Mathematical Needs of Young Employees

by

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1. Introduction

We were commissioned by SCAA in 1996 to undertake a survey of the mathematical needs of young employees in business, industry and the public services. Our brief was to find out as much relevant information as possible, and to produce a report. The work itself was understandably both interesting and informative; and we wish to thank SCAA (and, in particular Richard Brown) for the opportunities this work provided us. We should add that the views expressed here are our own, and not necessarily representative of the views of SCAA (or the more recent body QCA which has taken over the work of SCAA).

Given limited time and resources, this approach could at best be only a broad representation of the spectrum of employment, and be used essentially as a case study approach. Our aims were to interview -

- employers
- employees

in order to find out

- what mathematics was perceived as being needed by employers
- what actually seemed to be used by employees
- what in house tests for mathematics/numeracy were used
- has all this related to current GCSE maths syllabuses

This paper summarises our main survey results, and gives some details of the interviews with particular young employees which are representative of those interviewed.

Finally in this paper, we put forward the recommendations that we made, and their implications if adopted. We hope that these results and our recommendations will help in the wider debate on what is seen as the "maths problem" in this country.

2. Testing Young Employees

Most of the employers that were interviewed do not test, in a formal sense at least, mathematics. A number of firms that used to either test, or require a GCSE at grade C have changed their policy, since it was said that neither the test nor the GCSE qualification gave an accurate assessment of the competencies that the employer required. Of those employers that do test potential employees, many were unable to let us see their test papers as they were bought in from a commercial organisation. Some though did give us access to the test that they used.

A consistent theme among those who administered the tests was that the ban on the use of calculators caused problems for the interviewees. One firm did not warn potential interviewees of the existence of the test. They assumed that if the interviewees had sufficient intelligence to either simply do well on the test, or to do the research to discover that the test was a likely contingency, then they would make good employees. Two employers said that they had several potential employees withdraw their application when it became clear that they would be tested without a calculator. It did however seem to be the case that these tests were deliberately made more difficult, in that none of the employers forbade the use of calculators in the workplace - indeed in interviewing employees in these firms it became clear that calculator were used when required.

Examples of tests used now follow.

Army

The Army actually tests at different levels, namely for soldiers, technicians and officers. The **soldiers' test** is one that is computer generated and so is readily available for perusal, indeed potential recruits are given an example paper to go away to practice on, but it is not really mathematical, although it has some elements of logical thinking in it.

At **technician** level the army requires not only a GCSE at grade C or above in mathematics - plus others, but also a good pass on their own 'in house' test which has been developed by the Defence Research Agency.

Rubber Manufacturers

The New Employee Assessment Test (NEAT) - 1 is shown opposite. The personnel officer is not convinced of its usefulness, but is constrained by management to keep it. No calculators are allowed, and over the past year the bulk of applicants have scored between 40 and 60 %, the accepted pass mark for operatives. Some of those with higher scores have not been offered employment and vice versa - the overriding consideration being the interview. In discussion with the personnel manager it transpired that although the questions would seem relevant to day to day life, in terms of relevance to the work carried out, there is only a limited overlap between the test and the workplace. The management however believe that a good grasp of number will enable the operatives to be more useful to the firm.

The New Employee Assessment Tests (NEAT)

- NEAT - 1

NAME …….. DATE ……..

