Unit 4.3 – Cognitive Development

Additional materials

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A question of intelligence?

The multiple intelligence model (see Figure 4.3.1) of Howard Gardner gained great popularity in schools. Part of the reason for this was because the idea of different intelligences makes intuitive sense. In the classroom, teachers will notice that different pupils think about concepts tasks in different ways. Gardner proposed that these relatively autonomous intelligences can be exerted along or combined in different contexts at different times. A number of intelligences may be needed in order to carry out some tasks, e.g., in the case of art and design both spatial intelligence and bodily kinaesthetic intelligence might contribute to learning. As explained in the textbook, the concept of multiple intelligence shas been challenged and criticised, even by Gardner himself so that it's importance in school have greatly diminished.

Where Gardner's ideas did become prominent is in the area of 'learning styles, an idea now debunked as a neuromyth (White 2005). This is somewhat unfair to Gardner who never perceived his theories being applied in this way (Gardner 2021). But, as with many theories of learning, the multiple intelligences model became transformed from a highly theorised and complex model of learning to an oversimplified idea, sometimes conflated with the notion of 'learning styles', an idea which has been shown to be a neuromyth (Newton and Salvi, 2020). In some schools, tasks would be designed with specific reference to which 'intelligence' it supported while learning styles were used as labels for pupils. Not only are these poor ways of thinking about and using education research, they also have the potential to stop pupils from flourishing and taking risks. That being said, Gardner's work has been shown to be transformative in some cases, for example in science education (Cavas and Cavas, 2020) and offers insight for teachers about how education research can be applied in the classroom.

There is an opportunity to further explore these ideas for yourself in task 4.3.1 but before that look back at the list of characteristics of intelligent people identified in Task 4.3.1 in the textbook. How well to they map on to Gardner's set of intelligences?

