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1. Science education for gifted learners?

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This book is about *science education for gifted learners*. Such a title implies that

- we can identify groups of students that we might consider 'gifted' , and
- that some particular brand or type of science education is best suited for these specific learners.

Neither of these assumptions would be universally shared. Therefore it is important to establish, at the outset, the understanding of some key issues that has informed the book. In this introductory Chapter, therefore, I explore the intellectual landscape into which the later chapters will be located, each contributing something to the scenery. To do this, I address a number of core questions relating to the notion of 'science education for gifted and able learners':

- How valid is the notion of 'gifted learners'?
- How is the term 'gifted' used in this book?
- Why should we *expect* gifted learners to have 'special needs' in science?
- How can teachers identify gifted learners in science?

- What kind of science education meets the need of gifted learners of science?

These are 'big' questions, and this Chapter will introduce the main issues and arguments, and establish a framework for reading the other, more detailed contributions in this book. The last question, in particular, is explored in various forms throughout the book.

How valid is the notion of gifted learners?

The term 'gifted' (along with similar descriptors, such as 'exceptionally able') is commonly used in educational discourse, and along with related labels such as 'intelligent' and 'creative', tends to be well-understood *in general terms* without there being a clear consensus of what *exactly* is being defined. Most teachers, and others working in education, would have a vague idea of what to expect of a gifted learner, without their necessarily being any detailed agreement between different users of the term (Maltby, 1984).

It seems that there are at least three problematic aspects to the notion of a gifted learner in science:

- how gifted is gifted?
- how broad is the 'gift'?
- how fixed is the 'gift'?

There are no definitive answers to these questions: rather our answers depend on our *choice* of definition for the term.

How gifted is gifted?

Commonly, students are assigned to groupings such as gifted and able in terms of their ranking within a cohort. So, current UK government policy on 'gifted and talented' students refers to the *top* 5-10% of students

> All schools are required to identify a gifted and talented pupil cohort comprising 5-10% of pupils in each relevant year group. These are pupils who achieve, or who have the ability to achieve, at a level significantly in advance of the average for their year group in their school.
>
> DfES, 2004a, p.25

Under this policy the 5-10% includes three groups of students: those with ability in one of the 'academic' subjects (the 'gifted'); those with talent in art, music, PE, sport or creative arts (the 'talented'); and those with 'all-round' ability (the gifted *and* talented!).

Collectively, the gifted, and the talented (and the gifted *and* talented) are also referred to as 'the able' in some UK government documentation (DfES, 2002a), where the label 'exceptionally able' is used for *the most able 1%* of the cohort *nationally*:

> 'This group includes a very few outstandingly able pupils, such as the boy aged seven who could write the caesium/water reaction balanced symbol equation and another of a similar age who described fusion in terms of the mass and atomic numbers of hydrogen and helium.'
>
> DfES, 2003, p.4.

Although this example is taken from a recent government initiative, it is reminiscent of work on gifted learners undertaken in the 1960s (before a focus on gifted learners became unfashionable). Fisher described how a group of gifted primary pupils (c.10 year-olds) with an interest in science were able to discuss the gas laws,

> 'This desire to take an active part in discussion has led more recently to a consideration of the factors which affect the pressure of a gas, being treated in a semi-formal manner, and here was a powerful demonstration of the advanced ability to separate variables and exclude variables in the investigation of relationships. Preconceptions were dealt with in a more immediate manner and progress was very rapid; this topic involves mathematical concepts'
>
> Fisher, 1969, p.131

Definitions of 'gifted' etc. are clearly arbitrary to some extent, so – for example – one research study into giftedness used the term *gifted* for the top 10% of the sample, *highly gifted* for the top 5%, and finally, *extremely gifted* for the top 2% (Heller, 1996). Clearly, any definition that *implies* an objective scientific measure of giftedness, in terms of percentiles, is based on the assumption that students can be ranked along a single dimension. An obvious dimension to use here is 'intelligence', although that is itself a highly contested concept. None-the-less, it is not unusual for giftedness to be defined in terms of attaining a certain cut-off on an IQ test: e.g. the 3-4% of students having a measured IQ score of 130 (Montgomery, 2003a).

There are well-established, and reliable, ways of measuring IQ that may make such an approach seem relatively attractive (see Chapter 3). However, reliability does not imply validity – just because IQ scores can be approximately reproduced on re-testing, that does not mean that IQ is a good indicator of what we might find it helpful to mean by giftedness. Indeed there are significant doubts about the IQ construct (e.g. Gould, 1992).

