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CROSS-CURRICULAR TEACHING

Mathematics at the heart of the curriculum?

An approach to primary education that involves cross-curricular study has been regarded by some people as a matter of fashion. The introduction of the National Curriculum led many schools to focus on single-subject teaching, but, as both the Rose Review (Rose 2009) and the Cambridge Primary Review (Alexander 2010) affirm, curriculum areas or subjects need not shape the way in which teaching is organised. Both reviews maintain mathematics as an identified subject area or domain, but highlight the importance of cross-curricular studies. As Rose (2009: 25) suggests:

There are times when it is right to marshal content from different subjects into well-planned, cross-curricular studies. This is not only because it helps children to better understand ideas about such important matters as citizenship, sustainable development, financial capability and health and wellbeing, but also because it provides opportunities across the curriculum for them to use and apply what they have learned from the discrete teaching of subjects.

Rose adds that: 'This approach respects the integrity of subjects but lessens the rigidity of their boundaries. Among other things it encourages children and teachers to think creatively "outside subject boxes"' (Rose 2009: 28).

We would go further. Children learn mathematical (and other) skills best at the time when they need to use them in meaningful, relevant and real contexts. Mathematics teaching and learning being based on cross-curricular activity creates opportunities to set mathematical ideas and concepts in an environment where they have real purpose, relevance and meaning. If mathematics is placed in the context of other areas of learning, children's understanding is enriched, challenged and affirmed. Just as talking about mathematics is more challenging than just hearing about it (see Chapter 4), so applying mathematics in a variety of contexts ensures that understanding is heightened and knowledge is made more secure.

In order to leave *Mathsland* behind (see Chapter 3), teachers must address what Rose terms those 'important matters' and allow mathematics education to become part of the

real world. This can best be done by exploring with children what the applications of mathematics are in their everyday lives. If mathematics is to become a more creative subject, it must break through those 'subject boxes'. All too often, teachers are happy to integrate the teaching of history and art, for example, but lack the confidence to break free from what Boaler (2009) terms the *ladder of rules*, which rule mathematics. Of course, there must be room for both discrete and integrated teaching, but, at the moment, the pedagogy for mathematics is somewhat skewed in favour of the former.

In this chapter, we will consider, broadly in line with the recommendations of the Rose Review (2009), five areas of the curriculum (omitting, for obvious reasons, mathematics). This will include consideration of the role of ICT in supporting children's mathematical understanding across the curriculum. We think there is much merit in Alexander's (2010) suggestion that ICT should be seen as part of communication. However, in this chapter, it is largely considered, in line with Rose (2009), as part of scientific and technological understanding. Although neither document has informed the latest National Curriculum in England, the approach they suggest continues to have merit for approaching mathematics creatively.

UNDERSTANDING COMMUNICATION

The Cambridge Primary Review (Alexander 2010) refers to this domain as 'language, oracy and literacy' and suggests, as indicated above, that ICT should, in the main, be linked to communication. Under what Rose (2009: 76) terms 'essentials for learning and life', he lists four areas of mathematical understanding. Of these, three are directly about communication:

- 1 Represent and model situations in mathematics, using a range of tools and applying logic and reasoning in order to predict, plan and try out options.
- 2 Interpret and interrogate mathematical data in graphs, spreadsheets and diagrams, in order to draw inferences, recognise patterns and trends, and assess likelihood and risk.
- 3 Use mathematics to justify and support decisions and proposals, communicating accurately with mathematical language and conventions, symbols and diagrams.

Ideas such as representing, interpreting and interrogating, justifying and communicating are clearly important elements in this domain, and ICT has an important role to play in this respect. The role of oracy, including drama, in supporting and developing mathematical understanding is a key strand of this book. Language was explored specifically in Chapter 4, and the role of story and dramatic play was considered in Chapter 6.

It has become popular to think of literacy in much broader terms than merely being able to read and write (Kress 2003; Bearne and Wolstencraft 2007; Marsh and Hallet 2008). Kress (2003: 1) suggests that current changes in the literacy needed by today's children will have 'political, economic, social, cultural, conceptual/cognitive and epistemological consequences'. He is not alone in this view. Bearne and Wolstencraft (2007: 2) argue that conventional approaches to literacy are not sufficient for the needs of tomorrow's citizens:

Texts that children are familiar with – including computer games and hypertext – often follow a different structure from sequential narrative, instruction and

explanation. Presentational software and websites extend possibilities for hypertextual composition, and digital technology, with its facility for importing pictures and manipulating text, means that presentation of writing can be more varied, involving design features that paper-based writing does not allow.

Talk of visual literacy or computer literacy is commonplace. Emotional literacy has become a household term, and, in Chapter 1, we cited the OECD's use of the term 'mathematical literacy'. This argues for an approach to mathematics that goes way beyond structured, desk- (or carpet-) bound activities. It requires a full understanding of and engagement in mathematics, and this will undoubtedly require integration into other subject areas or domains.