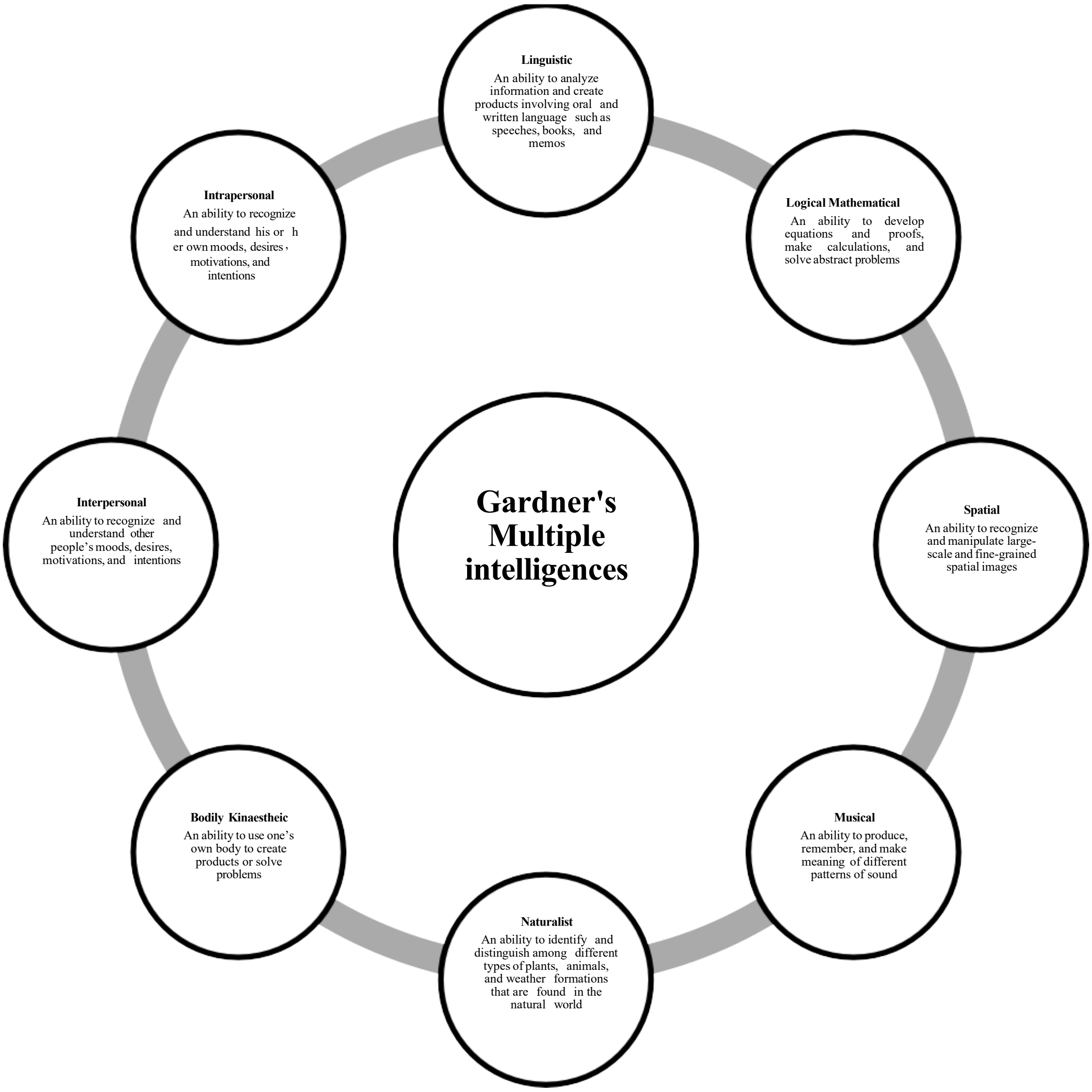

Figure 4.3.1 Gardner's Categories of Multiple Intelligence

Task 4.3.1

Multiple intelligences and Design and Technology (D and T)

Locate online the D and T curriculum for England (DfE 2017). Select teaching D and T at KS3, download the Programme of Study and read the sections 'Aims', 'Attainment targets' and 'Subject content'.

Using this document, identify the skills and intelligences demanded by D and T at KS3. Be sure to consider how pupils with different abilities would access the learning and what support they might need.

These questions may help you.

1 In which ways do the demands of D and T link to the importance attached in school to linguistic and logico-mathematical aptitude?

2 Using Gardner's 'theory of multiple intelligences', discuss the teaching and learning of D and T as the utilisation and development of different intelligences.

For discussion on the place of D and T in the school curriculum; see Owen-Jackson (2015, Chapter 1). Summarise your findings, including details of what the task has taught you about catering for the needs of all learners, to discuss with your tutor or the D and T teachers in your school. File the final document in your professional development portfolio.

END OF TASK

Measuring cognitive development and intelligence tests

Cognitive ability is not easy to define or measure, and part of the skill of a teacher is to set up a classroom environment where every pupil can succeed. An important aspect of how pupil progress is assed is through testing. The main purpose of many tests and examinations is to assess, rank, select and make predictions about progress (see Unit 6.1). IQ tests were first developed by Binet to identify pupils who may need special education (Gould, 1981: 148 *et seq*.). Intelligence testing assumed great importance in the UK after the Second World War owing to the 1944 Education Act. Pupils were selected for grammar, technical or 'modern' schools by means of the 11+ examination, a type of intelligence test. Despite being developed into a reliable sophisticated tool, the examination failed to take account of late developers or the effects of pupils' social background. The tests also favoured pupils with good linguistic skills, those who had a good vocabulary and were familiar with middle-class culture, and girls. Girls on average mature faster than boys and the 11+ entry had to be modified to ensure equal access to grammar school for boys and girls. It was shown, too, that performance on the tests could be improved by training, which suggested that, in part at least, learned skills were being tested rather than purely innate intelligence.

