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Mathematics or numeracy?

This chapter will help you to:

- improve your understanding of the mathematics involved in real-life situations
- appreciate the value of putting mathematics in context
- understand the structure and principles of the numeracy strategy

What is mathematics?

As adults when we reflect on our experience of learning mathematics through primary and secondary school, we tend to think of it in compartments in terms of the lessons and topics we encountered. If asked to list them, many adults would suggest that mathematics is arithmetic, geometry and algebra, maybe statistics or calculus. We might consider mathematics as being divided into pure or applied mathematics. However, mathematics can also be considered in a broader sense, involving problem-solving, searching for patterns and communicating ideas.

Mathematics is one of the core subjects in the primary school curriculum, along with English and science. It is a government recommendation that it is taught every day and it is viewed as an essential life skill.

What is numeracy?

The term numeracy has been widely adopted in primary schools recently, rather than mathematics. Numeracy is a recently coined term, being a contraction of 'numerical literacy'. It has been defined in a variety of ways such as the ability to use mathematics or the application of mathematics in other areas of the curriculum.

In the National Numeracy Strategy it was defined as:

> … a proficiency which involves confidence and competence with numbers and measures. It requires an understanding of the number system, a repertoire of computational skills and an inclination and ability to solve number problems in a variety of contexts. Numeracy also demands practical understanding of the ways in which information is gathered by counting and measuring, and is presented in graphs, diagrams, charts and tables. (DfEE, 1999: 4)

This definition focuses on the content of what is being learnt and taught in the different areas of mathematics. Numeracy, as a term, seems to reflect the way in which children approach their mathematics, valuing the confidence in and understanding of mathematics. The National Numeracy Strategy suggests that 'the outcome should be numerate pupils who are confident enough to tackle mathematical problems without going immediately to teachers or friends for help' (DfEE, 1999: 4). The term numeracy seems to reflect the competence level of the mathematics to be learnt with more of a focus on the skills to be achieved.

Mathematics in everyday life

Consider the complexities of selecting a suitable mortgage from the baffling selection available, probably one of the biggest financial decisions most of us ever need to make. We need to be certain of the options on offer so we can select the one which will be beneficial and affordable, taking into account all the possibilities available. Having a clear understanding of mathematics is socially empowering so we are not at the mercy of those who are more mathematically astute.

TASK 1.1

HLTA 1.6 Be able to improve your own practice through observation, evaluation and discussion with colleagues.

Take a few moments to note down where you have used or encountered mathematics over the last 24 hours. This could involve calculations, making estimations, using measurements including time, handling data or working with shapes. Discuss how you have used maths knowledge most with a colleague. See Appendix 1 for some ideas.

Simply arriving on time for work or school involves many mathematical skills, for instance the ability to tell the time, read a timetable, calculate the time needed to walk a certain distance or, in the process of driving, estimate the speed of the oncoming traffic and use your spatial awareness to reverse into a parking space. Every shopping transaction involves a mathematical decision, even if it is just, 'Can I afford this?' This is known as *functional numeracy*, having sufficient mathematical knowledge to cope effectively on a day-to-day level (De Villiers, in Goulding, 2000: 140). We also need a *practical* understanding of mathematics; this comes into play when we are trying to redecorate a room or plan a new kitchen. This includes the ability to measure accurately and to calculate the area of floors or walls for buying carpets or tins of paint.

Ways of learning mathematics

If you think about how you undertake the everyday mathematics discussed above, it probably involves informal methods and estimation rather than the formal methods you were taught at school. These will be discussed further in Chapters 3 and 4. Working as a Teaching Assistant, you may have found that mathematics teaching today is very different from when you were at school. Some of this is due to research demonstrating that there are different ways of learning mathematics and different types of learner.