Data handling as communication

Clements (2004: 56) highlights data handling as a means of communication – finding ways to communicate what the data mean. He writes that, 'Data analysis contains one big idea: classifying, organising, representing and using information to ask and answer questions.' He continues by suggesting that:

After gathering data to answer questions, children's initial representations often do not use categories. Their interest in data is in the particulars . . . For example, they might simply list each child in their class and each child's response to a question. They then learn to classify these responses and represent data according to category.

By these means, they develop ways of getting data to 'speak' to them. A simple example of this might be a survey about children's means of getting to school. In the early stages, children will simply list names and write or draw beside them 'bus', 'car', 'walking' etc. Over time, they learn to cluster the names under a picture of a bus, for example. Gradually, the children can be represented by a block or plastic cube – the representation gradually being made more abstract, using picture graphs or bar graphs. This process involves written, spoken, graphic and digital representation, which in turn communicates in a range of ways. There are also many new and exciting approaches to the presentation of statistical and mathematical data that may inspire children (see, for example, McCandless 2012, 2014).

The role of drama

Kress (2003) compares a print-bound world with the world of today, in which, he believes, images hold sway. He terms these 'world-told' and 'world-shown' perspectives. However, drama (which is inextricably linked to narrative) has a particular role to play. Rose (2009: 27) identifies drama as 'a powerful arts subject which also enhances children's language development . . . [and] enrich[es], say, historical and religious studies as well as personal development by exploring concepts such as empathy'.

Although this is undoubtedly true, such a view limits unnecessarily the impact that drama can and does have. It fails to take account of the powerful role that drama has in bringing together the 'world-told' and 'world-shown'. Acting out a story both tells and shows, but it does more than that. It gives insight into what might be, by drawing on imagination. In so doing, it promotes the conjectural thinking essential to creativity and

problem solving, including mathematical problem solving. Listening to a story, with or without images or props, requires imagination – as does drama. The actor has to imagine that he or she is someone else, somewhere else, in another time, in different circumstances. The audience must imagine that a white umbrella is a swan, that someone wearing roller skates is a train, or that a crate with a cloth thrown over it is a house, a cave or a palace.

As we saw in Chapter 1, imagination is part of the mathematical process. It is the bedrock of the abstract thought that is essential to mathematical understanding. It is also where creativity enters the world of literacy (and literature) and, with cross-curricular studies, can also inform and enter the world of mathematics. In the case study that follows, the teacher of a Year 4 class that had had difficulty tuning into fractions created a story, which they acted out.

MATHS FOCUS **FARMING FOR FRACTIONS**

- Problem solving
- Fractions
- Division

Scenario

A wise old farmer decides he is going to take a long holiday and gives responsibility for managing the farm (consisting of one fruit field and one vegetable field) to his two sons. The brothers decided to take a field each and to grow two crops in each field.

A seed seller arrives and tells the brothers that, if they buy seeds from her, they will grow twice as many crops. A week later, she returns with new seeds that will help the brothers grow twice as many crops again. The brothers are now growing eight different crops each. Getting fed up with his field, the older brother asks his sibling if he can have a quarter of the fruit crops, in return for one-eighth of his vegetables. The younger brother agrees, and they rebuild the fences between the farm.

The younger brother is happy until he realises that he has fewer crops. They agree to swap again: half of the younger brother's field for two-eighths in return. As soon as the fields are divided, they begin arguing again. When their father returns, he is angry that his sons have not been able to manage the farm without arguing. As a final test, he gives the brothers twenty-four animals to divide fairly: twelve cows, six pigs, three horses and three sheep. But what is the best way to do it?

Exploration

- 1 The children are invited to act the story out, marking the fields and the dividing fences with masking tape, string or playground chalk (if working outdoors).
- 2 As the fences between the fields change, marker pens, coloured string or coloured chalk are introduced to differentiate the new boundaries.

Outcomes

- Bringing fractions to life on a large scale can really help to engage children in exploring mathematical ideas. No longer does maths need to be an activity where children sit at their desks dividing circles with pencil lines.

continued . . .

MATHS FOCUS **FARMING FOR FRACTIONS** . . . *continued*

- Although working with smaller numbers sometimes helps children to understand or solve number problems in particular (see Chapter 3), many problems can best be understood by working on this larger scale. This gives children more scope for physical action and alternative 'ways of knowing'.

