1 Numeracy in the workplace

In recent years, concern has been expressed by various organisations that students leaving education and entering the workplace are inadequately prepared for the numeracy requirements of their everyday work. Following publication of the CBI Education & Skills survey of 2011, John Cridland, CBI Director-General, commented:

> It's alarming that a significant number of employers have concerns about the basic skills of school and college leavers. Companies do not expect them to produce 'job-ready' young people, but having a solid foundation in basic skills, such as literacy and numeracy, is fundamental for work.

The project described in this book investigates ways of improving of the numeracy skills for employability of students undertaking level 3 courses within a range of subject areas in Further Education.

The Confederation of British Industry (CBI, 2010) has set out objectives for the levels of mathematical skills required of employees:

> Employers want all employees to be numerate – confidently handling numbers, demonstrating general mathematical awareness and being able to apply basic skills in practical contexts, such as working out percentages, spotting rogue figures and making estimates. And every employer needs some employees with logical and problem-solving skills which are grounded in an appreciation of mathematical theory – from finance professionals to project managers. Effective use of statistics and probability, complex calculations and algebra are common currency in modern workplaces.

It is apparent that the skills required by employers go beyond a simple application of standard mathematical methods, such as calculating averages or percentages, and require a wider ability in problem solving, estimating, and evaluating data.

Changes to working practices, brought about by technological developments, are identified in the CBI survey:

> Rapidly growing technological advances are making the need for numeracy skills more critical within the workplace. With greater numbers of workers engaging in more sophisticated tasks, numeracy is recognised as an essential employability skill. Also, it has been acknowledged as a potential employment equity issue, as adults with poor numeracy skills are more likely to have relatively low work positions with fewer promotion prospects and lower wages.

The impact on the future workforce is likely to be very significant. According to a CBI/Pearson study (CBI, 2012):

> More employers expect to decrease the number of low-skilled employees in the next few years than to increase the number. While most employers are confident there will be enough people available to fill their low-skilled vacancies, employers are not confident of meeting their need for high-skilled employees.

A report produced by the Advisory Committee on Mathematics Education (2011), outlines the country's mathematical needs, again focussing on the need for higher levels of numeracy skills:

> In the workforce there is a steady shift away from manual and low-skill jobs towards those requiring higher levels of management expertise and problem-solving skills, many of which are mathematical in nature.

A similar trend exists when preparing students for admission to Higher Education courses. The Advisory Committee on Mathematics Education report comments that:

> The quantitative demands of almost all university courses are increasing; even subjects like history, which traditionally had involved no mathematics, now recognize the importance of statistics.

Increasing opportunities are being provided by companies for employees to work autonomously, organising their own projects and making their own decisions. The UK Commission's Employer Skills Survey 2011 (UKCES, 2012) discusses 'High Performance Working':

> 'High Performance Working Practices' are those designed to increase employee discretion over their work and effectively use and develop skills that employees possess. Most establishments in Wales were engaging in practices that could be considered 'high performance working practices', most commonly through providing a varied, flexible working environment where employees have discretion to do their work.

High Performance Working makes additional demands for non-routine problem solving, inevitably requiring a high level of mathematical competence.

Within the diverse workforce of modern Britain, we therefore find a spectrum of activity ranging from occupations with minimal numeracy demands, to occupations where advanced cutting-edge numeracy techniques are being developed and applied. This situation can put an obligation on vocational tutors to prepare students for a wide variety of numeracy activities at a range of levels.

When interviewed, employers often mention a requirement for competence in the use of number. However, other skills may be considered equally or more important for employees. The CBI survey (CBI, 2010) comments:

> Many occupations use numeracy that requires accuracy in the actual job tasks and capability in the language, by use of appropriate terminology and industry-related jargon. Explanation, elaboration and analysis, for example, are frequently presented along with numbers. As such, there is a language challenge that needs to be considered in numeracy tasks.

A study by Riall and Burghes (2000) found that personal qualities of employees were crucially important:

> Most employers stated that numeracy was not their major problem when recruiting. 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.

A study by Howard (2010) similarly observed that:

> Although functional literacy and numeracy are essential skills, most employers value motivation and positive attitudes at least as highly; some valued the two equally. At recruitment, the majority of employers value energy, positive thinking and 'fit with the company's culture' more highly than basic skills, provided the level of basic skills approaches functionality for the job on offer. Several employers see skills in general as easier to develop than attitudes.

In developing students for the world of work, teachers should consider a broader approach than simply imparting facts. The development of a positive attitude to work and good interpersonal skills for employment might be seen as important objectives of numeracy education.