How broad is the 'gift'?

It is generally recognised that IQ scores tend to correlate well with academic attainment, but there are major problems with using IQ as a means for identifying the gifted. It is likely that this correlation is largely an artefact of traditional notions of what academic study is about: that the types of items on IQ tests tend to test verbal and logical abilities that have traditionally been central to academic study and assessment (Gardner, 1993), but may relate to a narrow definition of intelligence (cf. Sternberg et al, 2000). Whilst such a correlation offers some ability to predict academic success for students across much of the range of scores, it may have little to say about the exceptional abilities that gifted students can show (see for example Chapter 4, and Chapter 6).

One problem is that if we are interested in exceptional individuals, their exceptionality may go beyond the abilities needed to do well on IQ tests. Stepanek argues that 'as the concept of intelligence becomes more fluid and multidimensional, the concept of giftedness also evolves' (1999, p.6). For example, being gifted in science could be considered to be as much about being 'creative' as intelligent. Heller (1996) uses a multidimensional concept of giftedness (the 'Munich model', p.44), where giftedness comprises:

- intelligence (intellect)

- creativity
- social competence
- musical ability
- psychomotor ability/practical intelligence

According to Heller's research these five areas make up *independent* domains of giftedness, and few students are gifted in several of these distinct domains.

Sternberg (1993: 6-9) has proposed a 'pentagonal implicit theory' of giftedness, suggesting that a person has to meet five criteria to be judged as gifted:

1. the excellence criterion (extremely good at something relative to peer group);
2. the rarity criterion (showing a high level of an attribute that is rare among peers);
3. the productivity criterion (the dimension of excellence must potentially lead to productivity);
4. the demonstrability criterion (demonstrable through one or more valid tests); and
5. the value criterion (the dimension of excellence must be a valued one in the society judging the person as gifted).

In Sternberg's model, giftedness is defined in terms of exceptional ability (relative to the rest of the population) that can be clearly demonstrated, and is able to lead to some tangible outcome. However, Sternberg sees 'giftedness' as relative in another sense as well: that we should only recognise giftedness in areas that are culturally valued (be that sprinting, taking free kicks in soccer, rapping, or building up profitable businesses). Sternberg's model resembles Gardner's (1997) analysis of what allows an individual such as Mozart or Virginia Wolf to be extraordinary enough to be judged a genius – that the individual may have exceptional talents, which relate to an existing domain of human activity (composing music, writing novels, etc.), and are recognised by those other individuals who at that time make up the 'field'. (For example, in Chapter 2, Gilbert and Newberry discuss Nobel laureates – scientists receiving the ultimate recognition from their peers.)

One advantage of Sternberg's model is that he does not define giftedness in vague terms such as 'academic ability'. So using Sternberg's approach, *we may chose to* consider a student as gifted in terms of their ability to build circuits, visualise molecular structures, undertake accurate and precise titrations, develop scientific analogies, interpret complex graphical information, draw accurate scientific diagrams, mentally obtain order-of-magnitude mathematical solutions, or indeed *any* of the myriad skills that are important in learning science.

This is important, as most science teachers are aware that the most able learners are not always exceptionally strong 'across the board' even within science, or within an individual science discipline such as chemistry. Ignoring this point can lead to both putting too much pressure on the nominated gifted students (see for example, Chapter 4) in areas where they are not especially strong, and also ignoring the potential of other learners to work at very high levels on certain types of tasks.

How fixed is the gift?

One of the associations of the term 'gifted' is that it may seem to imply something innate: there at birth and giving the potential for achieving at exceptional levels. It is undoubtedly the case that an individual's genetic make-up has a significant influence on their manifested strengths, and on the ease with which they are likely to develop different skills and abilities. It is also true that any potential has to be relative to particular environmental conditions.

So, for Sternberg giftedness implies a potential that should lead to exceptional achievement *without* exceptional support: i.e. to meet his five criteria of giftedness 'with a minimal amount of practice or without good environmental support' (Sternberg, 1993: 18). Other commentators take a different view, and consider 'giftedness' may derive from experience as much as genetics.

Stepanek argues that 'if intelligence is not static and can be learned, then giftedness can also be developed' (Stepanek, 1999, p.6). Allowing for under-achievers and the masking effects of learning difficulties (see Chapter 3), would mean setting the cut-off for identifying gifted learners at a much lower percentile. Montgomery (2003a) suggests that some *potentially* gifted pupils are found among those with IQ scores of 110-115, so that all students in the top 20% should be considered as possible candidates.