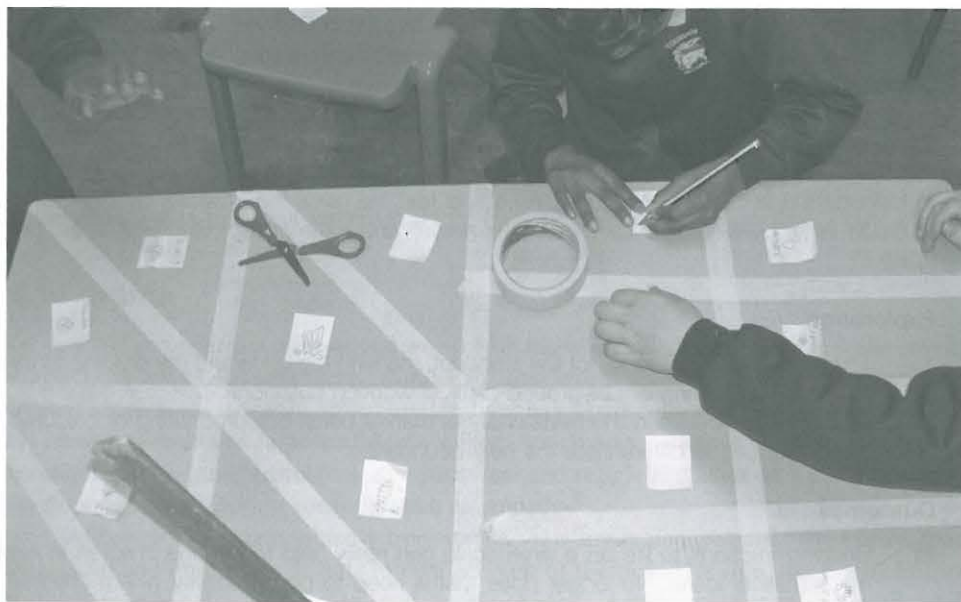
Quote from evaluations

I was so inspired by the INSET and the idea of teaching maths through story-telling that I was determined to create a story to help my Year 4 class who were struggling with fractions. Once I got the idea it didn't take me that long to work into a lesson plan, but I have never had so much fun in a maths lesson. The children really enjoyed it too and they really got it. This is a powerful approach that I will definitely use in the future. I just need to think of a story to explain multiplication next.

(Year 4 teacher who created Farming for Fractions)

Further information

We have found that, by bringing fractions to life in this way, we are able to engage children in more complicated mathematics than the curriculum would dictate for their age group. Year 2 pupils working on a similar division exercise were engaged in dividing up an island equally between everyone who staked a claim in it. These young children were able to consider how they might have one-thirty-second of the island. All of this took place on a large piece of lino shaped like an island and involved lots of discussion on how to divide equally.



■ **Figure 8.1** Children attempt to divide fields accurately and fairly as part of their work on Farming for Fractions

SCIENTIFIC AND TECHNOLOGICAL UNDERSTANDING

In general, it is clear that science and design and technology are the application of mathematics. The data that are collected from a scientific investigation often involve numbers. Their analysis may require pattern identification, and the results will need to be presented in a way that is meaningful to an audience. Making something often involves accurate measurement, as well as problem-identification and problem-solving strategies. The draft programme of learning (Rose 2009: 175) for scientific and technological understanding states that this area of learning:

provides purposeful contexts for children to develop and apply mathematical skills, in particular number, measurement, graphing, data handling, interpolation and extrapolation and costing their own products. Children can develop their ICT skills by using ICT for capturing, organising and analysing data and presenting results; and for sequencing instructions to control events and products.

The exciting thing about the cross-curricular studies that are proposed here is that the integrity of the mathematics and the other subjects involved is maintained. In order to do real science, you have to use real mathematics. In order to design and make something real and worthwhile, functional and aesthetic, you have to use real mathematics. Construction will be explored further in Chapter 10, but it is an important aspect of cross-curricular activity, with a great deal to contribute to mathematical understanding.

A Sussex school undertook a food technology exercise. Children sought out recipes and cooked and sold cakes and biscuits. This involved:

- sourcing recipes that would not be too expensive;
- increasing recipes to make sufficient for sale;
- shopping for ingredients;
- counting, calculating, weighing and measuring to make the items;
- estimating a price that would be acceptable to the buyers but would still provide some profit.

Over time and through discussion and investigation, they modified their approach. They decided to sell some fruit and vegetables, as a healthy option, and they undertook surveys to determine what kinds of cake and biscuit were most popular. Most of this work relied on mathematical understanding, but, when they were carrying it out, mathematical understanding was enhanced because there was a context. The work was real, with tangible outcomes and benefits.

Similarly, work in Years 5 and 6 on scientific enquiry requires mathematical understanding and application. Planning the enquiry involves problem-finding as well as problem-solving strategies. Gathering data, explaining results and considering evidence all involve mathematics. This is, by its nature, a cross-curricular area of study.

ICT

It is beyond doubt that mathematics and ICT have many close links. Programmable toys such as Bee-Bot, Roamers and Pixies offer mathematical opportunities at different stages

of development and expertise. Multimodal work, based around sound, images and robotics, is both supported by and supports a great deal of mathematical thinking and understanding – time, planning, sequencing and so on.