1.	ADD TOGETHER FORTY-FIVE AND THIRTY-SEVEN	
2.	68 - 43	
3.	MULTIPLY TWENTY-FIVE BY EIGHT	
4.	HOW MANY WEEKS ARE THERE IN 56 DAYS?	
5.	WRITE IN FIGURES THREE THOUSAND AND FORTY-SEVEN	
6.	HOW MANY CENTIMETRES ARE THERE IN ONE AND A QUARTER METRES?	
7.	WHAT TIME PM IS FIFTEEN FORTY FIVE?	
8.	FIND THE AVERAGE OF TWO, SIX AND SEVEN	
9.	WHAT IS 10% OF 280?	
10.	FIND THE COST OF 6 STAMPS AT EIGHTEEN PENCE EACH	
11.	WHAT IS THREE QUARTERS OF SIXTY?	
12.	6.2 X 100	
13.	HOW MANY QUARTERS ARE THERE IN TWO AND A QUARTER?	
14.	WRITE EIGHT THOUSAND SEVEN HUNDRED AND SIXTY-EIGHT TO THE NEAREST HUNDRED	
15.	FIND THE AREA, IN SQUARE INCHES, OF A SQUARE 9" X 9"	
16.	HOW LONG, IN HOURS, WILL IT TAKE TO COVER FOURTEEN MILES AT THE RATE OF FOUR MILES PER HOUR?	

Nursing Profession

There is no homogeneity about mathematics entry requirements for nursing, and the routes into nursing are now radically changing. The college actually visited in the survey generally required GCSE Mathematics at grade C or above, but were able to use a test known as the DC Test for mature entrance without GCSE maths. A short extract is shown below. It should though be noted that the tutors had reservations about the relevance of the test to the mathematics needed once in employment.

The DC Test

Guide for DC Test Candidates

ANSWER

SECTION II

Calculate the following and write each answer in the box provided.

8. Express 30 centimetres as a fraction (in the lowest terms) of a metre ☐

9. Express 0.00874 to two significant figures ☐

Read the problem and formulate an answer. Write the answer in the box provided.

10. 264 tablets are divided into 4 different sized bottles. Half must go into one bottle, half the remainder into the second, half the remainder into the third. How many tablets remain for the fourth bottle? ☐

TAKING THE DC TEST ANSWER

Use the following table to answer the question below the table. Write the NUMBER of the answer in the box provided.

NUMBER OF ALL AND TWIN DELIVERIES IN ENGLAND AND WALES DURING 1941 - 1985.

YEAR PERIOD	ALL DELIVERIES (millions)	TWIN DELIVERIES (thousands)
A (1941 - 45)	3.4	41
B (1946 - 50)	3.9	50
C (1951 - 55)	3.4	43
D (1956 - 60)	3.7	45
E (1961 - 65)	4.3	49
F (1966 - 70)	4.1	44
G (1971 - 75)	3.4	34
H (1976 - 80)	3.0	29
I (1981 - 85)	2.5	26

11. On the year periods A to I, which two give the largest difference on twin births?

A and I (1) C and G (2) B and I (3) D and E (4) E and H (5) ☐

3. **What Mathematics is needed**

As part of the interview, all employees and most employers were asked to complete a proforma which asked for assessment of the relevance of topics in the mathematics National Curriculum. The mathematics National Curriculum was divided into the 45 sometimes overlapping topics (as given in Appendix 1).

They were asked to score each topic according to the following criteria :