Research summary – Mathematical understanding

Skemp (1989) considers mathematical understanding to be of two forms: relational and instrumental. Relational understanding is having the ability to see the connections and relationships between numbers and areas of mathematics and to be able to apply them to new situations, 'knowing what to do and why' (Skemp, 1989: 2). Instrumental understanding involves the learning of mathematical rules and being able to carry them out effectively. Most mathematical learning is a mixture of these two ways of understanding and there are times in the learning of mathematics when both are appropriate and useful. Each has its value but having a relational understanding gives a depth of understanding and the opportunity to apply it. Most teachers seek to develop this understanding in their pupils and it is certainly encouraged in the National Numeracy Strategy framework. The ability to make connections is vital in learning in all subjects, especially the link to prior understanding, which helps to put new learning in context. Throughout this book the connections between the different aspects of mathematics will become more apparent.

Further work on different types of mathematical understanding has been undertaken. Two types of cognitive styles were identified by Bath and Knox (1984) and developed further by Chinn (1997) (both cited in Henderson et al., 2003: 25). These are identified as grasshoppers and inchworms; their characteristics are described in Table 1.1.

Table 1.1 Learning style characteristics

Inchworm learners	Grasshopper learners
Are prescriptive	Are intuitive thinkers.
Like facts	Like 'the big picture'
Write information down	Make estimates
Look for formulae	Look for patterns
Avoid verifying	Like to verify information
Follow procedures	Solve problems mentally
Use a single method	Make flexible use of methods which change
Use numbers exactly as given	Adjust numbers for ease of calculation
Enjoy analysis	Enjoy investigations

Much of Chinn's work considers children with dyslexia and looks at ways to support different types of learners. However, these cognitive styles are appropriate for all learners of mathematics, whether children or adults. As with relational and instrumental understanding, we all use a combination of both styles, often depending on the situation.

TASK 1.2

HLTA 2.5 Know the key factors that can affect the way pupils learn.

Try the following question noting the method you use:

$2 \times 3 \times 4 \times 5 =$

Now consider the characteristics listed above and try to identify aspects of a particular style which you employed. In very general terms those who favour an inchworm style undertake the question beginning at the start and perform each step in order so as to be certain of completing the question. Grasshoppers tend to select numbers which are initially easier to multiply, often finding pairs of numbers and then finally multiplying them together. For example, 2×5 and then 3×4, followed by 10×12.

Chinn (1997) has found that most people use a combination of both styles and it may depend on the question asked, though some questions favour a particular learning style. There can be difficulties with both ways; for instance, those who favour an inchworm approach may struggle if they are unable to remember a method or strategy upon which they rely, whereas grasshoppers need to learn to document their work so they can keep track of their thinking and their work can be understood and any errors identified.

Having a connected understanding of mathematics aids the understanding of new concepts and reinforces those already established. It helps us to begin to think mathematically. 'Thinking mathematically is not an end in itself; rather a process through which we make sense of the world around us' (Mason et al., 1982, in Tanner and Jones, 2000: 104). It is important to consider the value of the mathematics being taught and learnt and to put this into a context which will be meaningful to the learner.

When revisiting negative numbers with adult students, an abstract question such as 'minus fifteen subtract five' can cause confusion when reflecting on half remembered rules. However, when the question is rephrased in terms of an increasing debt, for example 'You are already £15 in the red and you spend £5', the question becomes more accessible and therefore solvable. In order to be effective, a real-life example needs to connect to children's actual experience and be as close as possible to their real world. Many suggested examples in published schemes tend to be unrealistic, sometimes just using words from everyday life in a word problem. This will be discussed further in Chapter 7.

Research summary – Street mathematics and school mathematics

An interesting example of the learning of mathematics in a real-life context was a study undertaken by Carraher et al. (1993) in Brazil. Their intention was to determine the effectiveness of traditional mathematics instruction in the elementary school versus mathematics learned informally through working. Their focus was children working as market traders in Recife, Brazil.

Much of the researcher's time was spent shopping in the street markets undertaking the same transactions at each stall; this was designed to measure particular arithmetical skills which were being taught in school. These same questions became part of a paper and pencil exercise undertaken with the same children in school. One of the examples included in the study is the purchase of four coconuts which cost 35 *cruzeiros* (Cr$) each. The twelve-year-old boy replied: 'There will be one hundred five, plus thirty, that's one thirty-five . . . one coconut is thirty-five . . . that is . . . one forty' (Carraher et al., 1993: 24).