With the development of new technologies, such as augmented-reality programs, the full potential to link ICT and mathematics has perhaps yet to be realised. Holding a card with a picture of a car on it in front of a computer fitted with augmented-reality programming will result in an image of yourself holding the paper, with a three-dimensional car in your hand. Touch a green box on the paper you are holding, and the car changes colour. Touch another box, and the car spins around. Another box activates the seat storage, and immediately you can see how much storage room there is in the car you are thinking of purchasing. (To view videos of augmented reality on your computer, visit <http://demos.t-immersion.com>)

Although the technology is in its relative infancy, augmented-reality software that explores geometry and allows pupils to examine three-dimensional images, from pieces of paper containing an outline of a shape, is already in existence, and this technology's capacity to create incredible new uses for ICT in the future promises to get greater. The reality of this is summed up in the powerful video short *Did You Know? 'We are living in exponential times'* (see YouTube: www.youtube.com/watch?v=IUMf7FWGdCw). The video suggests that technology is enabling us to become more global and states that, 'We are currently preparing students for jobs that don't yet exist, using technologies that haven't been invented yet, in order to solve problems we don't even know are problems yet'.

The programmes of study for computing in the National Curriculum (DfE 2013: 118) suggest that the aim of the subject should be to ensure that pupils:

- can understand and apply the fundamental principles and concepts of computer science, including abstraction, logic, algorithms and data representation;
- can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve such problems;
- can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems;
- are responsible, competent, confident and creative users of information and communication technology.

Problem solving and creativity are mentioned, but missing from this description is mention of 'modeling, visualization and real life experiences', which were felt, at the time of the Rose Review (2009), to be an important element of ICT. On a positive note, perhaps renewed emphasis on writing and debugging programs will reawaken interest in the work of Seymour Papert. Kafai and Burke (2014) highlight Papert's work and argue that programming computers enables children to learn to think mathematically, as well as giving them insight into their own learning. They add that this process may be aided by computerless approaches in which children learn about computing through games and puzzles involving card, string, pens and running around! This underlines the importance of a variety of modes of representation in all learning – perhaps particularly in relation to mathematics, as it is such an abstract subject.

Although *what* children should learn has generally been uncontentious, the emphasis on programming is not without critics (Reilly 2013). The *how* has been more contentious.

Alexander (2010: 269) challenges Rose's view (2009) that ICT should be seen as a 'skill for learning and life' and suggests that ICT is in danger of becoming 'a tool without apparent substance or challenge other than the technical'. He continues by arguing that ICT should be seen primarily as an aspect of communication. This, he suggests, would 'enable ... schools to balance and explore relationships between new and established forms of communication, and to ensure that the developmental and educational primacy of talk, which is now exceptionally well supported by research and evidence, is always maintained' (Alexander 2010: 270).

Alexander (2010) is by no means alone in urging caution. There is such a groundswell of popular support for more time and resources to be spent on technology that it may require some creative or 'out of the box' thinking to consider some alternative points of view.

Neuroscientist Susan Greenfield (2004, 2011) urges caution. Her evidence to the Cambridge Primary Review team is cited by Alexander (2010: 270). She warns that:

The mid-21st century mind might almost be infantilised, characterised by short attention span, sensationalism, inability to empathise and a shaky sense of identity ... If the young brain is exposed from the outset to a world of fast action and reaction, of instant new screen images flashing up with the press of a key, such rapid interchange might accustom the brain to operate over such timescales ... Real conversation in real time may eventually give way to these sanitised and easier screen dialogues ... It is hard to see how living this way on a daily basis will not result in brains, or rather minds, different from other generations.

More than a decade ago, Healy (1999) was voicing similar concerns about children's use of ICT. She argued that children need kinaesthetic activity and real-world experience. Over-reliance on technology will not build 'intelligent muscles'. It is all too easy to develop (and to choose or purchase) software that produces convergent rather than divergent thinking. This is particularly true in mathematics, where, as we have seen, there is already an over-dependence on the one-right-answer approach. Although some children may gain from some practice sessions with lists of sums, this can and should never replace practical experience and opportunities to discuss and justify answers, both to complex problems and to simple computations. The excitement of appearing to hold an apparently three-dimensional augmented-reality car (which moves and changes colour, as if by magic) in the palm of our hand should not persuade us that concrete practical experience is no longer necessary.

A third major area of concern, of which teachers concerned to address the need for a curriculum for the twenty-first century should be aware, is commercialism. Much software (and indeed hardware) relies on heavy and highly influential marketing. Twenty-first-century teaching should be alerting children to this manipulation of choice and decision-making. Blind and uncritical use of technological resources that involve such influences should be used with great caution. Although it may have many other applications, augmented-reality software, for example, is being developed for marketing purposes. When using ICT, we need to ensure that children have the critical powers to deal with market influences. Creative approaches to mathematics can give children the skills they need to identify problems, to categorise and to analyse.

HISTORICAL, GEOGRAPHICAL AND SOCIAL UNDERSTANDING

Alexander (2010) proposes some parallel but different domains of learning from those suggested by Rose (2009). These include citizenship and ethics, faith and belief, as well as place and time. Devlin has suggested that mathematics might be taught more successfully as an aspect of human culture – in which case, much of it could be subsumed into this domain of learning! (See Chapter 10 for more information on this topic.) Rose (2009: 167) suggests that cross-curricular studies involving both mathematics and this area of understanding might involve ‘creating timelines, using plans and maps and using data to analyse a real problem in the community’. The case study below develops mathematical understanding through the device of a Tudor market.

