Investigation (Enquiry)

DEFINITION

Investigation (or enquiry) in mathematics is understood in this entry to refer to a task given to pupils that uses mathematics and which to varying degrees gives the pupils the opportunity to pose their own questions, to determine their own approaches, to make their own discoveries, and to articulate and communicate their findings to others.

EXPLANATION AND DISCUSSION

Mathematical investigation achieved particular prominence in school mathematics in the UK following the publication of the influential report of the Cockcroft Enquiry (Cockcroft, 1982). In its famous paragraph 243, the report listed six components that should be present in mathematics teaching at all levels: exposition by the teacher; discussion between teachers and pupils and between pupils themselves; appropriate practical work; consolidation and practice; problem solving; and investigational work. However, in giving such prominence to problem solving and investigational work, Cockcroft was doing no more than lending support to what was emerging in the 1970s and 1980s as good practice in mathematics teaching. This was characterized by less of an emphasis on didactic teaching of routine processes and more of an emphasis on encouraging pupils to pose questions, to conjecture and to engage actively in developing strategies for solving problems. Following the Cockcroft Report there was a flurry of activity and publications promoting the incorporation of investigations in the mathematics curriculum, both primary and secondary.

The introduction of the Numeracy Strategy framework (DfEE, 1999b) brought about a decline in the use of investigative approaches in primary mathematics classrooms in England. This was partly because the framework's yearly teaching programmes, which were adopted by many schools, left no scope for extended activities or anything other than focusing on specific objectives in terms of knowledge and skills. However, the review in 2006 of the National Strategy for primary

schools has clearly once again embedded investigational work (now called 'enquiry') in the primary school mathematics curriculum. Enquiry features as one of the five key themes within the *Using and Applying Mathematics* strand in the revised framework for primary school mathematics. The guidelines provided for this strand provide a positive slant on the experience of primary pupils involved in investigative mathematics: 'Learners are engaged by successful and exciting learning. They become involved in finding out for themselves, asking and answering questions, and sharing what they have discovered with others' (DfES, 2006b: 9).

Building on this description, we would suggest that the key components of successful mathematical investigations are that they provide opportunities for pupils to:

- engage with a task they find challenging, interesting, stimulating;
- pose their own questions about mathematical situations;
- plan their own approaches;
- use important mathematical skills and knowledge they have learnt already;
- make their own discoveries and experience the satisfaction of finding things out for themselves;
- articulate and communicate what they have found out to others;
- add to their developing understanding of mathematical concepts and relationships.

The DfES guidelines suggest that initially children will be given the questions to investigate by their teachers, but 'as they get more skilled at planning and organizing their strategies and thoughts, and more confident at sustaining such activity, new questions will arise. These can be gathered, discussed and refined, so that children can pursue those that appeal to them' (DfES, 2006b: 9).

The importance of using investigations in mathematics in primary schools is not just that they are enjoyable experiences, which will motivate pupils to engage with mathematics and which are likely to promote positive attitudes to the subject. Nor is it just that learning makes more impact on us when we have discovered something for ourselves. It is also that when engaged in investigations learners will have to go beyond just rote learning – relying on the use and application of algorithms, rules and routine procedures – to develop their own understanding of general relationships. Jaworski (2003: 2) argues that 'inquiry

or investigative methods in mathematics teaching are seen to fit with a constructivist view of knowledge and learning as they offer challenges to stimulate mathematical thinking and create opportunities for critical reflection on mathematical understanding'. To ensure that the experience of engaging in an investigation is worthwhile, it is essential therefore that teachers spend time with pupils after they have completed their enquiries, helping them to reflect on what they have discovered and to recognize what of all that they have been doing is significant and how it relates to other things they have previously learnt or experienced.

PRACTICAL EXAMPLES

Here are five examples of starting points for investigation by pupils at various stages in primary school. To varying degrees, each of these examples provides opportunities for pupils to frame their own questions, to determine their own approaches, and to make and articulate their own discoveries.

1. What things in the classroom can you find that are heavier than a pencil and lighter than a pair of scissors? Make up some other questions like this to investigate.
2. You have a box of sticks of different lengths: 4 cm, 6 cm, 8 cm, 10 cm and 12 cm. Close your eyes and pick up three sticks. Use them to form the three sides of a triangle. If you can …
3. Here's an interesting situation to explore! Meg and her father have the same birthday. This year it just happens that Meg's age is her father's age with the digits reversed. Meg wonders if this will ever happen again … or if it has ever happened before …
4. You have four sheets of paper of different sizes: A2, A3, A4 and A5. Find out as many interesting things as you can about these paper sizes and how they are related. What would you expect to find if you were given a sheet of A1 paper? Or A0 paper? Or A6 paper? Can you find any pieces of card or paper at school or at home that are A7 or A10? How would you know?
5. Figure 17 shows what happens when you write the sequence of numbers 5, 4, 3, 2, 1, over and over again in a grid with four squares in each row. Using squared paper, continue this for ten more rows. Then write down any interesting patterns that you notice in the ways the numbers are arranged. Investigate whether these patterns

5	4	3	2
1	5	4	3
2	1	5	4
3	2	1	5
4	3	2	1
5	4	3	2
1			

Figure 17 *What patterns do you notice?*

or other patterns occur for other sequences of numbers (such as 6, 5, 4, 3, 2, 1). Then, what about other numbers of squares in the rows of the grid? Can you explain why these patterns happen?

FURTHER READING

Burton (1984) provides a lively, challenging but practical guide to problem solving and investigational work in mathematics, with analysis of a number of examples of pupils engaging with mathematical enquiry. For a useful source of ideas for investigations see Thyer (1993). For those working with younger children, the approach advocated by Tucker (2005) incorporates many of the principles and features of investigative work described above. A key document in relation to mathematical enquiry is the guidance *Using and Applying Mathematics* in the National Strategy for primary schools in England (DfES, 2006b).