Making Connections

DEFINITION

Making connections in mathematics refers to the process in learning whereby the pupil constructs understanding of mathematical ideas through a growing awareness of relationships between concrete experiences, language, pictures and mathematical symbols. Understanding and mastery of mathematical material develops through the learner's organization of these relationships into networks of connections.

EXPLANATION AND DISCUSSION

Haylock and Cockburn (2003: 3–8) offer the model illustrated in Figure 18 as a simple way of discussing how children's understanding can be developed, particularly in relation to their understanding of number and arithmetic operations.

The model is based on the idea that the development of understanding involves making cognitive connections between some new material or some new experience and our existing ideas. If we cannot make connections then we have to resort to trying to learn by rote. The more connected are our experiences, the more secure and the more useful is the learning. Our understanding of complex mathematical concepts, such as subtraction, equality or place value, for example, can be conceived of as a process of gradually constructing networks of connections. This notion can be perceived in some form or other in most theoretical models of learning mathematics. Piaget, for example, described the development of understanding in terms of the learner relating new experiences to their existing cognitive structures, by assimilation and accommodation, to develop what he called 'schemas' (Piaget, 1953).

When children are involved in number work there are four kinds of things that they engage with:

- real, physical objects (concrete experience), such as counters, toys, containers, fingers, dice, groups of children, board games, sticks and stones, and so on;

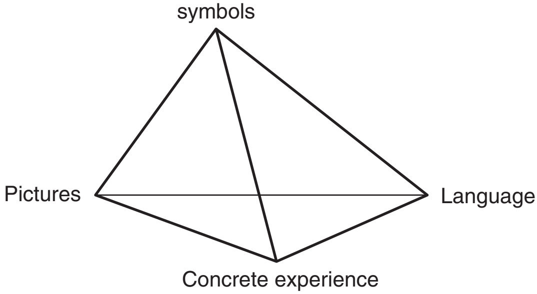

Figure 18 *Making connections*

- language – both formal, abstract mathematical language (such as 'subtract' and 'equals') and natural language that describes an experience (such as 'take away' and 'how many are left?');
- pictures, particularly sorting and matching diagrams, number strips and number lines, pictograms, and simple block diagrams and bar charts;
- mathematical symbols, particularly those used for numbers (0, 1, 2, …), operations (+, –, ×, ÷) and equality (=).

These are the building blocks of experiences with which pupils in primary schools construct their mathematical understanding. Liebeck (1990) proposes that children's understanding involves building up connections between these four components through sequential experience, starting with concrete experiences, then adding in the appropriate language, and then pictures and finally the mathematical symbols. Haylock and Cockburn (2003) do not see the model as implying a fixed sequence, but are more concerned to raise teachers' awareness of the need to provide experiences that help to establish such connections as the basis for developing children's understanding.

PRACTICAL EXAMPLES

Children's understanding of subtraction illustrates powerfully the model of making connections. There is a wide range of concrete experiences and associated natural language that have to be connected with the formal language of 'subtract' and the mathematical symbol for subtraction (–). For example, 'twelve subtract nine equals three' (in symbols, 12 – 9 = 3) can be connected with:

- counting out 12 cubes, taking away 9 and counting how many are left;
- having 12p to spend in the class shop, but spending only 9p and having 3p left to spend;
- matching a set of 12 ducks and a set of 9 chickens in the model farm and finding that there are 3 more ducks or 3 fewer chickens;
- having 9 plastic eggs in a box that holds 12, and finding that 3 more are needed to fill the box;
- counting the 9 children in a group of 12 that walked to school today and noting that there were 3 children who did not walk to school;
- comparing a rod of 12 linked red cubes with a rod of 9 blue ones, to find the difference, how many more red, or how many fewer blue;
- comparing a stick 12 cm in length with one of 9 cm in length, to find out how much shorter or longer is one than the other;
- placing 12 red counters in one pan of a balance and 9 blue in the other and then finding how many more blue are needed to balance the red.

This list, which is far from exhaustive, illustrates what a complex network of connections there is to be established. Then Figure 19 illustrates some of the pictures associated with this subtraction that pupils must also learn to connect with the language and symbols, to further their understanding. These include:

- by counting off 9, partitioning a set of 12 into subsets of 9 and 3;
- comparing two sets, one of 9 and one of 12, by matching, to determine how many more in one set or how many fewer in the other;
- a subset of 9 within a set of 12, with 3 that are not in the subset;
- comparing columns of 9 and 12 in a block graph;

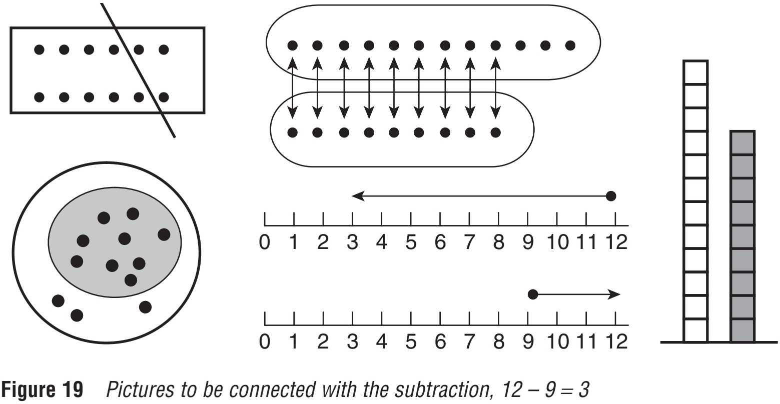

Figure 19 *Pictures to be connected with the subtraction, 12 – 9 = 3*

- counting back 9 steps starting at 12 on a number line;
- counting on from 9 to 12 on a number line.

The importance of having such a network of connections in place is illustrated by the difficulties many pupils will have later on in understanding a subtraction involving a negative number, such as '5 – (–3)'. This cannot be understood if subtraction is connected only with the language and experience of taking away and finding how many are left or how much is left. However, a pupil whose understanding of a subtraction like '12 – 9 = 3' includes connecting it with counting on from 9 to 12 on a number line can readily assimilate the experience of counting on from –3 to 5, and hence can understand that 5 – (– 3) = 8.

FURTHER READING

Liebeck's *How Children Learn Mathematics* (1990) is very readable and well worth reading. The model of learning based on the idea of making connections outlined above is explained in more detail in chapter 1 of Haylock and Cockburn (2003); this is then used as the theoretical framework throughout the book for consideration of the number curriculum for children aged 3 to 8 years. Turner and McCullogh (2004) emphasize teaching strategies that seek to establish relationships between language, symbolic notation and pictorial representation.