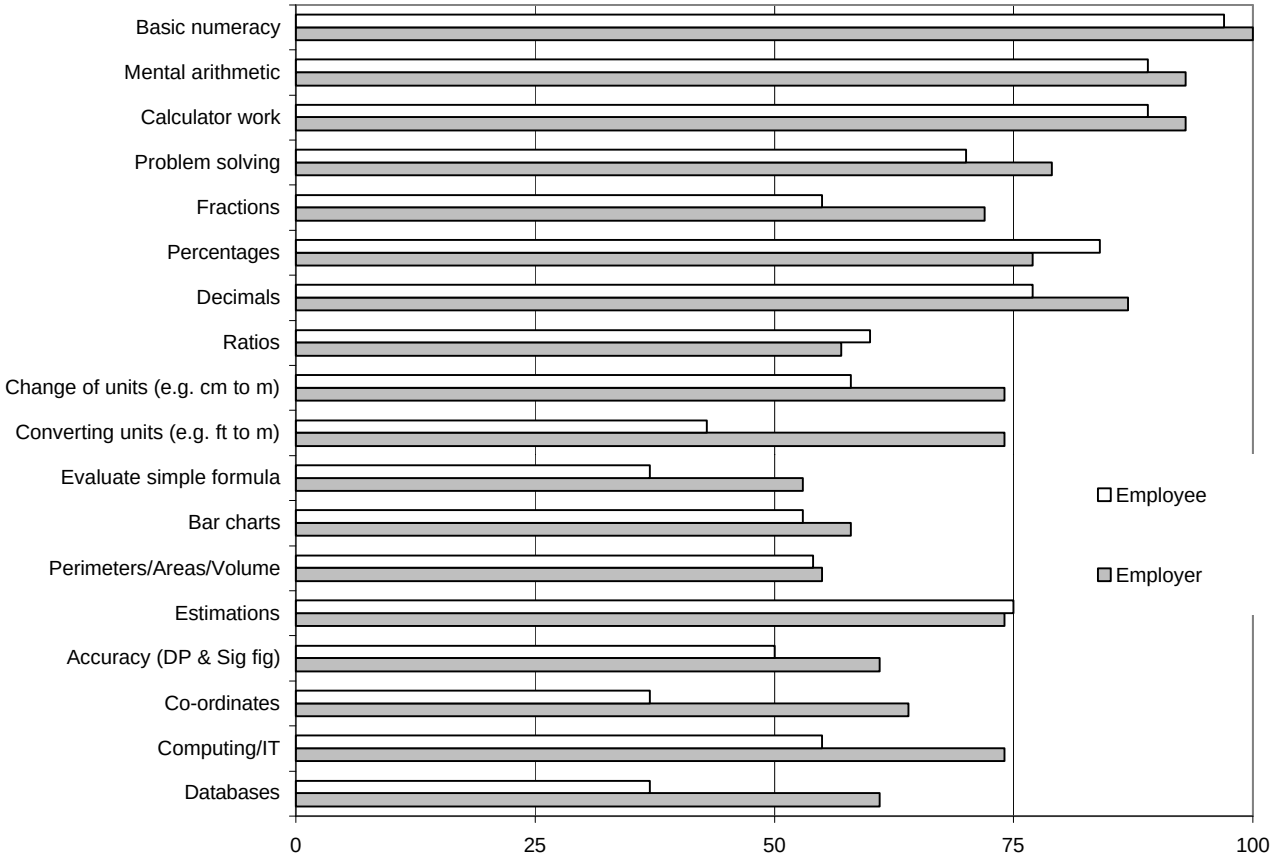
High relevant	**-**	**2**
Sometimes relevant	**-**	**1**
Largely irrelevant	**-**	**0**

Inevitably there was a high degree of subjectivity about some of the topics, but respondents were asked to err on the higher side if there was any doubt.

The following chart indicates the response of :

(i) employers (ii) employees

to some of the topics that figured highly. Note that the 100% level represents all respondents using the '2' - highly relevant - rating.



As will be seen these results correlate well with views expressed in the qualitative results (Section 4). However the following points are worth noting.

(a) The whole sample gives a very negative view to :

- straight line equations
- Sine/Cosine and Tangent in Right angled triangles
- Indices
- Quadratic Equations
- Sine and Cosine Rules
- Complex probability and the use of tree diagrams
- Linear Programming

(b) Employers' and employees' responses are similar, but employers perceive a greater need for mathematics than employees do. This was not supported by the evidence of the visits, but employers take a longer term view and see the needs that their employees will have in the medium term rather than simply the present.

Further it should be noted that the employments requiring Mathematics GCSE at grade C or above as an entry requirement are still relatively congruent with the whole sample, though exhibiting generally a higher requirement. The analysis for this is not given here.

4. Interview with employers and employees

Qualitative Results

The results from the interviews have been compiled below under sub headings, with both employers' and employees' views together where appropriate.