Confidence in the whole issue of selection was undermined by research from Ireson and Hallam (2001) showing that it had negative impacts on pupils from less advantaged backgrounds. In due course many local authorities abolished grammar schools and moved to a fully comprehensive secondary system on grounds of equity, although some retain selection, e.g. Kent and Buckinghamshire (Ireson and Hallam, 2001). Moreover, concerns about the impact of home background on pupils' achievement in national examinations have led to a call for the use of cognitive abilities tests in selecting young people for gifted and talented programmes and entrance to university to be stopped. Unlike tests focused on learning potential, IQ tests give a specific score based on intelligence testing. IQ testing is sometimes used by educational psychologists to assess pupils who, in various ways, find school difficult.

This procedure may be necessary for the identification of special educational needs such as dyslexia (see Unit 4.6). Other reasons for standardised assessment may be for research purposes as part of monitoring a population. See Unit 6.1 for further information on assessment.

Schools sometimes use national tests to determine learning potential. Two examples are MidYIS and ALIS. These tests provide teachers with data about what learning outcomes they can expect for individual children. While these tests are very robust, there is a worry that they might place a 'ceiling' on pupil outcomes. For this reason, most schools do not share the test data with pupils but use it for curriculum planning.

Cognitive acceleration

As discussed in the textbook, designed to accelerate cognition, The Cognitive Acceleration programme. Initially developed by Shayer and Adey (2002) for Science education, the programme takes an approach of teaching pupils about how learn and make meaning for themselves. The programme is based on the Five Pillar Model, see Figure 4.3.2.

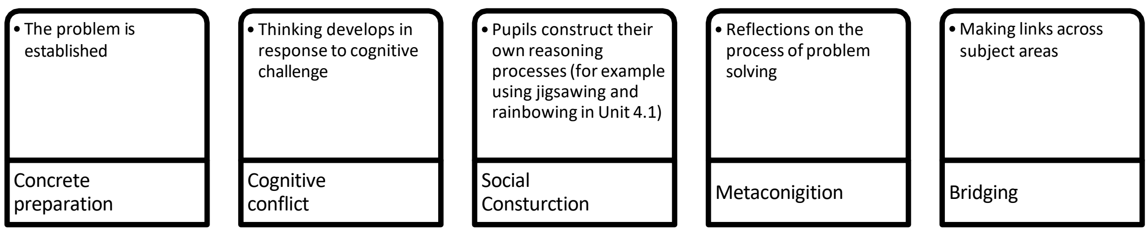

Figure 4.3.2. Five Pillar model of the Cognitive Acceleration Programme.

The programme is highly prescribed and builds up pupil thinking in a number of stages. The first component is 'concrete preparation' which involves you setting activities to ensure that pupils are familiar with the context of a problem and any technical vocabulary. You then give pupils problems to discuss in small groups, designed in such a way that all pupils are able to contribute to the discussion (See jigsawing and rainbowing in Unit 4.1). An important feature of the programme is that pupils are encouraged to think about their own thinking (metacognition). Both you and your pupils are encouraged to think about links between their thinking in other aspects of the curriculum. Results suggest that pupils can be taught to think in generic ways that help them to learn better across a range of subjects and context (Adey and Serret, 2010). The programme has been developed for a number of other subjects.

Task 4.3.2 asks you to develop a lesson which maps against the Five Pillar model of CASE. When completing this task, a good start point is to consider any misconceptions that pupils may have before you enter the Concrete Preparation stage.

Task 4.3.2.

Cognitive challenge and accelerated learning

Devise a lesson that follows the five-pillar model of Adey and Shayer's Cognitive Acceleration Programme. To help you, follow the steps below that provide information about each stage in designing your lesson:

1. Concrete preparation: this involves a series of activities that set the scene about the topic that the pupils are exploring and learning about. Think about the key ideas the pupils need to learn. Is there any specialist vocabulary that they need to access? How will you make the focus of the learning clear to the pupils?
2. Cognitive conflict: this part of the lesson should introduce cognitive conflict where the pupils are presented with an idea that challenges their own ideas and misconceptions. You will need to research ideas about what pupils think about the specific learning focus. You may find that resources such as Concept Cartoons help support this stage of the lesson;
3. Social construction: in this stage, organise the pupils in small groups and design activities

that encourage discussion about the learning focus. Think about how to best group the pupils and the roles they may play in the group that ensures everyone has a chance to contribute. When listening to the groups, it is important to step back and let them talk, so it might helpful to make a list of prompt questions you could ask to encourage deeper discussion;