In Chapter 7, we considered the drama technique known as the Mantle of the Expert, which has enormous mathematical potential. As highlighted earlier in this chapter, Rose suggests that drama is helpful in developing historical understanding. In one history topic, pupils were put in MoE roles as placement checkers responsible for Second World War evacuation procedures from London to Essex. The pupils were involved in map-making of the village of Little Heddington, recreating the map in three-dimensional form from the information they had about the village. They also needed to create criteria for checking the people who had agreed to take evacuees, sort out which children should go to which houses and whether boys or girls would be more suitable for one house than another, and make sure that all the children had somewhere to go. Alongside this, pupils were engaged in a range of other activities, making decisions about people’s suitability to have an evacuee, writing their memories of the trip for a national newspaper and deciding on their values as a team with the responsible role of rehousing children.

Although this was essentially a history topic, through dramatic engagement, the pupils became involved in large amounts of mathematical thinking – including gathering and presenting data and problem solving. The process of turning language-based information into a three-dimensional image also has mathematical implications to do with distance, space, ratio and area.

UNDERSTANDING PHYSICAL DEVELOPMENT, HEALTH AND WELL-BEING

There are any number of mathematical applications arising from physical and fitness activities, either in competition with others or in improving personal performance. Similarly, a developing sense of well-being can be enhanced through the way in which mathematics is taught. A conjectural, problem-solving approach, collaboration and discussion can all help to enhance a child’s sense of self.

An understanding of the role of physical action in mathematical development is rarely considered, and yet brain studies show an increasing awareness of the interdependence between brain and body (Blakeslee and Blakeslee 2007). Dramatic mathematics, acting out mathematical scenarios and stories with a mathematical focus, can give children a different perspective. It offers an alternative ‘way of knowing’ (Claxton 1997). Gardner’s theory of multiple intelligences (1999) emphasises the interrelatedness of different intelligences. There is long-standing evidence of the impact of spatial awareness on

MATHS FOCUS TUDOR MARKET

- *Fractions and percentages*: all the special-offer labels require groups to work out the new price of the goods they are purchasing and selling
- *Problem solving and strategic thinking*: creating a scenario where there is no right or wrong approach, and where pupils need to think about how cheaply to sell their goods to encourage buyers, but also consider how not to make a loss

Scenario

The Lord of the Manor is holding a competition to find the most enterprising stall owners in the land and he invites the children to set up their stalls, create a name for their shop and price their goods so as to attract the most buyers. He announces that there will be a prize for the person who earns the most money.

Exploration

- 1 The children are divided into groups and given an area of the room in which to set up their market stall. Each stall sells exactly the same products as the other.
- 2 The products are the types of thing you would see in Tudor times: a pig’s head, a cup and ball etc. All the prices the children are given to sell the goods at are in Tudor crowns, and they are exactly the same price for each group.
- 3 Each group is then given the same number of special-offer labels, which enable them to reduce the price of some of their goods. The labels can state that this item is half-price, or has a 20 per cent discount etc.
- 4 The groups have to decide in secret which items to apply the discounts to. Do they place it on the item that is the most expensive, or will that mean that they will lose potential income on a sale? When they have decided, they place their discount cards and reveal their stall to the rest of the room.
- 5 Each group is given a shopping list of items it must purchase from other stalls and has time to wander around to find the best deals. Lists are kept of who purchases what from whom, and, at the end of the first round, the amount of money made by each stall holder is noted.
- 6 The pupils then have time to discuss if they need to change which items they discount for the second round.

Outcomes

Often, pupils try to sell the most expensive items without a discount, but the group that first takes the risk of lowering the price of this item soon discovers that more people want to shop from them.

Quote from evaluations

The children really enjoyed this sophisticated version of playing shop, and began to get more and more tactical with each round.

(Year 5 teacher)

Further information

This idea can be adapted to fit any period in history. A Roman market would have the added benefit of providing a context for learning about Roman numerals, as required at Key Stage 2. It is also possible to extend the approach to explore enterprise education in a modern-day context.



■ **Figure 8.2** Children explore mathematics in a Roman market, examining coins and merchandise

mathematical understanding (Clements 2004) – the numerical aspects, as well as those more expected elements concerning shape, space and measures.

Kinaesthetic mathematics

Mathematical ideas can be explored kinaesthetically as part of a more physical approach to the subject. Simple techniques of throwing balls around the class to get answers to different mental-maths problems can generate urgency and speed that add a dimension of fun. Standing all the children in two lines and getting them to pass a clap as fast as they can, from the front of the line to the back, and then changing this to calling out the numbers of one of the times tables, one at a time, from the front of the line to the back, can add a different dynamic that can put the fun back into lessons for children who need a more physical approach. This team approach often results in children supporting each other in remembering which answer they have to call out and, played regularly, can help to remind children of their tables.