Mathematical Ability

With only minor exceptions, the employers felt reasonably satisfied with the mathematical knowledge of their employees, to the extent that they had not had to sack anyone because of their lack of ability, or been unable to fill a post because of a lack of a suitably qualified candidate. One of the exceptions was a semi-literate and mostly innumerate employee of a sewing factory who had somehow circumvented the selection process, and was found to be unable to fill in the forms required to keep track of stock. The other was a clerk in a hardware store who had performed satisfactorily at interview but was unable to balance columns of figures from the till rolls on a daily basis.

The only particular mathematical skill highlighted by employers as being a real problem area was that of percentages. There was a widespread feeling that too few employees really understood what was meant by percentages, and that even with a calculator they could not work them out. This problem was not simply at the lower levels: a factory personnel officer cited the case of a trainee personnel manager, who was in the second year of a business management degree, who could neither calculate a percentage nor get the figures into the correct order to enter into a calculator. At a lower level, the research officer was in a department store during a "Blue Cross" sale which offered a 5% reduction on marked ticket price. Whilst standing in the queue he overheard a man discussion with his friend the sale price of a pair of trousers marked with a price of £35. Neither of them could work out the new price, and nor could the sales assistant, even when using a calculator! Eventually she rang the goods into the till just to determine the sale price, and then cancelled the transaction.

Calculators and Mental Arithmetic

These two subjects are discussed together, partly because they are related in their use and partly because all interviewees discussed the two subjects as one. Many of the employers had strong feelings about this subject, and felt that the biggest problem for many of their new employees was the abrupt parting from the calculator and consequent reliance upon mental arithmetic. Examples abounded :

- the nursing tutor who found that many candidates for a place at the college incorrectly answered the question;

What is ¾ or 72?

(often giving the answer 96)

- the supermarket stockroom supervisor who routinely has to complete the value column in the stock wastage book (where quantity and price are first recorded and the value calculated) because employees find it too difficult to calculate the required sum (and calculators placed at the desk kept disappearing);

- the shoe shop assistants who go to the cashier to find out how much three items will cost the customer (normally priced at £n.99 or £n.49).

It became apparent that those employees who had studied one of the GCSE syllabuses that set an aural (non calculator) exam, which created a classroom environment where mental arithmetic was practised, were consequently generally more at ease in the workplace. Many of the employees questioned claimed that they had rarely, if ever, routinely practise mental arithmetic in the classroom during secondary education. Most that needed to had however adjusted to life in the workplace without a calculator and found that the regular practice of the sums required made them relatively simple. A warehouse operative in a large supermarket claimed that he had been 'useless at maths at school' but that he was now happy with the 12 times table up to 30, and demonstrated this knowledge with great ease and rapidity. (He was also good with 5's and 10's, but saw no need for 7's and thus had made no improvement to his knowledge of this particular table.)

The second aspect of the calculator debate that concerns employers in particular is that of appreciating the reasonableness of a calculated answer, or as a modern apprentice tutor put it 'they say the answer's got to be right because that's what the calculator says.'

As for the examples of non ability to calculate mentally, examples of the problems were plentiful:

- the army instructor who was teaching magnetic compass calibration (a process to determine the individual error of a particular compass when measuring against a know bearing - and which includes the magnetic variation for that particular point on the earth's surface) and one of the students determined by calculator that the calibration correction to be applied was 173º , when in fact it should have been 4º (and a common sense check should have revealed that the compass as reading almost diametrically the wrong direction);

- the case of the stock supervisor who was assured by a new operative that there should be 33 cases of whisky left in the stockroom, when in fact the stockholding was only 10½ cases (the decimal point having been neglected from a delivery of 2.5 cases).

The majority of employees, when questioned as to whether they checked the output of their calculator, admitted that they did not and those that did, mostly simply guessed at what the answer might be. The few exceptions to this were among, management trainees who mentally calculated an approximate answer (some very approximate) to check.