4. Metacognition: in this stage, encourage the pupils to share their ideas with the class. Think about how you will select pupils and help them frame their answers. An important part of this stage is that the pupils need to explain their reasoning. You should ensure that as many pupils as possible contribute to this stage. By doing you this you will hear a greater range of ideas and reasoning;
5. Bridging: in this stage you make links between the lesson and other learning. It is helpful to think about how the learning relates to real life contexts as well as learning that the pupils might do in different curriculum areas.

Once you have developed your plan, write 500 words that explain the decisions you made. Use your own learning, ideas from this unit and readings to support your writing. Try to justify the decisions you have made and use evidence from your readings to critically analyse the design of your lesson. Store your plan and reflection in your professional portfolio and use this to underpin further use of the five-pillar model in your teaching.

END OF TASK

Developing cognitive abilities

How pupils develop their knowledge can be delayed by everyday beliefs and naïve, or intuitive, conceptions. For example, intuitive interpretations of historical events tend to be quite simplistic and stereotypical; there is often a good versus evil narrative, with evil leaders taking on great importance and the good usually winning in the end. Even when pupils have learned that events such as the Second World War have complex causes and that war is seldom due to the behaviour of a single evil leader, they may slip back into simplistic ways of thinking (Gardner 1991; 2021).

This tendency is not surprising if we think of learning as a process of building mental representations that help us to make sense of our surroundings. Indeed Dehaene (2020) states that 'to learn is to form an internal model of the external world' (Dehaene, 2020, p.5). He goes on to argue that our brains acquire thousands of mental models, including mental maps of our neighbourhoods, of the language we speak, our bodies and the people around us. These mental models help us make sense of the world around us and enable us to make predictions. Some models are true to the realities we encounter but others are less so and in time may be adjusted when we come across contradictory information. Hence, your pupils will come to class with a variety of mental models, some of which will be broadly in alignment with ideas you teach, while other models will have a less good fit.

The next two tasks that follow encourage you to think about what aspects of your subject pupils will find challenging and what you can do to support them. Task 4.3.3 is focused on challenging concepts in your subject and how you can find out move about why pupils find them challenging.

Task 4.3.3

Cognitive challenge in your teaching subject

This leads to master's-level Task 4.3.4

Select a coherent piece of work and identify the concepts pupils usually get wrong, stumble over or misunderstand, or you find hardest to teach. As well as your day-to-day classroom experience, use the results of end-of-unit tests or GCSE examination. What is it that makes the concept(s) difficult? Here are some reasons:

- The subject matter is too abstract or lacks relevance.
- Pupils do not have the necessary vocabulary.
- Pupils cannot access sufficient background knowledge.
- Pupils are asked to apply existing knowledge to new situations.
- Pupils are expected to make connections between different areas of knowledge.

- Pupils need to consider multiple factors in a situation.
- The task requires pupils to look for patterns in information.
- Pupils are expected to abstract generalisations from a situation.
- The task asks pupils to make judgements or criticism about propositions or generalisations.