The danger of labelling learners

These considerations suggest that in looking to meet the needs of 'gifted' and 'able' students we should be wary of the potential effect of labelling students in schools. If we decide that, say 5%, of the students in a school are gifted in science, then we are signifying that the vast majority have not been endowed with such gifts. This majority will *not therefore be expected* to demonstrate exceptional ability, and are not considered suitable to be considered for 'gifted provision'. This is important, as teacher and learner expectations are known to be very significant factors in subsequent attainment (e.g. Rosenthal & Jacobson, 1970/1966), so it is important that such expectations are carefully informed. Yet, the discussion of giftedness above suggests that identifying a group of students as 'the gifted science learners' in a school is not straightforward. Particular identification criteria may well disadvantage groups such as girls (see Chapter 4) or students from cultural minorities (see Chapter 5).

So identifying gifted learners through standard test scores is clearly an over-simplistic approach. Even assuming that such tests are reliable, they only show attainment of students under the current regime. If some learners are better suited to different, more challenging, curriculum demands then we cannot assume they are always those who score highest on the current standard assessments. Also, science is not a unitary activity: the most creative may not recall the most facts; those who can plan experiments or write accurate observational descriptions are not always the same individuals who excel in calculations.

Many students in schools are already recognised as having special needs which impede their progress: they may have specific learning difficulties (dyslexia), attention deficit problems, partial deafness, or any of a host of conditions and problems that could readily mask their exceptional potential in science (see Chapter 3). Some of the most talented scientists even suffer from behavioural traits found on the autism spectrum (e.g. Sacks, 1995; see also Chapter 4).

A related concern is the implication that it is *students* who are able or gifted, whilst others are not. This reinforces an implicit view that gifts or abilities are fixed at birth, or at least by school age, and need to be recognised, but could not otherwise be nurtured. Clearly, children do show different levels of attainment from their earliest schooldays, and it is generally the case that current academic attainment is a good indicator of future progress – at least in the 'academic' context,

> 'high test-scores or marks in school are not a reliable indicator of adult careers, except for those who continue in a similar path, such as teachers and academic'
>
> Freeman, 1998, p.7

We would certainly not see this as justifying any model where people are labelled as being of some fixed ability without the potential to develop (Hart, et al. 2004). Even if Einstein's lack of achievements at school is often exaggerated, there is little doubt that one of the greatest scientific minds in human history was very unlikely to have been identified as a gifted student (Pais, 1982).

Education is about trying to help people reach their potential, and it seems likely that very few of us ever reach our potential to the extent that no further educational experience is indicated! This clearly does not mean that all students can be moved into the top 5% if given enough support, whatever testing regime we instigate. However, we should be wary of any system that at one point in time identifies gifted or able students who will be exclusively able to learn from some special educational approaches or provision, whilst excluding other students as *permanently* unable to benefit.

Educators still have a lot to learn about the educational provision that will be optimal in developing students so that they can make the most progress in their scientific skills and understanding (see Chapter 16). All students, whatever their current levels of attainment, have 'gifts', have abilities, have propensities, have potential to attain more. It is not unreasonable to believe that a better designed science curriculum, more effective at matching demand to a student's immediate potential for development, could produce many more learners attaining at levels we *currently* consider exceptional.

Who are the gifted in science?

Despite the genuine caveats discussed above – that the term gifted is used in different ways; that learners may be gifted in some aspects of science and not others; that the distinction between the gifted and other learners is a permeable one – it is clearly useful that a book about science for the gifted should suggest how we might define gifted learners in the context of school science.

The suggestion here is that we should consider as gifted learners in science those students who, given appropriate support, are able to either:

- achieve *exceptionally* high levels of attainment in all or some aspects of the normal curriculum demands in school science (for example: completing substantial sets of numerical problems quickly and with very few or no errors; speedily obtaining full and highly precise sets of results in school practical work; able to produce highly detailed and accurate accounts of science topics at the level presented in the curriculum); or

- undertake some science-related tasks at a level of demand well above that required at that curricular stage (for example: apply complex algebra not expected at school level; demonstrate the ability to use sophisticated models not normally met in school science; synthesise and relate apparently disparate areas of science without prompting, etc.)

If we consider the term *able* learners to apply to those students capable of meeting current curriculum demands to a high level in science - the students who will be in 'top sets' and will attain the top grades in school leaving examinations – then we would usually expect gifted students to be a subset of our able learners.