'Feel for number'

Although in some ways this is similar to the above discussion, it impinges far more upon the changing technological face of the workplace., There is increasing reliance upon automation of all sorts, and operatives at all levels are being required to make relatively sophisticated judgements about the reliability of the output of the machine that they are tending. As an extreme example of this, the Multiple Launch Rocket System (MLRS) that created the 'Black Rain' which caused such consternation among the Iraqis during the Gulf War, is very highly automated, with a positioning determining system and fire control system that determined the required bearing and elevation for the rockets to be fired at. The crew need to be capable of gross error checking to see that there has been no system malfunction, as unfortunately as with modern high technology there is the possibility of partial malfunction which will produce an incorrect answer - with possible catastrophic results. So, for example they might check that if the target is at a range of approximately 20 Km then the elevation should be in the order of 500 mils (a mil being the angular measure used by the Army where 6400 mils describe a circle).

At a more general level, the Post Office recently had a major internal inquiry to discover why there had been an increase in the South West mail levels of the order of about 10, only to discover that the new operative having been told to 'round up' the number (to the nearest 10) had simply added an extra zero.

Most shops, especially supermarkets, have gone over to computerised tills and have to cope with the 'nightmare' scenario of a total loss of power and consequent inability to check customers out. Customer relations being particularly important in the competitive marketplace, the simplest solution of simply sending the customers away without their goods is not appropriate. Calculators have been tried by at least two of the shops in the sample, but been rejected as being too slow and error prone, and the accepted solution seems to be to get the customer to guess the value of the goods in the basket. This is them either accepted by the supervisor, who often trains in the estimation of the value of a basket of goods, or rejected and in these cases a calculator will be used. No shop in the survey admitted to having to go through this process, but apocryphal stories abound of shops that have had to do it.

Team Work

Most employers highlighted the importance of teamwork and collaboration in the running of their business, most employees highlighted the individual nature of their school lives and especially the maths lessons. One supermarket operative having discussed that most of his maths had been learned from a text book, noted that 'when the teacher explained using all the proper big terms nobody really understood, but some of us understood from the book and told each other and that was the way we learned most of our maths.'

Relevance

Almost the entire population of the study said that they had had to learn at school some maths that they had never then used again. This was particularly the case with those whose mathematical ability was at a lower end of the scale; attitudes were best summarised by the garage mechanic who said 'I think that a lot of maths that is taught is not used in later life. I've forgotten most of what I had to learn as I never use it'. Allied to this was a feeling that maths was somehow therefore boring, perhaps because it was too theoretical, and that much of the fun left maths lessons on entry to secondary school.

A number of employees commented on the fact that they had found mathematical skills easier to assimilate in workplace training, partly because they were using the skills more regularly than had been the case when in school and partly because of the more easily perceived relevance of the subject matter, and hence greater motivation. For example, a bank employee who 'never really understood ratio at school' said that 'in the bank though, the figures meant something real, and I found it easy to relearn this topic' and a soldier who found 'compass bearings and co-ordinates a real nightmare at school…. But in the army the lessons were clearer and we knew we would have to walk further if we got things wrong! Also we talked a lot about what we were doing, and worked as a squad taking it in turns to lead'.

Some employers felt that there was a problem with applying theoretical skills to practical applications in today's rapidly changing workplace. This was highlighted by the personnel officer in a County Council Treasurers Department who found that the application skills of new employees, particularly in terms of report writing, was often poor. Richard Osmond [1] (Secretary of the Post Office) wrote

> 'The ability to make the mental transfer from one context to another … to think "Ah , yes, I could use such and such an approach to tackle that problem" - in short the awareness of the practical application of theoretical learning - is important'.