As part of your classroom experience select a topic covered and ask pupils to talk about how they completed it and to identify any aspects of the work they found easy and those they found difficult. Rank these ideas in terms of how well the pupils coped with the topic. How pupils experience difficulties varies in different subjects. For example, in mathematics pupils find modelling, proportionality, estimating and probabilistic reasoning challenging. In learning languages vocabulary and following grammatical irregularities can be a problem. Pupils' intuitive explanations of phenomena in science result in what are commonly termed 'naïve conceptions'. An example that explores the difficulties that pupils may have in geography is explained below. Pupils often have difficulty in understanding the structure of the Earth and geological processes like continental drift. The Earth's crust appears to be very stable and solid, and, for most of us, our everyday life experiences confirm this to be the case. It is only when earthquakes and volcanic eruptions occur that we are able to observe the dynamic nature of the thin crust on which we live. To properly understand the changing structure of the Earth, pupils would need to be able to use these concepts:

- The Earth's crust only forms a small fraction of the total mass of the Earth
- Most of the Earth is composed of liquid, molten rock
- The solid crust floats on the molten rock beneath it
- Very high temperatures and enormous pressure causes rock to melt and move
- The Earth is around 4.6 billion years old
- Most geological processes take hundreds of thousands of years before they can be observed

Therefore, when teaching about topics such as continental drift, you would have to ensure pupils were familiar with many of these concepts at the start of the lesson, and make sure they are able to make use of them by the end of the lesson. For your own example, consider which ideas are most difficult for pupils to understand. Talk to more experienced teachers about what makes the ideas challenging for pupils. Think about a particular pupil who struggles in your subject and write a short plan outlining how you could specifically support their developing understanding of the topic.

END OF TASK

Having completed Task 4.3.3 (above) move on to Task 4.3.4 and use this to inform a detailed lesson plan to support the entire class of pupils with developing their knowledge and understanding of the concept you have identified as being challenging.

Task 4.3.4

Helping pupils to understand difficult ideas

Write a lesson plan for a short teaching episode that may make a difficult idea more accessible to pupils. This might be an aspect of photosynthesis in science, a challenging section of a poem in English, interpretation of complex evidence in history etc. In devising your plan, address some of the points we have made in this chapter.

1. Establishing what required knowledge pupils already have (you might, for example ask pupils in a previous lesson to put forward their own ideas or explanations of what you are about to teach and make notes of what they say or do; ask more experienced teachers what pupils might be expected to know and do).
2. Making the learning purpose worthwhile (think about contexts that help pupils make sense of new content).
3. Using a range of strategies (think about two or more strategies you might use to support learning. Discuss with peers and colleagues).

4. Incorporating required thinking (e.g. inference-making, deduction, problem-solving).
5. Ensuring all pupils can access the learning. Think about what is the minimum understand required to show competency in the topic, what support might pupils who find the topic challenging need, how will you assess their learning and who might you ask for help in planning the learning experiences?

Write about 500 words justifying your plan. In so doing you should draw on what you have learned in this chapter as well as two other academic texts (these might be referenced in this chapter or texts drawn from your particular subject area). Such a justification would be in the form of an explanation backed up by literature that makes a convincing argument for your approach.

END OF TASK

Continuing with the theme of challenging concepts, the next task provides an example of a reasoning problem which appears straightforward but reveals much about how pupils think and understand the world. The task is an exercise commonly given in science lessons to pupils aged between 12 and 15, the exact timing depending upon their level of development. Pupils are set a problem-solving task in which they are invited to identify the factors that affect the rate at which a pendulum swings (called a 'time period') – see Task 4.3.5. The task is practically based and has real-life connections as pendulums are used to control timepieces, such as a longcase clock which contains a rod (pendulum) with a heavy weight at one end. The length of the pendulum is adjusted to control the accuracy of the timepiece. The task comes from research into pupils' thinking about science concepts; see Shayer and Adey (2002).

The activity concerns *understanding* and *how understanding is gained* rather than knowing and recall. The pupil's task involves planning an investigation, identifying patterns in data and making deductions, in other words, enquiry skills and thinking skills. The exercise illustrates, too, the ways in which pupils respond to data. The analysis of the data requires abstract thought and the ability to handle a complex situation in which several factors (variables) have to be considered.

Task 4.3.5

Enquiry and understanding: Which factors (variables) affect the swing of a pendulum?