However, as gifted students may have particular abilities and aptitudes rather than an even profile of strengths, it is quite possible that under this definition some gifted science learners may *not* be among those generally considered able. The implication here is that able learners are self-evident in most classrooms (they are by definition the ones doing well in science!), but *the gifted learners may not always be so obvious*. The gifted learners are capable of the exceptional, but may only be exceptional when given the right opportunities and encouragement.

The special needs of gifted learners in science

This definition of gifted learners in science implies that these individuals have special needs. The basis for making this claim is a view of what education is about – helping people achieve their potential. If gifted learners are those able to attain exceptional levels of achievement on current curriculum requirements, or with the potential for achievements that go beyond what is required in school science, then current provision does not provide them with the basis for achieving what they are capable of, and so developing new skills and abilities.

Vygotsky's notion of the zone of proximal development (ZPD) is useful here. According to Vygotsky (1978), educational assessment should be less about what an individual can currently achieve unaided, than what is currently just 'out of reach' without help. According to this view, working within current capability (in the present 'zone of actual development', ZAD) may increase accuracy or speed (or confidence), and is sometimes useful, but does little to help the learner attain *new* capabilities. Genuine development takes place in the ZPD, and the skilled teacher provides suitable support ('scaffolding') to challenge the learner to move beyond their current capabilities. The principle is that attaining new skills and abilities with suitable support enables subsequent attainment with less (and eventually no) support. At this point what was previously just out of reach is now part of what can be achieved unaided within an extended ZAD, whilst the ZPD has enlarged to include what was previously well beyond reach.

If learners are to show what they are capable of, then they need to be challenged to work outside their ZAP and within their ZPD a significant amount of the time. Students *able* to achieve at exceptional levels in school science, or able to meet demands beyond those experienced in the classroom, are seldom working in the ZPD, and will not be developed further.

Not only are these learners not being developed, but they are also in danger of being bored. Gifted learners in science may ‘be easily bored by over-repetition of basic ideas but enjoy challenges and problem-solving’ (DfES, 2003, p.15). Most *able* students may well be satisfied in meeting the current demands made of them, but it is unlikely that students capable of performing at exceptionally high levels are really feeling fully challenged by their work in science. Gifted learners ‘are dissatisfied with over-generalised explanations and inadequate detail’ in their science classes (DfES, 2003, p. 15). The highest achievers spend extended periods of time familiarising themselves with the nuances of a field (e.g. Gardner, 1997), and such level of engagement is essential if gifted learners are to experience an authentic ‘cognitive apprenticeship’ (Hennessy, 1993) in science (see Chapter 2).

Csikszentmihalyi (1988) has explored the nature of the ‘flow’ experience, where engagement in a task leads to a level of concentration and satisfaction that enables much to be achieved apparently ‘effortlessly’. In such a state, learners become oblivious to the passage of time, and other environmental conditions, and totally absorbed in the task. It is doubtful that gifted learners often experience such a state in response to standard curricular demands. No wonder that the gifted may ‘be critical or appear disinterested and can display unacceptable behaviour’ (DfES, 2003, p.15). Clearly as educators, we have a responsibility to develop the affective response to science (see Chapter 4): and we do a disservice when we bore the most able learners.

All students have an entitlement to be challenged at a level where they can succeed and make progress. Many learners at school level experience limited success in science. Our *able* learners succeed, although it is likely that the *range* of challenge in school science is restrictive, even when the *level* is well-matched. Our *gifted* students may feel very little challenge in school science, and may look for that challenge in other subjects, or – failing that – become disaffected with school completely.

How can teachers identify gifted learners in science?

If we are to identify the gifted in science, then we need an approach that identifies them in terms of their aptitude for learning from more demanding science instruction, and not just their high scores on existing tests. A number of characteristics of able learners in science have been suggested (Stepanek, 1999; Gilbert, 2002; KS3NS, 2003a; see also Chapter 2). These characteristics may be considered to form a number of clusters. The first of these concerns *scientific curiosity* (see Box 1.1, cf. Chapter 2, Chapter 4).

It has been suggested that gifted science learners:

- have hobbies where they collect and compile data or scientific artefacts;
- may be interested in collecting, sorting, and classifying objects;
- have strong curiosity about objects and environments;
- show high interest in investigating scientific phenomena;
- have a tendency to make observations and ask questions;
- may be inquisitive and want to seek explanations for the things and events they observe, often asking many questions, especially 'Why?';
- may have an interest in the derivation (roots) of science terms;
- may demonstrate intense interest in one particular area of science to the exclusion of other topics;
- want to quantify experimental results by counting, weighing or otherwise measuring.

