but also remained stationary at other times.

Average speed

The app calculates the simple average speed. This could be used to compare journeys and see how different terrain affects performance. My average speed is higher on flat ground whilst journeys involving steep hills or rough terrain result in a slower average speed.

Maximum speed

It's interesting to look at the maximum speed value and compare it with the average speed. When walking in the countryside these values are not much different. However, when walking in cities, the maximum speed can be over 10 km/hour faster. The chart reveals that these speeds were maintained only briefly and no doubt occurred when scuttling across a busy road before the lights changed.

Average moving speed

This shows how fast you actually moved when you were walking or cycling, ignoring the periods when you were stationary.

You can share the route on social media if you wish to do so.

What I use the app for

I find that setting goals and tracking the amount of exercise I do each week helps to keep me motivated, especially during the times when I'm doing the same local walks over and over again. I therefore have an Excel spreadsheet to record daily mileage which I update each day. Having a simple app to record walks and cycle rides makes goal setting and record keeping much easier. Some people like to use devices like pedometers or activity trackers such as the FitBit to record data continuously, but I just want to know how far I went during a particular exercise session. I set the app to record at the start of a walk and stop it at the end. It does have more advanced features for recording times between particular points, but I haven't ever used those.

The app works really well in both urban and rural environments. The screen shots above show a walk done in London. Here is a walk I did in the Peak District. You can choose whether to display the route on a map or on the satellite view.