Background information

A simple example of a pendulum is a piece of string suspended at one end with a weight at the other (see Figure 4.3.2). Pupils are sometimes expected to use experimental data to deduce factors that influence the rate of swing or 'rules of the pendulum'. They may be given the data, or derive the data for themselves. The task is not to learn the rules, but to understand how the rules derive from observation. The focus of this exercise is to work out what can, or cannot, be deduced from the set of data.

The pupil's task

Two pupils were given a task to find out which factors affected the rate at which a pendulum swings. They were not told exactly what to do but the teacher had suggested investigating the effect of length, weight and push on the time period. They decided to measure the number of swings made by a pendulum in half a minute. They changed variables of the pendulum each time, by varying:

- the length of the pendulum; they had one short pendulum and one long pendulum
- the size of the weight on the end of the pendulum, a heavy weight and a light weigh
- the height it was raised to set it going – the push. One 'push' was high up, the other 'push' low down. See Figure 4.3.3

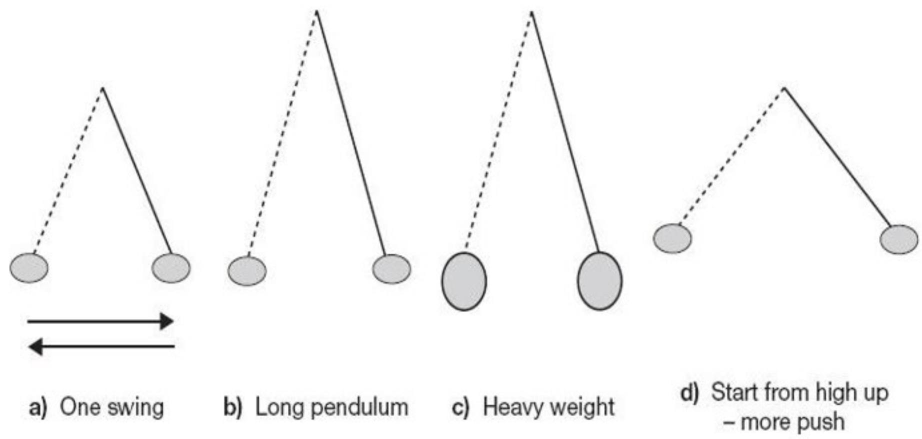

Figure 4.3.3 The pendulum: three variables, length, weight and 'high up'

Your task

From the evidence *alone* in Table 4.3.1 what do you think the data tell you about the effect of *length*, of *weight* and of *position of release* on the number of swings per half minute of the pendulum?

Table 4.3.1 Data on different pendulums obtained by pupils

Experiment	Length of the pendulum	Size of weight on the end	Push at start	No. of swings in 1/2 minute
1	long	heavy	high	17
2	short	heavy	high	21
3	long	light	low	17
4	short	light	high	21

Listening to pupils as they try to solve the problem can be very valuable as it provides clues about their thinking skills (cognitive processes). There are some interesting features of this task. Intuitively, pupils expect the size of the weight and the 'push' to have an effect on the time period, or rate of swing. They tend to expect heavy weights to 'do more' than lighter weights. The results are contrary to common sense and pupils often think they are wrong. This conflict with everyday conceptions is not an uncommon experience even for adults. Evidence that the magnitude of the weight at the end of the pendulum has no effect on the time period is often rejected intuitively or put down to error. Common-sense notions can be in powerful opposition to evidence.

Some pupils also do not accept that if two variables are changed at the same time, then it is not possible on that evidence alone to make a deduction. In this situation, some pupils may then bring in evidence external to the investigation to support their argument, instead of using the data they have.

When pupils are faced with the need to get evidence for themselves they frequently choose trial and error methods rather than logically constructed enquiries. Trial and error methods often lead to data that do not provide clear cut answers to questions; this can lead pupils to make unwarranted inferences from the data in an attempt to get an answer.