When facing the question in the market setting, the boy began by breaking the problem up into simpler ones based on his prior knowledge which was that three coconuts cost Cr$105. Then, to add on the cost of the fourth coconut, he first rounded the cost of a coconut to Cr$30 and added that amount to give Cr$135 and added in the correction factor to give the answer Cr$140. However, when facing the same question in the school situation his response was 'Four times five is twenty, carry the two; two plus three is five, times four is twenty.' He then wrote down '200' as his answer. Here he has applied a formal algorithm for column multiplication, although as he was able to maintain the positions of the places the respective numbers would occupy, he was unable to apply the necessary carrying rule resulting in a much larger price. While he was able to answer this question in the real setting, he did not apply this knowledge or an appreciation of the magnitude of the anticipated answer in the school setting.

The study gives many similar examples from other children who worked as market traders showing the interesting situation where children could calculate when the mathematics was presented in a real-life situation which they could relate to (street mathematics) but not when presented in a standard arithmetic form. There was a purpose to the street mathematics, where the question makes sense and has meaning, in direct contrast to the standard symbolic approach taken in the elementary school. The findings from this study make very interesting reading and reinforce important issues for mathematics teaching in all countries. One of the most important is the value of putting mathematics in an appropriate and realistic context for children (and adults) to make sense of, so they can apply their understanding more effectively by being able to construct appropriate meanings to all the abstract concepts and methods they will encounter in school.

TASK 1.3

HLTA 3.1.3 Contribute effectively to the selection and preparation of teaching resources that meet the diversity of pupils' needs and interests.

Consider the areas of mathematics which you have encountered most recently. Were there examples of real-life situations linked to the mathematics undertaken? For example, the children were learning about addition. Were all the questions just straight calculations or were they set in the context of real-life problems? Can you think of ways to develop, extend or include real-life opportunities into these sessions?

Public perceptions of mathematicians

There is growing concern over the diminishing numbers of children choosing to study mathematics at a higher level. Fewer pupils select to take their A levels in mathematics leading to a lower take-up for degrees in mathematics. Secondary schools are finding that there are fewer qualified teachers of mathematics. There are a great many reasons for this, one of which being the wide range of subjects offered in universities which are attracting larger numbers of students. Another is the way that mathematics and mathematicians are perceived by society.

Research summary – Children's perceptions of mathematicians

In the 1950s a pilot study was undertaken by Mead and Metraux (cited in Chambers, 1983) to discover the attitudes young people held towards science and scientists in order to ascertain why they were not following previously popular careers in science, especially engineering. This was the Draw A Scientist Test (DAST) later developed by Chambers (1983). Through this they could discover the views and images held by pupils. It was found that very stereotypical views were held of bespectacled men in lab coats.

A similar range of studies has been undertaken examining views of mathematicians, usually focusing on children of 12 and 13 years of age. Berry and Picker (2000) conducted a study comparing children's drawings of mathematics in the UK and the USA. In more than 300 responses from both countries, the majority of drawings showed white males, similar in nature. A range of themes emerges from the drawings, generally strongly negative stereotypes. The following is just a selection of comments which annotate the drawings. 'Mathematicians have no friends, except other mathematicians. They are usually fat, unmarried, aren't seeing anyone, and have wrinkles in their forehead from thinking so hard' (2000: 25). In the UK, Carol Vorderman from *Countdown* appeared occasionally as the sole representative of a female mathematician. The image portrayed, as with the scientists, is not a good one and inevitably reflects society's view. When asked about the employment of mathematicians, calculating taxes or working in a bank were suggested. Some suggested that teachers may be mathematicians and the drawings reflect this, but they did not generally consider their own teacher as such. It would seem from the study that many young people hold a negative view of mathematicians and feel far removed from those people they perceive as mathematical. Other studies have been undertaken in Finland, Germany and Romania which have generated very similar findings.