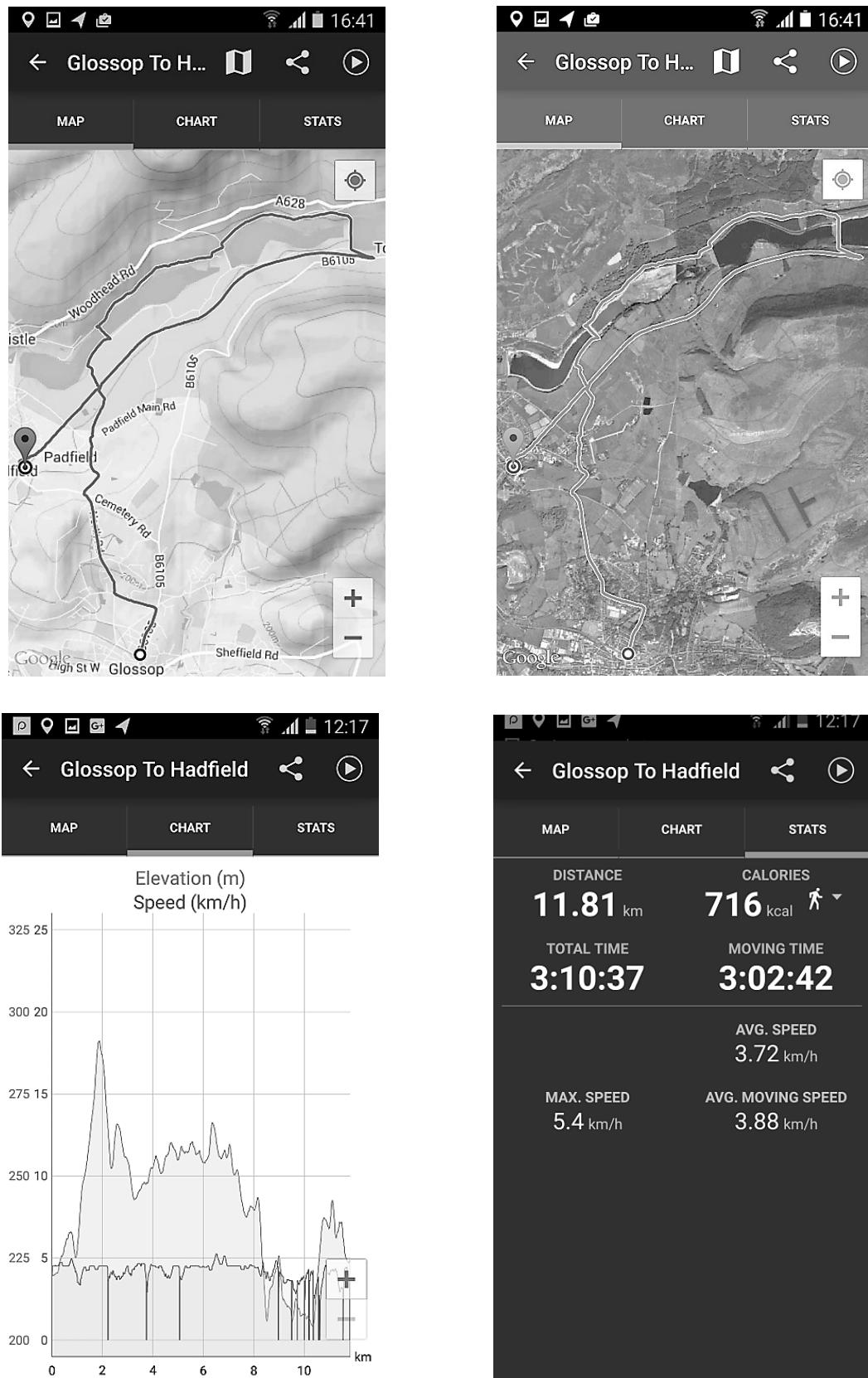


Figure 56: The My Tracks app recording a walking route in the Peak District

Other possible uses

If you are walking, driving or cycling in unknown territory, the app makes it easy to retrace your steps and prevents you from getting lost.

Because it records distance and time and calculates average speed, maximum speed and average moving speed, it can be used to not only find the shortest driving routes for regular journeys but also to see which will be most economical with regard to fuel consumption.

Mobile phone applications using GPS functions can provide an interesting and motivating environment in which students can develop and practice their numeracy skills.

Data logging

The final example we give in this chapter is the use of data loggers in numeracy projects. A data logger collects signals from a measuring device, then stores the values in digital format in an electronic memory chip for later download to a computer. The data logger usually contains a timer, to allow the user to set the start and end of the recording period, and the intervals at which data values will be collected.



Figure 57: Data logger

Figure 57 illustrates a simple data logger. This is fitted with its own electronic thermometer and relative humidity sensor, and can also accept input signals from external devices such as a wind speed recorder. This type of data logger could be used for continuous monitoring during an environmental studies project. The student would only need to visit the recording site occasionally to collect the stored data. Once downloaded, the data can be transferred to a standard spreadsheet application for analysis, and displayed as tables or graphs.

As an example of a project using this type of equipment, we can examine a study of the effects of forestry operations in Coed y Brenin. This is an area of very high rainfall, leading to the growth of extensive moss cover beneath mature conifer and mixed woodland.

It appears that moss growth is important in controlling the rate at which water runs down the hillsides during rain storms, and this in turn reduces the risk of flooding.

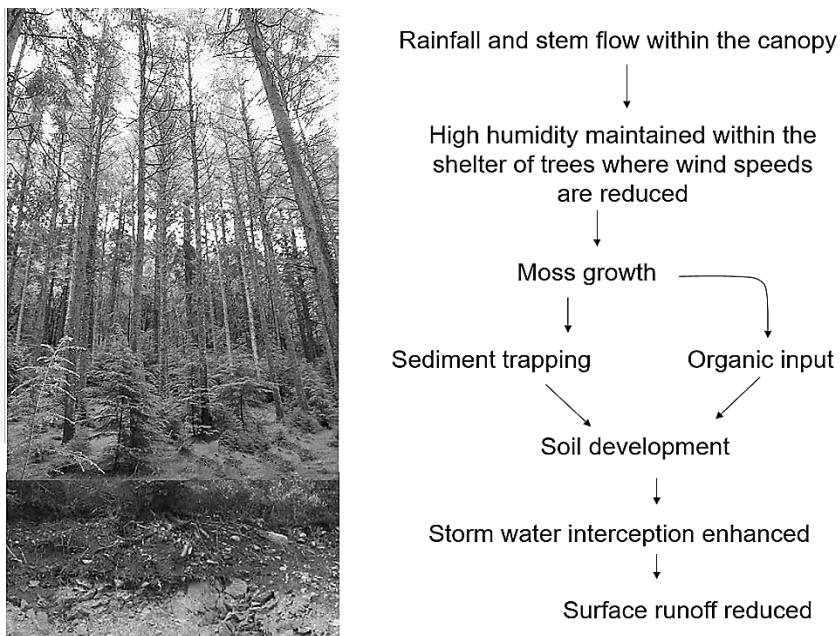


Figure 58: Growth of ground vegetation in mature forest, and effects on storm runoff

If forest is felled, moss cover quickly disappears and storm runoff increases. The environmental factor affecting moss is thought to be humidity. To investigate this, data loggers were set up to monitor relative humidity in an area of mature forest, and on a nearby clear felled hillside.