Table 8.1 is an example of a physical response to learning number properties that was developed by MakeBelieve Arts as a revision exercise for Year 6 pupils. The chart was written on the board, and various numbers were called out to the class. As soon as the pupils heard the numbers, they needed to respond with all of the appropriate actions that the specific number required.

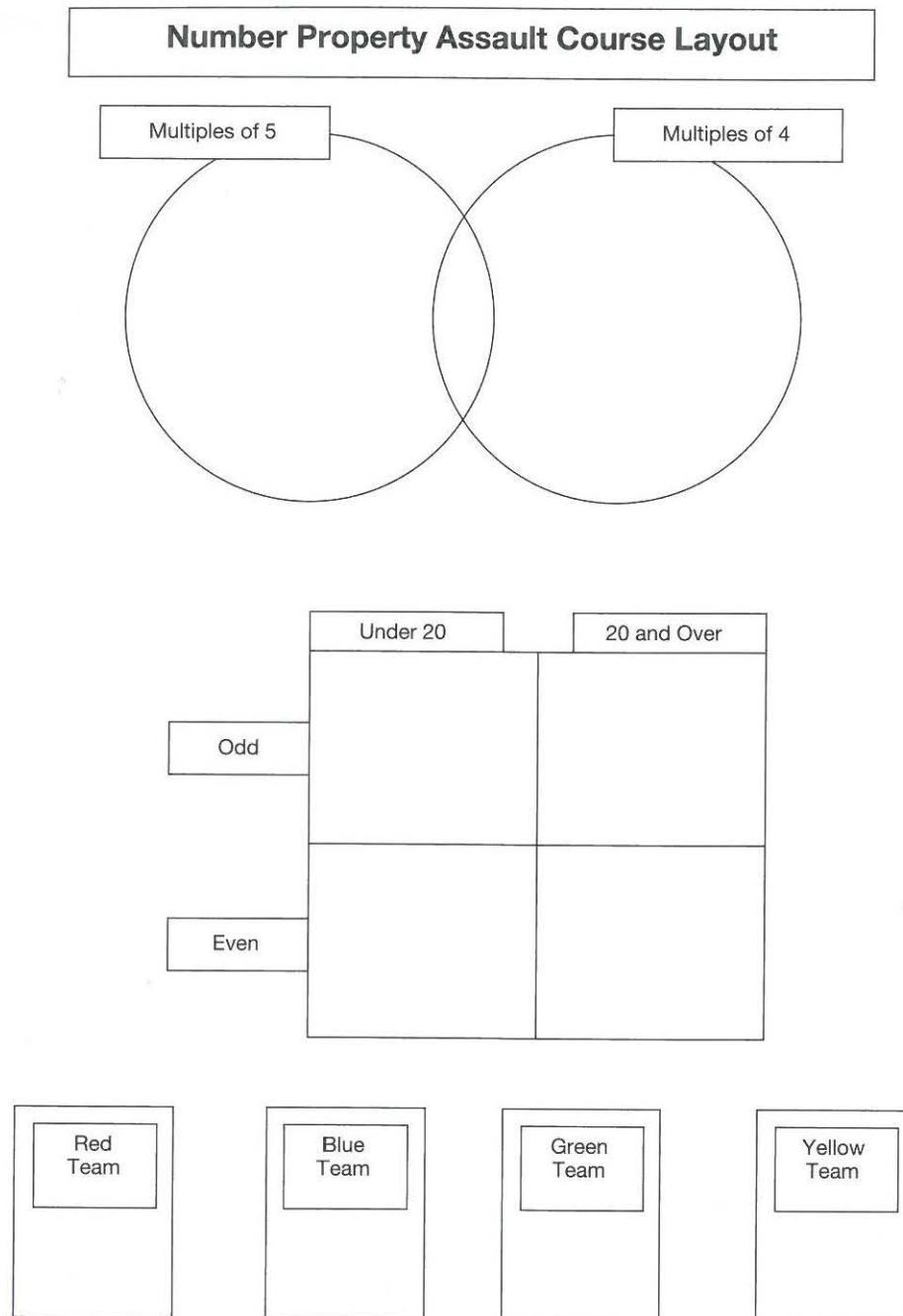
For example, if the number 80 was called out, the class responded by rolling their hand, raising their left arm and then raising their right arm and finally by standing up. On the other hand, the number 29 would only get a clap and an oooh.

Inviting a class to create physical shapes for plus, minus, equal, division and multiplication can be used to solve simple sums written on the board that are missing the signs necessary for them to make sense. Thus, presenting children with three numbers, such as 3, 6 and 18, would involve them in adding the movements for multiply and equals.