Whilst many employers consider that GCSE Mathematics is an important standard for potential employees to have reached, the study by Riall and Burghes identified a number of areas of numeracy which were generally not found useful by employers or their employees:

> 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.

However, in the Advisory Committee on Mathematics Education study, employers emphasised the importance of staff having studied mathematics at a higher level than they will actually use. That provides them with the confidence and versatility to use mathematics in the many unfamiliar situations that occur at work.

> A frequently heard comment was that too many young people have only learned to do the sort of questions that are set on GCSE papers.

The importance of appropriate use of calculators and computers is appreciated by employers. The study by Riall and Burghes found that:

> 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.

It is evident that calculators and computers are of great value in reducing the workload of calculations, but it is essential that staff are able to adequately interpret the output produced and appreciate the significance of anomalous results. Howard (2010) comments:

> IT is an essential skill and has had a mixed impact on the need for literacy and numeracy in the workplace. The introduction of standardised computerised communications, 'tick-box' reporting, spreadsheets and calculators has reduced complexity and made literacy and numeracy tasks easier in some ways. However, many employees need to develop IT skills for literacy and numeracy and are trying to use them with low levels of competence and little training or no training. This leads to errors.

If we are to accept the views of employers that numeracy standards of new employees are often inadequate, then further training will be necessary in the workplace. According to Riall and Burghes (2000):

> 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.

Eraut(2000) has carried out studies which conclude that most workplace learning occurs on the job rather than off the job. Learning from others at work may take place through formal training sessions. However there is also much informal learning in the workplace. Teamwork is often an essential component of problem solving.

An adult learning model may be constructed, which consists of the three components:

> **Pedagogic learning,** describing formal study in which a teacher provides the core knowledge required in a subject.

Participation in a community of practice, referring to the way in which students learn from experienced practitioners within a practical apprentice relationship (Lave and Wenger, 1991; Eraut et al, 1998).

Reflection, describing the way in which students make sense of events and learn through experience (Schön, 1983; Boud and Walker, 1998).

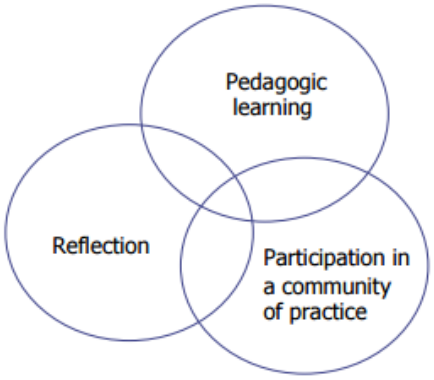


Figure 1: Components of an adult learning model

The model may be represented as overlapping circles on a Venn diagram. Effective learning activities often combine more than one of the components, for example: attendance at a specialist conference may involve pedagogic learning during lectures about new innovations, reflective discussion sessions with colleagues about professional practice, and more informal exchanges of ideas with delegates within the community of practice.

In a study of the essential skills requirements of employers on the island of Jersey, Howard (2010) comments:

> Employers offer much work-related training and development using basic skills, though literacy and numeracy are generally not explicit in the offer. It is 'embedded', but not fully addressed; indeed a tutor's skillset may not include effective training in basic skills. The common assumption is that the state tackles adult literacy and numeracy, while employers undertake related training in communications, IT, management, health and safety, alongside vocational and job-specific skills.

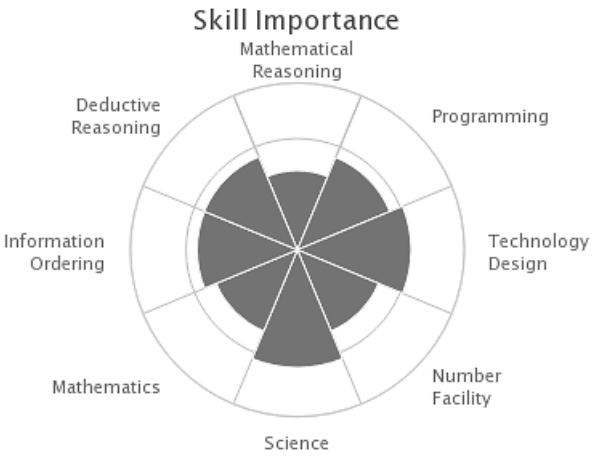
There can be considerable advantages for teachers in Further Education to follow a approach similar to the adult learning model, extending beyond set activities in the classroom or workshop, and allowing students to personally engage in experimentation, project planning and problem solving in a realistic work environment.