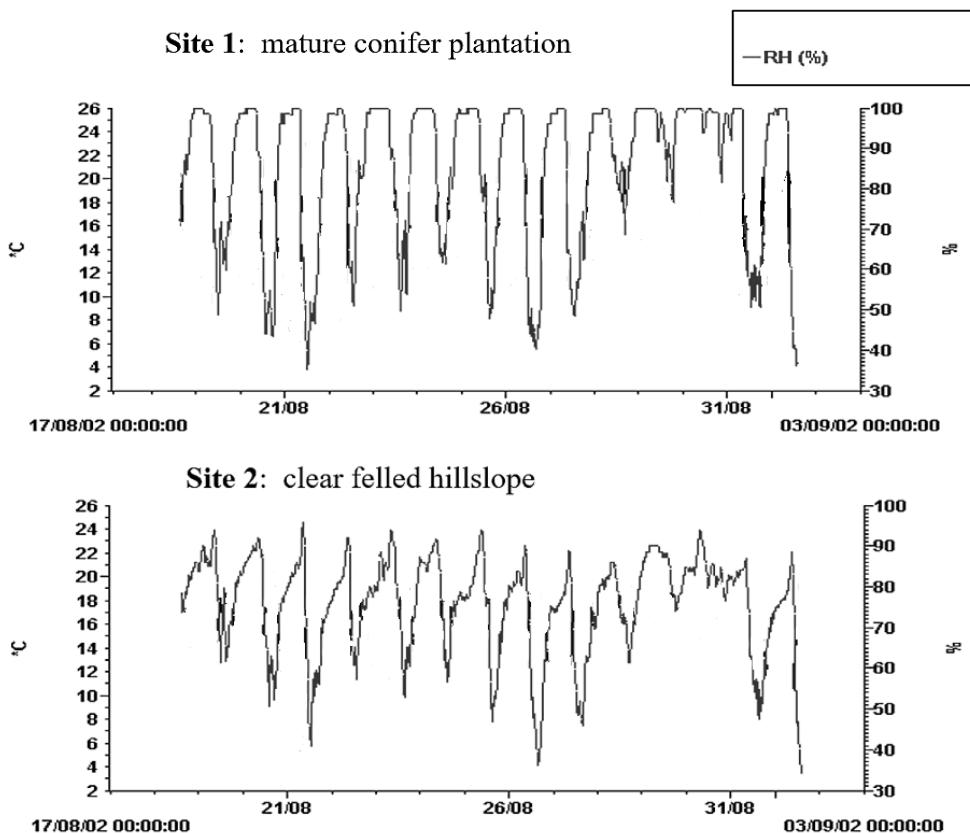


Figure 59: Relative humidity measurements in mature forest and on a clear felled hillside

Comparison of the graphs shows that relative humidity in the forest is maintained at nearly 100% saturation for large periods of time, whilst the relative humidity on the open hillside never reaches saturation.

Data loggers have many uses in environmental studies projects. They may be attached to small continuously-recording rain gauges, so that rainfall patterns for particular storm events can be mapped.



Figure 60: Automatic rain gauge in the Aran mountains

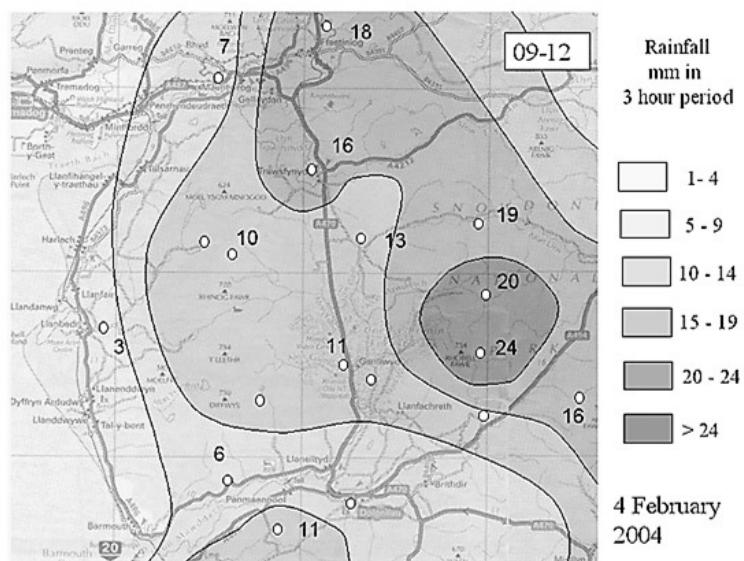


Figure 61: Rainfall map for a storm over southern Snowdonia

Other uses of event recording equipment include the automatic counting of cars or pedestrians during traffic surveys.

Electronic data logging has made it possible to continuously collect data at times when students would not otherwise be available to carry out surveys. This makes large and detailed data sets available, encouraging students to develop their statistical and analytical skills in numeracy based projects.

In summary, we feel that the use of new technology can be motivating to students when undertaking numeracy activities, and can help to develop techno-mathematical literacy skills which are of value to employers.