Other concerns

Most employers stated that numeracy was not their major problem when recruiting. Whilst they had some concerns as addressed above, large numbers commented adversely on literacy, presentation skills (both written and personal) and a wide variety of interpersonal skills, particularly obedience to rules. They regarded these factors as more important than numeracy skills.

[1] Osmond, Richard. "What do Employers want from school leavers? Is there an easy answer? " in Teaching Mathematics and its Applications, Volume 13, Number 1, 1994.

5. In Depth Visits

Three firms (a supermarket, bank and the Army) were selected for in depth visits.

In each case three different sites were visited and two different employees were shadowed for a working session, the length of which depended upon the time of day but generally was in the order of two or three hours. There was then an interview, the length of which depended upon what had occurred during the shadow session.

The outcomes of these in depth studies, in terms of the mathematical requirements have been incorporated into the other sections of this report as and where appropriate. It should be noted though that, when comparing the results from other similar firms in the survey which were **not** the subject of in depth study, the results in terms of the utility of specific mathematical topics are remarkably similar. Equally the differences between the perceived requirement of employer/employee were as evident in the in depth firms as they were elsewhere.

Here are some notes on the shadowing and interviewing with a limited number of the employees :

ARMY

(a) This soldier is a 19 year old who had three GCSE's which did not include mathematics and is employed as a clerk. His principal duties were typing, filing and coffee making, but he was the office general duty person and was likely to be employed on a wide variety of tasks. The research officer spent some time with this soldier, the greater part of which was spent on the office computer which he was using as a word processor. This computer is on a network, which carries a distributed database of personnel records, and sometimes (though not during the visit) he is required to access data on the personnel within the Battery. Although the database is complex, he is only authorised to access a limited amount of data, and not to input any, and in effect does all that is required by rote.

During interview he claimed to have learned little maths at school, and required even less during his work. His employer endorsed this view that little maths was required of this soldier, and the evidence of the visit did not contradict these views.

(b) This soldier is an 18 year old with 5 GCSE's including mathematics at grade C. He is employed as a storeman in a store that had a wide variety of equipment. The research officer spent some time with him in the store, during which time he was almost wholly devoted to preparing the store for a forthcoming inspection - which was creating an amount of stress in his life, to which the visit was adding. The work was mostly

re-stacking items, and ensuring that they were of a sufficiently high standard of cleanliness (which they had not been on a pre-inspection check!). There was evidence of a requirement for low level numeracy, in terms of counting and, from discussion, some manipulation of number to determine requirements for particular events, such as 25 soldiers on rations for 4 days - how many 10 and/or 4 man ration packs required, but little else mathematically.

BANK

(a) This clerk is 19 years old and has 8 GCSE's including mathematics at grade B. She is currently working in the typing pool of a large city centre bank and spends the greater part of the day audio typing. She also has a secondary role to input data for the operations section, which inputs cheque data into the computer. There is little requirement for any mathematics in either of these two roles, both of which are about keyboard operation.

(b) This clerk is 20 years old and has 6 GCSE's including mathematics at grade C. She has recently been appointed a manager's clerk, and has a reasonably wide ranging role in assisting her manager. During the visit she was going through a loan application from an owner of a public house, checking the arithmetical accuracy of the details, and transferring data to the various ratios that the bank works with to determine the viability of a business. She mostly requires mental arithmetic, but occasionally will use a spreadsheet package on the computer - either a 'bespoke' bank system or a 'free style' system. She was a keen and enthusiastic employee, both as evidenced during the visit and testimony from her manager. Full advantage was taken of the in-house training packages - and in fact some twenty minutes were spent showing the research officer through the computer based training package.

SUPERMARKET

(a) This employee is 17 years old and has 5 GCSE's including mathematics at grade D. He is employed in the warehouse in the fruit and vegetable section. His work involves parts of all aspects of stock control, excluding the ordering, under the supervision of his line manager. He spends much of his time filling the display shelves with stock and checking that the stock on the shelves is of 'merchandisable' quality - which is a slightly subjective judgement, predicated in part by the 'sell by' date and in part by the lack of blemishes. He uses quite a lot of mental arithmetic in the stock control aspects, but it is a very limited subset of mathematics, comprising little more than the four rules and percentages.