In the Advisory Committee on Mathematics Education (2011) study, it is recommended that:

> Teachers should be provided with information about the wider uses and value of particular mathematical ideas. Teachers need to know about the mathematical needs of employers and what is desirable on courses in HE; they must be encouraged to frequently include non-routine and unfamiliar situations, and opportunities for reasoning, in their teaching.

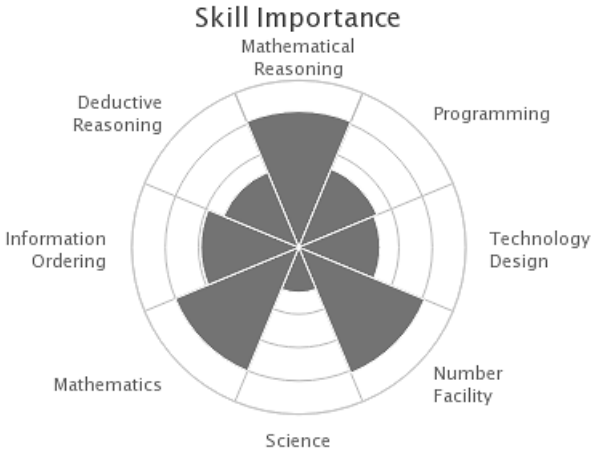
There is clearly a great diversity in the types of work that students may undertake during their careers. The *icould* organisation (Mulcare, 2016) provides case studies of professionals employed in a wide range of occupations, roughly divided into those where ***mathematical skills***, ***problem solving***, or ***use of technology*** are dominant. Analyses are presented in the form of circular diagrams showing the relative importance of the various work components within the area of numeracy. Some example occupations are:

Conservation and environmental professionals
Emphasis on skills in science and technology



Financial and accounting technicians

Emphasis on mathematics



Senior officers in fire, ambulance, prison and related services
Emphasis on problem solving skills

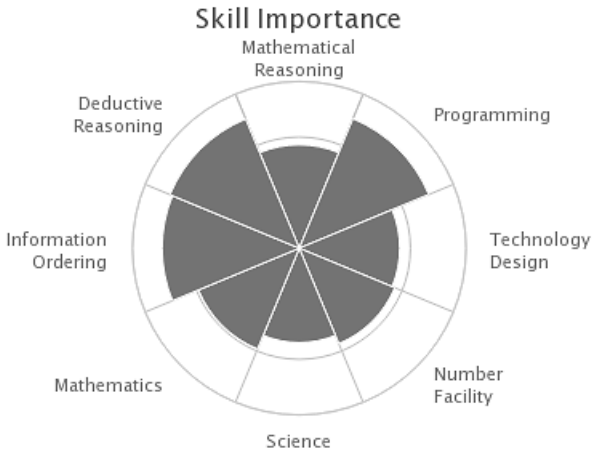


Figure 2: Numeracy requirements of occupations

Data collection and processing, often involving computer technology, mathematical techniques and problem solving can all be accommodated within the broader spectrum of numeracy.

Out of the vast range of occupations that exist in the present day world of work, we might select at random three where numeracy represents a significant requirement. Case studies were collected by the ACME (2011) report:

Measuring the deviation of railway lines

On-track machines (OTM) are used to monitor the on-track geometry by travelling quickly along the tracks. Ten different measurements are taken. Measurements are taken every 6 inches, and the standard deviation of measurements for every 35 meters of track is calculated. The equipment produces a range of displays, which are like a SPC (statistical process control) chart.

Hydrological modelling

The work of a hydrologist can vary considerably according to the sector, employer and area of specialism. However, typical activities may include:

- understanding and interpreting maps, geographical data, historical evidence and models to build up a picture of the groundwater and surface water regime, often based on incomplete information;
- using computers to model groundwater flow and surface water flow and man-made influence;
- undertaking field work and site visits for investigative and monitoring purposes;

Health Care Assistant

Duties include

- Undertaking specified clinical activities and tests for named patients, within the scope of established clinical protocols, policies and procedures, including venipuncture, urine testing, blood pressure readings, ECG's, weight monitoring, audio assessments and medicals.
- Ordering and maintaining stocks of dressings and equipment as directed.
- Providing relevant health information to patients and carers within defined protocols.

