Developing Numeracy in Further Education

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Contents

Preface 4

PART 1: Investigating numeracy for Further Education

1. Numeracy in the workplace 9

2. Student numeracy 19

3. Embedding numeracy activities 32

- Re-roofing a building
- Holiday planning
- London Eye
- U-values
- Beach gravel
- Modelling fish stocks
- Car suspension

4. Use of technology 61

- Graphs
- GPS
- Room design
- Engineering CAD CAM
- Sage Accounts
- Data logging

PART 2: Case studies in embedding numeracy

5. Activity planning using number 92

- House renovation in terrace
- Hill farm tourism venture
- Garden design
- House Rewire
- Three Peaks yacht race

6. Measurement 110

- Capacitor charging and discharging
- River gravel survey
- Building a wind turbine
- Men's health

7. Shape and space 139

- Chapel conversion
- Curves in building construction
- Surveying: triangulation
- Industrial archaeology building recording
- Engine rotation
- Isometric projection

8. Using graphs and diagrams 185

- Graphs and diagrams in critical thinking
- Cyclic graphs
- Circular diagrams
- Vegetation transects
- Graphic log sections in geology
- Traffic flow
- Urban land use

9. Representing data sets 228

- Car braking distance
- River flow
- Human body parameters
- Three dimensional landscape modelling
- Powers of numbers
- Kirchoff's laws
- Boolean algebra

10. Statistical analysis 276

- Converting opinions to quantitative data
- Distributions
- Chi-squared statistic
- Mann-Whitney U test
- Spearman Rank Correlation
- Analysis of Variance

11. Mathematical modelling 320

- Theatre design
- Owls and mice population model
- Spread of an illness
- Traffic flow model
- Hillslope water flow
- Scree slope angle
- Expedition journey time
- Diet and nutrition

12. Calculus 356

- Accelerated motion for a roller coaster
- The exponential function
  - Bacterial growth
  - Carbon dating
  - Capacitor charging and discharging
- Solid shapes
- Optimisation models

13. Algorithms for problem solving 394

- Dijkstra's algorithm
- Travelling salesman algorithm
- Sorting
- Encryption
- Game strategy

PART 3: Developing a numeracy strategy

14. Assessment 432

15. Discussion and conclusions 451

References 458

Preface

The authors of this book are tutors working in a Further and Higher Education environment within a college in rural Wales. We have, between us, taught numeracy in a wide range of vocational areas including: construction, engineering, computing, environmental science, business, and art and design. We have also had the opportunity over several years to carry out practitioner research with our student groups, with the objective of identifying ways to deliver numeracy courses more effectively. This book has come about through our desire to share our experiences and ideas with colleagues, and perhaps suggest some interesting ways in which numeracy activities can be developed within vocational courses.

Mathematics and numeracy may have different meanings to different people, so we should from the outset indicate our interpretations of these concepts.

Mathematics and numeracy are often seen as the ***use of numbers*** in solving calculation problems. This is unfortunate, as it can alienate students who have had poor experiences of learning arithmetic at school, and deter them from further study of numeracy. Mathematics is about much more than number, and we prefer to see the subject as the ***study of patterns***. Patterns may relate to sets of numbers, but in many cases might be better represented by algebraic formulae or graphs. Patterns may also occur geometrically, describing for example: lengths, areas or volumes. Once patterns have been identified, the relationships can be used in problem solving in a wide range of contexts, including mathematical modelling and algorithms in computing.

Many authors make an important distinction between ***mathematics*** and ***numeracy***. Mathematics is generally taken to be a set of quantitative methods, such as simple arithmetic or more complex algebraic functions, geometry theorems, and statistical tests. Numeracy, however, is seen as a broader subject with essential links with the real world. In additional to mathematical methods, numeracy might include:

- A knowledge of the vocational area in which the mathematics is to be used, such as: engineering, business, or catering.
- Good communication. This is important when determining the exact problem specification. It will be necessary to present the solution in a format which is understandable to others and provides information appropriate for decision making.
- Problem solving skills. Numeracy problems arising in work situations may be new and unfamiliar. A range of possible solution strategies might need to be considered, and the most appropriate mathematical techniques selected. There may be no ‘correct’ solution to a problem – just some solutions may be better than others.

Numeracy need not be at an elementary level but might include, for example: the systems of differential equations used by engineers or scientists, the complex geometrical techniques used by surveyors, or the advanced statistical techniques used by economists.

In terms of a Venn diagram, the numeracy used in any particular occupation will select suitable mathematical methods and combine these with vocational knowledge in practical problem solving activities.

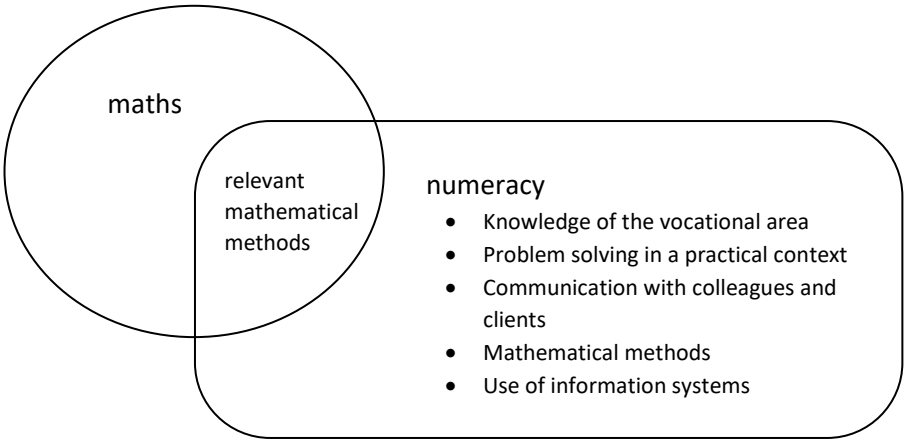

Figure 1: The relationship of mathematics to numeracy

Numeracy problems arise naturally in the course of everyday activities, and are generally posed in non-mathematical terms, for example:

> What is the quickest way to travel to my destination?
> How can my business run more profitably?
> What is the risk of my house flooding?