In recent years mathematicians have featured in major films: *A Beautiful Mind, Good Will Hunting* and *Pi* present three distinct images of mathematicians. Even so, these figures are all men and each suffers from one form of instability or another. These too are hardly strengthening the mathematical image.

As teachers of mathematics we need to avoid perpetuating a negative image of mathematics and mathematicians. Despite any earlier experiences we may have had in our own school careers which discouraged us or made us doubt our own abilities, it is important we do not demonstrate these feeling to the children we are working with. Society often reflects these negative feelings towards mathematics; it is socially acceptable, even funny, to acknowledge that you are not good at maths in a way that you would not dream of saying about other subjects. Our attitudes to different subjects are strongly influenced by our parents and our teachers. We can all remember enjoying a particular subject because we could relate to the teacher or because they made their subject interesting through their own enthusiasm for it. It is important then to portray a positive approach to mathematics which will be infectious to the children you are working with.

The following case study shows the value of putting mathematics in an exciting context and making the objectives accessible to the children.

Case study 1.1 Anne Marie Goode: Choosing a suitable context for mathematics

In groups of three, the children were asked, firstly, how many skittles there were (ten), secondly, to tell me what number was printed on each skittle (randomly), and then to set the skittles up in the way they thought would allow them to knock over the most skittles at one time. They then took turns to roll the ball and knock some of the skittles over, which brought us to the main aim of the activity. The children would count how many skittles they had knocked down and then how many were left standing, thus leading them to the conclusion that, for example, 'ten take away four leaves six'.

With closed questions, such as, 'How many are knocked over/left standing?' some of the children needed to count the skittles individually each time to give me an answer, while others remembered the calculation from a previous turn. A few of the children could sometimes tell me the calculation without counting the skittles from previously learned facts. For example, J told me that $10 - 5 = 5$ without even looking at the skittles. When I asked him how he knew that, he answered, matter of factly, 'because $5 + 5 = 10$'. He already was inverting addition and subtraction. R told me she had nine left standing when she knocked one down, 'because 9 is one less than 10'. Nevertheless, the closed questions did seem to convey a somewhat limited response.

The open-ended questions on the other hand led to some very interesting discussions. Although a few of the children were quite vague with their answers – for example, when one child was asked how she knew a particular answer, her reply was 'I just know' – the majority of them were happy to elaborate and get involved in a discussion. The open-ended questions allowed the children to hear other points of view and explanations and ultimately learn from each other's responses and strategies.

With a different group of children I used an activity from the National Numeracy Strategy's Springboard 3 programme. This game appeared to have a very positive impact on the children's comprehension of the place value concept. Throughout the activity the children and I maintained a constant conversation pertaining to the task and the methods used to complete it. I also asked a range of open-ended questions which were recommended in the programme, for example 'How do you know which is the largest and which is the smallest number?' or 'How do you know that the numbers are in the correct order?' The children took great delight in answering the questions correctly and, depending on how the questions were delivered, it appeared at times as though they were actually telling or teaching me something. I feel that this strategy works wonders for raising the self-esteem of these children, who in a whole-class session will not answer for fear of being wrong and therefore humiliated in front of their peers.

TASK 1.4

HLTA 3.2.2 Monitor pupils' responses to learning tasks and modify approach accordingly.

Reflect on the strategies employed in this activity. Identify those which helped to make this a positive and accessible experience for the children. See Appendix 1 for further comments.

The National Numeracy Strategy

The National Numeracy Strategy (NNS) was introduced into English primary schools in September 1999, following a period of individualised learning in the 1970s and 1980s, when many resources were published that were aimed at children working at their own rate. The view was generally held that children would benefit from an almost individual programme and that this approach offered differentiation. While children were working on these schemes, there was little direct teaching and many children were not able to progress as the materials were not at a suitable level. Although there were guidelines already in place in the form of the National Curriculum (DFE, 1995), there was seen to be a need to give schools more specific guidance. The 'Three Wise Men' report (Alexander et al., 1992) proposed that more whole-class teaching would be effective, rather than individual teaching and the use of published mathematics schemes which were favoured by many schools. In the Trends in International Mathematics and Science Study (TIMSS) for 1995, ten-year-old children in England were found to be performing at a lower level than those in many other countries, especially those in the Pacific Rim. This difference was particularly apparent in areas of mathematics such as mental arithmetic and basic number skills (Mullis et al., 1998). These all contributed to the formation of the National Numeracy Project which evolved into the National Numeracy Strategy.