Things that these three apparently diverse occupations have in common are:

New technology is used to make measurements (geometry of the railway track, water flows in rivers, patient's heart function…)

Staff have to be skilled in interpreting these measurements and detecting when action is needed (sending workers to examine defective railway track, giving flood warnings, notifying a doctor of changes in the patient's condition…)

> Complex mathematics is involved but is largely hidden within the technology. Staff do however need an understanding of: when to use the technology, what information it can provide, its accuracy and reliability
>
> Data has to be interpreted and recorded using Information Technology systems (track measurement charts, flood modelling maps, patient records…)

A factor which emerges from surveys of work place activities is that many numeracy skills may be dismissed as 'just part of the job', being inextricably bound up in work practice. The CBI survey (CBI, 2010) comments:

> A very small part of the mathematical activities in workplaces actually count as visible numeracy.

In a study of warehouse workers (Keogh, Maguire and O'Donoghue, 2010), manual employees did not consider that they made much use of numeracy in their daily work. It was discovered that they did in fact carry out many complex tasks falling within the broader definitions of numeracy given above, such as:

- Accessing data from computers. This data specifies items to be collected and their storage locations.
- Planning efficient routes around the warehouse to collect required items in a minimum time,
- Estimating the weights of the items required, in order to make up safe truck loads,
- Dealing with the reporting and reordering of items out of stock,

all done under time pressure, with serious consequences in the event of errors.

We might conclude that competence in numeracy in its broader sense is essential to most occupations, and employees who are unable to cope with everyday numeracy demands will face considerable difficulties.

The Advisory Committee on Mathematics Education identifies a series of common situations which require more complex mathematical techniques than the simple use of number:

> **Mathematical modelling**
> It was common to find individuals who used a model that was developed elsewhere in the company, or a software package that was essentially a mathematical model.
>
> **Use of software packages and coping with computer/software malfunction**
> Manual calculations may have to be made because of a breakdown in the IT equipment. More common, however, is the need to be able to input the correct data and make sense of the output.
>
> **Costing, including allocating responsibility and managing disputes**
> When things do not go according to plan, it may be necessary to carry out a detailed calculation to identify the responsibility for allocating the cost of putting the situation right.

Performance indicators and the use of ratios
Performance management through the use of appropriate performance indicators is increasingly common.

Risk Uncertainty
Trying to estimate in some way the risks involved in an enterprise and the consequences of unexpected outcomes.

Quality control and statistical process control
The widespread use of statistical process control (SPC) in industry means that increasing numbers of staff need to be able to read and act upon charts that show how product measures vary.

Non-routine work
In fields such as construction or manufacturing, staff often have to do non-routine calculations which require confidence in the use of mathematics.

Based on case studies in engineering and social care workplaces, Marr and Hagston (2007) identified the most important mathematical skills for staff as:

- algebraic thinking – for spreadsheets
- calculations – with and without calculators
- arithmetical estimation skills
- geometric thinking
- logic
- measurement
- accurate storage, retrieval, display and interpretation of data.

Hoyles et al. (2000) have summarised the mathematics related qualities required for the modern UK workforce, which they suggest go well beyond the use of number. In addition to knowing how to calculate and estimate and to have a feel for numbers, percentages and proportions, the skills required include:

- analytical, flexible, fast and often multistep calculation and estimation in the context of work (with and without the use of IT tools)
- complex modelling (of variables, relationships, thresholds and constraints)
- interpreting and converting between different representations of quantitative data, using number, graphs and algebraic expressions as appropriate.
- systematic and precise data handling techniques using IT systems.
- trend prediction and monitoring of models relating to different types of work activity.
- concise, clear communication of judgement
- recognising unusual effects and errors in answers

Summary

There seems to be considerable agreement amongst researchers who have investigated requirements for workplace numeracy. It is appreciated that students entering employment require a wider range of skills than mathematical techniques alone. It is necessary to analyse problems, decide on the data required for their solution and to collect and process this data, often with the use of electronic technology. It is necessary to communicate mathematical results effectively in a form that can be used for decision making.

Very few of the mathematical methods taught at GCSE level, beyond simple arithmetic, are actually required for a majority of occupations. However, the extended numeracy requirements of the workplace may be very challenging. In some occupations, very specialist and advanced mathematical skills may be needed.

It is seen as essential to develop the extended numeracy skills of Further Education students, particularly in analysing numeracy tasks, developing problem solving strategies, collecting and processing data, and communicating results to colleagues and clients.

We might summarise the principal numeracy skills required by employers as:

- financial control
- problem solving
- planning and organisational skills
- communication in the context of work
- use of IT tools
- effective group working
- determining appropriate accuracy
- estimation

Overall, it is essential for staff to present numerical results effectively in a form that can be used for decision making.

Consideration should be given to providing numeracy education in a way which simulates real workplace problems and projects, so as to motivate students and give realistic and relevant training experiences.