Another example of this type of work, developed by MakeBelieve Arts, was the creation of a number property assault course (see Figure 8.3), where Venn and Carroll diagrams were used in a relay race to engage children in answering sums, finding the answer in a Carroll diagram, where numbers were sorted into odds and evens, under 20 and over 20, and then running with the number to a Venn diagram taped out on the floor. On arriving at the Venn diagram, pupils had to place the number in the correct circle according to whether it was a multiple of 10, 4, both or neither.

■ **Table 8.1** Example of a physical response to learning number properties

Even	Roll your hand
Odd	Clap
Multiple of 5	Raise left arm
Multiple of 8	Raise right arm
Multiple of 10	Stand up
Prime number	Say oooh



■ **Figure 8.3** Number property assault course layout

The following comments are taken from students' evaluations of their kinaesthetic work on mathematics:

- 'People think because it is maths you can just sit down and listen and we need it to be more interactive. We learned so much more when we had the chance to get up and try things out' (Year 7 pupil, on a kinaesthetic maths lesson).
- 'Most of the time maths is boring. I like moving and learning and we don't do any of it, if we could learn maths through PE lessons it would be much more fun' (Year 6 pupil).
- 'I still remember the (physical) sign we made up for divide. It was really cool. I learned which way you do brackets and multiplication and I still remember it' (Year 6 pupil).

These young people are clear about the benefits of physical action to their learning. However, one of the difficulties that faces teachers is the perception of others. Sometimes, the children themselves are resistant to change and, following some kind of practical maths session, will ask, 'When are we going to do our maths?'. This may be because working with pencil and paper feels safe and secure, but it may also be because children know that their parents recognise what they are doing, as they are seated at a table, as mathematics. It may also be because they perceive the ambivalent attitudes of teaching and support staff themselves.

UNDERSTANDING THE ARTS

There is often confusion between the creative arts and creativity. Central to this book, and to the series, is the idea that the arts do not have a monopoly on creativity. However, the creative arts do have a particular role to play in creative mathematics. The role of story and drama has already been considered, but these and other forms of art all have a symbolic function. Pound (2008, 82) writes:

Stories – whether published, told by children or created by adults – can be developed in a number of ways. The telling and retelling of stories may involve dramatic play (both formal and informal; large scale role-play or involving small world figures), music and dance, paintings and drawings, models and sculptures. The process of translating ideas from one creative medium to another supports children's thinking.

As we have seen, mathematics is an abstract subject. This means that it requires symbolic underpinning – a means by which we can think about it. This may be provided through imagination – dramatic play and exploration of story, and these aspects are addressed in Chapter 6. It may come about through discussion and collaboration, as we saw in Chapter 4, but it is essential if children are to fully understand mathematics, exploring ideas and concepts creatively (Devlin 2000; du Sautoy 2004).

Music and mathematics are closely linked (du Sautoy 2004), and this will be explored more fully in Chapter 11. Brandt (2009) describes music as time in the mind, and du Sautoy (2004) suggests that music is internalised counting. Music – songs and rhymes – also creates representations of numbers in counting games and songs, rendering the number names

more memorable. The government initiative Sing-up (www.singup.org) advocates singing as a fun way to teach maths!

Both two-dimensional and three-dimensional art activities develop children's mathematical understanding in many ways. Three-dimensional art will be explored further in Chapter 10. Drawing and play with three-dimensional figures and models can 'offer powerful tools for expressing complex ideas' (Anning and Ring 2004: 117). Anning and Ring (2004) go on to emphasise the narrative thread that runs through both forms of play, as children explore and seek to understand the world, including the mathematical world.

We cannot, however, leave this aspect of cross-curricular work without thinking about the mathematics involved in Vasconcelos's giant model, made from saucepans and lids, of Marilyn Monroe's shoes (see www.christies.com/LotFinder/lot_details.aspx?intObjectID=5289859). They measure approximately 3 × 4 metres – and are stunning and exciting. There are many other sculptures and models that offer similar mathematical stimulation, such as Italian artist Neri's 10-metre-high table and chair. (For discussion of the world's largest chair, see www.roadsideamerica.com/set/CIVIchair.html)

The importance of mark-making

Worthington and Carruthers (2006) advocate an approach to young children's mathematical mark-making that they describe as 'bi-numerate'. By this, they mean that children don't just have to learn to represent ideas in oral language, but have to develop an understanding of the way in which mathematical ideas can be represented in secondary symbols. Teachers can support this process by understanding 'the importance . . . of translating from one language (or creative medium) to another. Representing (or re-presenting) ideas verbally, graphically, in imaginative play or block-building enables children to think and re-think their ideas' (Pound 2008: 85).

The government document entitled *Mark Making Matters* (DCSF 2008) also focuses on the importance of young children's graphic representations, highlighting the importance of encouraging

children's mathematical mark-making (which) often arises spontaneously through a need to communicate in a meaningful context. Through their marks, children's thinking becomes visible and practitioners then gain valuable insights into their developing understanding of complex concepts. When children are asked to record, after they have finished a practical mathematics activity, motivation and meaning are often lost. Recording may then lack in-depth quality of thinking and is more like copying. Children's mathematical graphics are their own personal response to meaning making and involve deep levels of thinking. It is important that children make links between the spoken and written representations.