While the framework of the NNS was not statutory, there was strong pressure for schools to adopt the guidelines as this would be a focus of OfSTED inspections. The NNS framework made specific recommendations to schools. The opening paragraph of the section titled '*Teaching Mathematics*' gives a broad overview. The approach to teaching recommended by the NNS is based on four key principles:

- dedicated mathematics lessons every day;
- direct teaching and interactive oral work with the whole class and groups;
- an emphasis on mental calculation;
- controlled differentiation, with all pupils engaged in mathematics related to a common theme.

(DfEE, 1999: 11)

These principles can be seen to be a direct result of the reports mentioned above and the findings of the first series of OfSTED reports, where elements of good practice in primary schools were identified and incorporated into the guidelines.

The introduction of the National Numeracy Strategy has raised the profile of mathematics in the primary school and has raised the standards in most aspects of mathematics. In the TIMSS report for 2004, England was acknowledged as one of six countries which have made a significant improvement since 1995; the report considers the progress of English ten-year-olds who now appear 36 points above the international average (Mullis et al., 2004: 212) compared to 16 points below in 1995. However, the strategy is being reviewed in 2006 in order to continue to raise standards. Methods and resources for teaching and learning mathematics continue to develop and it is important for those who are working with children to keep abreast of developments in mathematics, such as the use of ICT.

Mathematics in the age of technology

It is tempting to think that it is no longer necessary to teach mathematics to the same degree in the present technological age, where calculators and computers can calculate so quickly and accurately. However, it is probably more important to have a confident level of understanding in mathematics in order to function successfully in today's society. The place of calculators will be discussed in Chapter 3.

Computers have been used in British primary schools for approximately thirty years. Changes in equipment and programs available are rapid and many children are already familiar with the use of PCs, as a high proportion of families have a computer at home. In recent years the use of interactive whiteboards, laptops and stand-alone PCs, as well as digital photography and many other resources, has increased in the primary school.

There is a huge range of resources available commercially. As with all resources these need to be selected with care to ensure they are of an appropriate level, are suitably engaging and are value for money. They are rather variable in quality. There are many excellent web-based materials which can be used effectively with an interactive whiteboard. The Interactive Teaching Programs (ITPs), available on the Primary National Strategy website, are particularly effective and are linked to specific learning objectives. These are particularly designed to support the daily mathematics lesson, enabling the teacher or teaching assistant to give a focused input. The use of the interactive whiteboard means that all children can be involved and individuals can interact directly with the program, providing a teaching and learning opportunity. Many of these are very adaptable and can be used in an open-ended way.

Effective use of ICT in the teaching of mathematics has been reported by OfSTED and HMI (cited in Moseley et al., 1999). They suggest that using ICT as a demonstration and as a modelling tool with the whole class is particularly effective. A variety of working methods are also appropriate: focused small-group work perhaps with a teaching assistant; work with the whole class working in pairs in computer suites in order to practise skills modelled by the teacher. ICT is already used widely across the curriculum and its use is likely to increase. However, it is important to remember that ICT should be used to support the teaching and learning of a specific learning objective and should not be used for the sake of it.

TASK 1.5

HLTA 2.4 Know how to use ICT to advance pupils' learning, and use common ICT tools for your own and pupils' benefit.

Make a list of the ICT resources (equipment and programs) that your school uses to support mathematics. What mathematical concepts are addressed? What are the advantages of using ICT instead of another method?

Key Points

- Mathematics is an essential life skill.
- Presenting a positive attitude towards mathematics promotes more effective learning.
- The use of appropriate ICT resources can be a powerful tool for enhancing learning.

Reflections

What are your experiences of mathematics?

How will you portray a positive image of mathematics to the children?

Do you need to develop your confidence in using ICT to support mathematics?