(b) This employee is 17 years old and has 5 GCSE's including mathematics at grade C. She is employed in the customer café cleaning. Other than handling the money on the till there is little requirement for any mathematics in her employment.

6. Key points and recommendations

In the preceding sections, we have tried to present what we regarded as either important findings or representative responses. But this written information can never make up for the experiences gained by the researchers on their visits and interviews, and the recommendation formulated below clearly reflects this under spectrum of evidence.

Firstly then, the key points :

1. Most employers said that numeracy was not one of their principal concerns when recruiting new employees; literacy, communications skills and other interpersonal skills were more important attributes. However, those employers who required a Grade C for GCSE mathematics mostly regarded it as a level of competence that can be assumed, although they had little knowledge of what skills this actually ensured.

2. Employers were generally dissatisfied with young employees' reliance upon calculators and their lack of mental arithmetic skills. They were concerned with the unthinking acceptance of calculator results without any estimation of the 'rightness' of the result. They felt that, with increasing reliance on 'black box' technology, there is a greater need for employees (at all levels) to have a 'feel for number', which appears to be missing in many young employees.

3. There is a large amount of mathematics in the GCSE syllabus that is relatively little used by young employees; for example straight line equations, indices, quadratic equations and sine/cosine/tangent of angles in right angled triangles.

4. Employers perceive a greater need for maths than employees, whilst employees felt that too much school maths was either too theoretical, irrelevant to life or both. They further felt that learning mathematical skills in the workplace was often much easier than it had been at school, since it was directly relevant and often used.

5. The testing of mathematical ability by employers appeared to be waning, and of those that still tested, over half bought in commercial tests. Many of the tests seemed deliberately harder than actually required and calculators were usually not allowed. Some personnel officers are beginning to question the relevance of these tests to the future needs of young employees.

And now for the recommendation and implication for school mathematics :

1. Schools should give greater emphasis to mental maths, so that when calculators and computers are used, pupils will already have the necessary skills of approximation and estimation.

2. QCA should consider the development of a GCSE in Practical Maths, designed specifically for students who are unlikely to need further mathematical study; this should be less 'academic' than current Maths GCSE course, but emphasising the maths needed in practical real life situations; the grade C on this exam would then provide a suitable guaranteed minimum standard for students entering employment.

3. Develop a handbook of quick and efficient methods for calculating commonly used items such as percentages, proportion, change of units, mean value etc.

APPENDIX 1

1	Basic numeracy	16	Fractions	31	Decimals
2	Ratios	17	Percentages	32	Estimations
3	Change of Units	18	Negative Numbers	33	Accuracy (DP & Significant Figures)
4	Standard Form	19	Square roots	34	Indices
5	Evaluate Simple formula	20	Converting Units	35	Co-ordinates
6	Solve simple equations	21	Straight line equations	36	Graph simple functions
7	Solving inequalities	22	Manipulating formulae	37	Solve Quadratic equations
8	Compass Bearings	23	Perimeters/Areas/ Volume	38	Nets for 3D models
9	2D representation of 3D	24	Area/Circumference of circle	39	Pythagoras' Theorem
10	Similarity	25	Sin/Cos/Tan in right angle triangle	40	Sine & Cosine Rules
11	Bar Charts	26	Pie Charts	41	Mean/Range of data
12	Basic correlation	27	Simple Probability	42	Solve probability using tree diagram
13	Cumulative frequency	28	Methods of Sampling	43	Linear programming
14	Problem Solving/Investigations	29	Calculator work	44	Computing/IT
15	Mental Arithmetic	30	Spreadsheets	45	Databases

A:/general/MathsNeedsYE.doc/db/ts