Box 1.1: Gifted science learners show curiosity

A second cluster relates to their *cognitive abilities* (see Box 1.2, and also Chapter 6).

Gifted learners in science are said to

- readily learn novel ideas;
- recognise and use formal scientific conventions;
- have a more extensive scientific vocabulary than their peers when explaining things and events;
- have quick and extensive understanding of concepts, such as reliability and validity, when drawing conclusions from evidence;
- relate novel ideas to familiar ideas
- make connections rapidly between facts and concepts they have learned, and make connections between scientific concepts and observed phenomena;
- move beyond the information given, and move ideas from the context in which the have been learnt to an unfamiliar context;
- quickly understand models and theories in new situations and use these to explain phenomena;
- have the capacity to leap ahead or jump steps in an argument and detect flaws in reasoning of others, and rapidly perceive the direction of an investigation and anticipate outcomes;
- produce models, and mathematically model;
- generate creative and valid explanations;
- be willing and able to think abstractly at an earlier age than usual;
- be prepared to live with uncertainty;
- be willing to hypothesise, manipulate variables fairly and make predictions;
- identify patterns in data where the links are not obvious;
- suggest a variety of alternative strategies for testing predictions or gathering evidence.

Box 1.2: Gifted science learners demonstrate high-level cognitive ability

A third cluster of claimed characteristics concern the student's *metacognitive* abilities (see Box 1.3, and also Chapter 6).

Gifted science learners are said to

- be able to sustain an interest
- show good powers of concentration
- reflect on their own thinking and learning
- form overviews of sectors of a subject
- excel and persevere at their own choice of activity and produce high quality work;
- want a greater depth of understanding.

Box 1.3: Gifted science learners show metacognitive maturity

Finally, it has also been suggested that some gifted science learners will take on roles, and exercise effective leadership in group work.

As our choice of definition of gifted learners in science encompasses students who undertake some science-related tasks at a level of demand well above that required at that curricular level, it is important to be aware that we would not expect those we would consider gifted as having *all* these characteristics (especially when giftedness coexists with learning difficulties, see Chapter 3). Lists such as those should be seen as useful indicators when looking to identify gifted learners. Classroom teachers need to also be able to work with (all) their students to ask the fundamental question*: is the current curriculum provision really challenging and developing these learners?*

What kind of science education meets the need of gifted learners of science?

> 'Provision [for the gifted] should include extension in depth and enrichment in breadth: extension through additional support and challenge, and enrichment through opportunities in the classroom and outside school.'
>
> (DfES, 2002a)

Provision for the gifted could include *accelerated* learning - 'giving students school work that is in keeping with their abilities, without regard to age or grade' (NDE, 1997, p.56) and/or e*nrichment* ('the provision of in-depth multi-disciplinary exploration of content beyond that provided in the regular curriculum' (NDE, 1997, p.32). Sternberg (1993) argues that the type of provision that is appropriate depends upon what we value:

> 'If we value rapid learning, then acceleration makes sense. If we believe that what matters is the depth or care students take probing into what they learn, enrichment will be preferable. If both are prized, a combination might be best.'
>
> Sternberg, 1993, p.15

In these terms, enrichment might often be the better option for developing gifted learners who we hope will find science a source of fascination and intellectual satisfaction.

Within mixed-ability groups, it may also be possible to consider the *differentiation of roles* among learners (to complement differentiation approaches based upon different tasks, different levels of teacher support, or expecting different levels of outcome). This brings us to the very real issues of whether (a) gifted and able students should be separated from their (currently) less able peers, and (b) whether appropriate science education for the most able is something *other* than just very good science education. In the UK, setting in science has become the norm, especially in the upper secondary school, even though it is recognised that mobility between sets is often difficult, so that setting often seems to 'set' [sic] a limit on what a student may eventually achieve in school science. In some schools, setting also leads to unproductive ('difficult') classes where students *currently* showing limited attainment may include more capable students, due to disinterest or disaffection, and where much of the teacher's attention is focused on classroom management issues.