(DCSF 2008: 42)

Hughes's (1986) findings that many children at the end of primary school still did not know how to use symbols mathematically lies behind this emphasis on mathematical mark-making. The children had been taught to use symbols, but not to apply them to practical situations. Although the programme of study (DfE 2013) for maths in Year 1 places greater emphasis on an earlier introduction of numbers up to 100, this stage of

experimentation with symbolic forms should not be rushed, as it is where the foundation of understanding and using conventional symbolic forms lies.

Matthews (2003: 1) underlines the way in which children use anything and everything to symbolise their thinking:

Drawing especially helps the child's understanding of symbols, and signs and representation, understanding which will become crucial in her encounters with symbol and sign systems in home and school, and in the expanded world of literacy she will enter when she leaves school. This means that, in actions they can make with their own bodies, and in actions they can perform upon objects and media, but perhaps especially with drawing and painting media, children learn how to form representations, symbols and signs. This forms the basis for all thinking. If you think this through, this means that, far from being at the periphery of education . . . art has a central role to play in cognitive development. To think otherwise is a 'fundamental misconception'.

ICT, narrative and symbolism

'Digital literacy' (Marsh 2005) also involves children in symbolism and narrative. Smith (2005: 111) considers both 'play at the computer' and 'the use of computers for play'. In the first, she suggests, the development of play is similar to that with any other materials or equipment. She also suggests that computer use supports what she terms 'abstract transformation' (citing Vygotsky). Smith continues, 'the ability to use and understand symbolic representations in one context can then be transferred to another context' (2005: 114).

In relation to the use of computers as props for office, space travel or home play, Smith cites research (2005, citing Labbo *et al.*) that suggests that, 'using the computer as a prop at play centers [*sic*; meaning areas of provision rather than a setting] resulted in expanded symbol use, keyboarding skills, understanding of computer processes, and increased vocabulary' (Smith 2005: 111).

One important way of countering any harm that might come from the use of digital images is the growing and exciting practice of enabling children to make their own videos. Software currently available puts this well within the reach of children as young as 3 years of age. Nixon and Comber (2005) describe video-making with young children using video footage of the children themselves, but perhaps even more exciting is the production of animated sequences using soft toys, plasticine figures or Lego constructions. These have the advantage of demonstrating to young children how these visual representations are actually made. This, in turn, gives a great sense of empowerment.

Uptis *et al.* (1997) describe a relatively low-tech version in which a group of 8- and 9-year-olds create an animated film. The authors highlight the 'visual, mathematical, and musical potential' of the activity, but indicate that of even more importance is the memorable experience itself and the impact it will have on their mathematical experiences later. They write:

Where do ideas about rates of change, velocity, rotations, cycles and continuity (involved in trigonometry and calculus) come from? . . . In this animation project,

they have begun to grapple with a particularly fertile situation: one of a large number of 'real-world' situations where these ideas are fundamental.

(Upitis *et al.* 1997: 77)

IS IT CROSS-CURRICULAR?

There have, in the past, been many criticisms of cross-curricular work. As Upitis *et al.* (1997) remind us, it involves much more than doing sums on pumpkin-shaped paper because it's Halloween. Such an approach adds nothing, only detracts from mathematics, art and cultural understanding. They suggest that a truly integrated curriculum involves fluid movement from one area to another. Language, biology, ICT and mathematics were all involved in the animation project – learning in all these areas was enhanced through integrated and creative teaching.

CONCLUSION

Cross-curricular work is often regarded as being less challenging or meaningful than straightforward mathematics sessions. Although a possibility, this need not be the case, and integrated studies can help understanding and challenge thinking by providing a context for mathematical development. All areas of the curriculum are connected to mathematics, because mathematics is one of the ways in which we make sense of our world.

However, it may be important to remind ourselves of the role that feelings and emotions play in mathematical achievement (see Chapter 2) and to single out the following:

- Communication: As we saw in Chapter 4, talking about mathematics is of vital importance in developing understanding of mathematical concepts.
- The arts: They provide mechanisms for representing mathematical ideas and thus promote mathematical thinking.
- Physical development: It is easy to forget what an important part physical action plays in thinking. Mathematics is an abstract subject – the more ways that can be found to represent it, the better. We should also remember that good spatial awareness supports both spatial and numerical aspects of the subject.

FURTHER READING

- Anning, A. and Ring, C. (2004) *Making Sense of Children's Drawings*. Maidenhead, UK: Open University Press.
- Sedgwick, F. (2002) *Enabling Children's Learning Through Drawing*. London: David Fulton.
- Upitis, R., Phillips, E. and Higginson, W. (1997) *Creative Mathematics*. London: Routledge (see Chapter 3).

CHILDREN'S BOOKS

- Fox, D. (1998) *People at Work: Making a film*. London: Evans.
- Wenzel, A. (2010) *13 Sculptures Children Should Know*. London: Prestel.