As the data are not always clear cut, your judgement may have to be withheld. This may cause mental conflict because there is a powerful expectation that experiments yield positive information. Saying 'this enquiry tells us nothing about the question' is often not an acceptable answer, especially if you have set up the enquiry. Such feelings mean that attitudes of persistence and honesty are critical for the generation of real understanding. A full explanation of the pendulum task is:

1. The time period of a pendulum depends on the length of the pendulum; neither the magnitude of the weight nor the position from which the pendulum starts swinging (high or low) affects the time period.
2. From the pupil readings shown in Table 4.3.1, it follows that investigations 1 and 2 tell you the length has an effect on the time period, since only length was changed, weight and

position of release being held the same.

3. Investigations 2 and 4 tell you that weight has no effect on the time period, since length and position of release are held the same.
4. Finally, from 1 and 3, *if weight has no effect*, then since the length is constant in both experiments, the position of release has no effect on the number of swings per half minute.

It is useful to think about the level of difficulty of a task like this. The relationships that the data show can appear counter intuitive. This has implications for different types of learner, for example some might take these ‘rules’ very literally and think that patterns in Science are always this simple, others might struggle to identify the pattern or apply their knowledge. Considering these ideas in your lesson planning is an essential element of inclusive education.

END OF TASK

This investigation, and others like it, suggests that enquiries that involve handling together several variables (here, the weight, length and push) can be difficult for many pupils. Structured teaching is needed to improve achievement in these types of higher level skills. One example of structured teaching is the Five Pillar Model discussed above (Shayer and Adey, 2002). The aim of this model is to encourage the pupil to move their thinking forward through a series of carefully planned activities so that the pupil not only solves the problem but is able to articulate how it was solved (an example of metacognition; see Unit 5.1 ‘How pupils learn’). The higher level thinking skills relate to Piaget’s formal operational thinking, also discussed in Unit 5.1.

Another example of a common confusion is financial inflation: many adults expect the cost of living to come down when the inflation rate is reduced from, say 3 per cent to 2 per cent. Similarly, some adults have difficulty calculating real costs when sales advertising offers percentage discounts (see question (c) in Table 4.3.2). When pupils are faced with problems involving percentages, it appears that context is as important as the numbers themselves. In addition, the understanding of what constitutes a right answer is confused with 'what answer is good enough, given the context'. We might sympathise with this last point, e.g. when preparing a dish for four people and faced with a recipe that requires half a litre of cream for six people we might estimate rather than calculate exactly. The following example illustrates how context might influence pupils' responses to questions.

> A supermarket offered olive oil for sale labelled '50% free'. The bottle contained 750 ml and was priced £2.99, the same price as a regular bottle of oil containing 500 ml. A group of adult customers were arguing that this offer was wrong because the price was not cheaper, i.e. £1.50. Despite having the nature of the offer explained to them several times by another customer, most of the group refused to buy the item because it did not cost less than the regular item.

Table 4.3.2 Pupils' performance on questions involving percentage

a. Six per cent (6%) of pupils in school have free dinners. There are 250 pupils in the school. How many pupils have free dinners? The symbol '%' means per cent or per 100, so 3% is 3 out of every 100.			
Age/years	13	14	15
Success rate %	36	45	57
b. The newspaper says that 24 out of 800 Avenger cars have a faulty engine. What percentage of cars is this?			
Age/years	13	14	15
Success rate %	32	40	58
c The price of a coat is £20. In a sale it is reduced by 5%. How much does it cost now?			
Age/years	13	14	15
Success rate %	20	27	35

Source: Hart (1981, p. 96).

Pupils were given three questions on percentages, together with an introduction that explained the meaning of the symbol '%'. The questions (a, b and c) and the number of pupils getting the right answer (the success rate) for each of three year groups is shown in Table 4.3.2.

We suggest you read through the questions in Table 4.3.2 and check your own answers to the questions. Then consider possible reasons for the variation in the success rate shown by these pupils and the different contexts in which the mathematics is set. If ability is being judged by responses to questions such as these, then, clearly the context in which the mathematics is set matters. The author describes how pupils arrive at their different answers, the different strategies they use and implications for teaching (Hart, 1983).

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