Numeracy problems are often ***ill-defined***. A first step is to identify the factors which will be important in obtaining a solution, and any factors which can safely be ignored – at least in a first approximation. A practical common-sense approach is essential.

It will be necessary to collect whatever data is needed for solution of the problem. Only at this point are mathematical techniques introduced. It is often sensible to make use of a calculator, spreadsheet or specialised software application to simplify the data processing.

Once a mathematical solution is obtained, this needs to be interpreted in terms of decision making in the real world, for example:

> The travel route I should take, and when I should depart.
> How much money I should spend on advertising, and how many staff I should employ.

A key feature of numeracy is that solutions are often approximate. It may only be possible to estimate the time required for a construction project to the nearest day. However, some numeracy problems may require extremely accurate solutions, with sizes of components within a machine needing to be specified to a tolerance of less than a millimetre. An ability to estimate and use appropriate levels of accuracy is important.

Overall, we find numeracy a very exciting area in which to work as tutors. The subject requires the development of a wide range of skills in our students: a practical approach to

problem solving within the context of a vocational subject; ability to collect and record the required data; skills in mathematical techniques, often with the help of computer technology; selection of appropriate levels of accuracy; interpretation of results in a form suitable for decision making; and the communication of results to others in appropriate language, often non-mathematically.

In the first section of this book, we examine a series of topics which we feel are important and relevant to the design of numeracy activities within vocational courses:

In ***Numeracy in the workplace***, we begin by examining the numeracy requirements of employers, which go well beyond a simple knowledge of mathematical techniques.

Student numeracy considers various challenges faced by students in improving their numeracy skills. We particularly consider the importance of motivation, and the design of activities which can encourage motivation.

Embedding numeracy activities looks at approaches for integrating numeracy into vocational courses. We examine a framework proposed by Tang, Sui and Wang (2003) which identifies five levels for incorporating numeracy activities, representing a progression from applications set by the teacher, through increasing student involvement in the solution of real world problems, to totally independent project work.

Use of technology is an essential aspect of numeracy in many work situations. We consider the use of spreadsheets and electronic calculators, along with specialist software packages including computer aided design systems and computer aided manufacturing applications. We discuss the use of GPS and data logging devices in numeracy.

The second section of the book considers case studies in embedding numeracy in a variety of vocational courses:

Activity planning using number. Most businesses and organisations require their employees to carefully plan complex activities. Activity planning involving numeracy also occurs frequently in the everyday life of families. We look at a variety of activity planning projects carried out by students.

Measurement examines practical measurement and data collection in realistic work situations. We find that projects involving hands-on measurement can be motivating to students and encourage the development of problem solving skills in numeracy.

Shape and space. Many important numeracy applications are focused on the use of geometric data, including: land surveying, architectural and engineering design, and computer animation. We examine opportunities for students to carry out interesting projects in these vocational areas.

Using graphs and diagrams. Large quantities of complex data are often displayed in the form of graphs or diagrams, in order to make patterns and trends clearer and assist in decision making. We examine a variety of graphs and diagrams, some with specialist uses in

particular subject areas, such as: vegetation transect diagrams, traffic flow diagrams, and Venn diagrams for Boolean algebra.

Representing data sets addresses a major issue in numeracy: the ability of students to move easily between numeric, algebraic and geometric representations of particular collections of data. Patterns in data may be identified geometrically through plotting graphs or other diagrams, then represented algebraically for use in predictive problem solving. We examine various projects where links are made between tables of numerical data, graphs and algebraic functions.

Statistical analysis provides a powerful range of techniques for assessing the significance of data which has been collected. We present examples of student projects involving statistical analysis which have been carried out in the fields of: psychology, geography and biology.

Mathematical modelling allows predictions of system behaviour which can be of value for effective planning, for example: before large amounts of money are spent, or to guide choices between design options. We look at the mathematics underlying models produced by students in health and social care, biology, outdoor activity, and geography.

Calculus, with its two main techniques of differentiation and integration, allows the calculation of a wide range of important data. We examine, for example, the use of calculus to: determine volumes of solid shapes, analyse the motion of a roller coaster, and find the age of materials by carbon dating.

Algorithms for problem solving form some of the most interesting and innovative applications of numeracy in a modern world of computers. We look at student projects involving: determining shortest distances in transport networks, fast sorting of large quantities of data, encryption, and game playing strategies.

In the third section of this book, we draw together several themes relevant to numeracy in vocational education:

Assessment. Whilst we see many benefits from adopting an embedded vocational student-centred problem solving approach to numeracy, there are problems reconciling this approach with the specific syllabus requirements of examining boards. We consider how students' work on realistic ill-defined real world problems can be accommodated within existing numeracy assessment schemes.

In the chapter ***Observations and conclusions***, we draw together the key issues which have emerged from our study of numeracy education. Motivation is seen as central to successfully improving students' numeracy skills.

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