There is research suggesting that when mixed-ability teaching uses appropriate differentiation strategies it can be *at least as effective* as setting (Boaler, 1997). Yet, such approaches require skills that not all science teachers feel confident that they possess, and legislate against some less intensive modes of lesson planning (see Chapter 6). A review of research on ability grouping reports that at secondary level:

> 'Ability grouping in sets or streams has been found to have no overall effect on achievement, compared with mixed ability grouping; advantages for high ability pupils have been found where advanced curriculum materials have been used.'
>
> Harlen & Malcolm, 1999: 53

The UK policy on provision for gifted students requires that their programme 'must be distinct and discernibly different from that followed by pupils who are not part of the cohort', whist 'recognising that distinctiveness and difference can be achieved through effective use of differentiation in all settings'. The policy reminds teachers that differentiation is always an issue, 'but needs to be particularly effective when the range of abilities is wide' (DfES, 2004a: 28).

> 'It is certainly the case that the most able students benefit from the opportunity to work with others operating at a similar level, and this beneficial experience may be difficult if they are dispersed in many different classes. However, these students can also benefit greatly from taking on leadership roles in groups, and from providing peer tutoring for other learners: cooperative learning, if handled properly by a skillful teacher, enhances the learning of high-ability students.'

NDE, 1997, p.80

Perhaps the ideal allows the most able students to spend some time working in inclusive classes, but having some opportunities to work with peers having comparable strengths. One possible way of doing this is by 'target grouping - the formation of groups to tackle specific issues or projects for a relatively short period' (DfES, 2002a). It is also possible to consider enrichment opportunities outside the normal school day, such as programmes providing optional science sessions where keen and able students can undertake activities designed to challenge them intellectually (see Chapters 14 and 15), or through summer schools, schemes to develop students' creativity and Olympiads and science fairs (see Chapter 13). Another rather specific form of enrichment is that of providing gifted learners with mentors – 'experts in a field who may assist a student with his or her understanding in that area' (NDE, 1997, p.85).

Whatever the organisation of teaching, it is important that the nature of the learning that is promoted meets the needs of gifted learners, and so the challenge is matched to what they are capable of. A number of principles of good practice in this area have been proposed (NDE, 1997; VanTassel-Baska 1998; Stepanek, 1999).

Focus on concepts:

Teaching for the gifted should have significant and 'deep' content, with an emphasis on learning and understanding concepts (rather than memorising facts), and opportunities to engage in conceptual exploration in depth and over time (see Chapter 2).

Focus on enquiry:

Effective learning for the gifted may often be organised around an enquiry approach with students taking the role of active investigators, investigating real problems and situations (see Chapter 13, and also Chapter 11).

Higher-level thinking:

Teaching for gifted students in science should emphasise questions that enable the learner to analyse, synthesise (for example, providing opportunities for interdisciplinary connections) or evaluate information (see Chapter 6), and should model authentic scientific thinking (e.g. see Chapter 2).

Metacognition and self-regulation

Teaching should encourage gifted learners to use and develop their metacognitive abilities (see Chapter 6). Teachers can help learners develop towards self-regulation by looking to offer a choice of tasks and activities (see Chapters 5 & 12), providing opportunities for self-directed activities (see Chapter 14), and letting students take the lead in setting agenda (see Chapter 9).

Product and audience

Gifted learners can be set tasks producing authentic products; and set tasks exploring genuine problems - where their findings can be reported to a genuinely interested audience (see Chapters 4, 9 and 15 for examples).

Variety and pacing

It has also been suggested that it is particularly important to use a variety of teaching strategies when working with gifted students (e.g. see Chapters 10 and 11), and there may be distinct requirements in terms of organising curriculum time (see Chapter 2). A rapid pace is sometimes recommended for introducing new material to gifted learners, and any time 'saved' should be used instead to offer more opportunity later for reflection on, and integration of, learning.

Science Education for Gifted Learners

In this book we try to offer the best advice that is currently available, drawing upon our actual experiences of working with gifted learners of science, both within mainstream curriculum contexts, and in special programmes. More research is certainly needed, to find exactly what is possible in 'typical' classroom contexts (see Chapter 16). Our concern is that learners should be challenged to achieve more, but in conditions where they are suitably supported within appropriate learning environments, so that their potential may be realised without risk to their confidence, interest and self-belief.

Learning environments need to offer stimulating and relevant contexts (see Chapter 11); offer support for learners to take responsibilities for learning and for initiating dialogic exchanges with teachers (see Chapters 8 and 9). Such learning environments will allow the gifted learners to thrive, and - we suspect - may well facilitate many more learners to (at least on certain occasions, in certain contexts) demonstrate *exceptionally* high levels of attainment, and the ability to undertake some science-related tasks at levels of demand well above that usually expected.