PERSPECTIVES ON EDUCATION

Primary–secondary Transfer in Science

Issue 2 Spring 2009 ISSN 1758-7956

wellcome trust

The Wellcome Trust and education

The Wellcome Trust is the largest charity in the UK. We fund innovative biomedical research, in the UK and internationally, spending over £600 million each year to support the brightest scientists with the best ideas. Our interest in science education stems from the need to recruit young scientists as well as to foster a society able to support and engage with scientific and medical developments. We are committed to well-informed discussion and debate to inform policy and practice.

This series of 'Perspectives on Education' aims to provide a selection of accessible and authoritative pieces of writing centred on current issues in UK science education, with a view to stimulating wider discussion and debate. In each report, two or more well-respected authors give their perspective, including an analysis of the available evidence and recommendations for further research and policy development.

www.wellcome.ac.uk/perspectives

Education
Wellcome Trust
Gibbs Building
215 Euston Road
London NW1 2BE, UK

T +44 (0)20 7611 7221
F +44 (0)20 7611 8269
E education@wellcome.ac.uk

Contents

Citing articles from the Perspectives on Education series

We suggest that you cite articles from the series in the following way: Galton M. Moving to secondary school: initial encounters and their effects. Perspectives on Education 2 (Primary–secondary Transfer in Science), 2009:5–21. www.wellcome.ac.uk/perspectives [accessed 23 April 2009].

ISSN 1758-7956 (online)

The Wellcome Trust is a charity registered in England, no. 210183. Its sole trustee is The Wellcome Trust Limited, a company registered in England, no. 2711000, whose registered office is at 215 Euston Road, London NW1 2BE, UK.

Photography: *David Sayer*

DC-4221.2/04-2009/PE

Foreword

Hannah Russell
Project Manager – Education, Wellcome Trust

Issues relating to the change between primary and secondary school (often referred to as 'transfer') have been recognised for over 75 years (Board of Education, 1931). Young people spend a large proportion of their daily lives in formal education and there must be few who are neither excited nor apprehensive about making the move to 'big school', particularly where this involves a physical shift in location as well as a change in not only teachers and friendship groups but also pedagogy and curriculum. The majority of pupils make the transition to secondary school relatively easily and many look forward to the change in status from child to young adolescent that the move confers. Nevertheless, for a significant minority there is a sustained negative impact on attainment and attitudes.

For science education, any negative impact on attitudes and attainment is of course problematic, not just for those individuals affected but also because of its implications for both wider scientific literacy and the potential for development of future scientists. The dips in attitude, in particular, are concerning as they reflect downward trends in attitudes towards school science that are well recorded at secondary level and, more recently, towards the end of primary as well (for example Tymms *et al.*, 2008). Interestingly, international studies such as the Trends in International Mathematics and Science Survey (TIMSS) suggest that declining attitudes towards science education are not confined to the UK but constitute an international phenomenon (Tymms *et al.*, 2008). This, at least in part, appears to be related to the culture in which young people are growing up, with studies such as the Relevance of Science Education (ROSE) project showing a strong inverse relationship between the level of development in a country and the levels of interest expressed by students in learning about science and technology (Sjøberg and Schreiner, 2005).

Several factors appear to contribute to regression in school science after transfer to secondary school. In his review of the primary curriculum, Sir Jim Rose noted that although pastoral support is now usually good, "too little regard appears to be paid by many secondary schools to the reliable information on primary children's academic progress that now exists" (Rose, 2008) but that equally "secondary teachers often express longstanding concerns about the accuracy of information received from primary schools" (Rose, 2009). As a consequence, achievements from primary school are not always recognised or valued and many secondary schools still adopt a 'tabula rasa' (clean slate) approach, assuming either that the incoming pupils know little about science or that what they do know is so variable that it would be better to start 'from scratch'.

One of the main dangers of a clean slate approach is that it leads to topics and even activities being repeated, often without sufficient increase in conceptual challenge – sometimes in the same context and using the same methods. This quickly leads to boredom, particularly in more able pupils (Pell *et al.*, 2007), and is all the more disappointing when one remembers that many pupils have been particularly looking forward to doing 'proper science' when they reach secondary school.

Overcrowded, disjointed curricula at upper primary and lower secondary levels may also have negative impacts on pupils' attitudes to science, particularly where teachers 'teach to the test' to meet statutory testing requirements (for example, House of Commons Children Schools and Families Committee, 2008). The government's recent decision to remove the Key Stage 3 tests in England and to allow more flexibility in choice of content should provide an opportunity to improve pedagogy at secondary level and make science more engaging. Similarly, the proposed revision of assessment arrangements at the end of Key Stage 2 could add further stimulus to improving transition.

In this report, the second in a series of 'Perspectives' on UK science education, three leading experts in primary–secondary transfer issues look at the dips in attitude and attainment often associated with this change in phase of education, their particular relevance to school science, and what improvements can be and are being made to better support students through this transition.

The first piece, by Professor Maurice Galton at the University of Cambridge, begins by looking at different theoretical explanations for transfer issues and argues that a balance needs to be struck between ensuring continuity (keeping things familiar) and introducing discontinuity to give students a sense that they are changing from being children to young adults. It goes on to examine the changes taking place at transfer from the pupils' perspective, highlighting concerns about work, location, friendships and teachers, and looks at data and explanations for declining attitudes towards school science. The report also introduces two issues addressed by the other authors, namely the impact of school structures and the role of cross-phase units of work, or bridging units. It concludes that while strategies to improve curriculum continuity can help to support transfer, the main reason for pupils' dissatisfaction with lower secondary school science lies with poor pedagogy, including a relative lack of open-ended questions and discussion and an over-emphasis on facts and procedural instructions.

The second piece, by Martin Braund at the University of York, highlights the dip in pupils' performance in science following transfer. It then focuses on two main strategies aimed at alleviating transfer issues in school science, namely the role of bridging units, and that of teachers sharing practice, for example through co-planning and co-teaching. The report finds that bridging work is most successful when it is part of a coordinated programme of transfer measures that includes teachers sharing their practice through meetings, exchange of assessed work and co-observation of each other's teaching. The report concludes that high-quality sharing of pedagogy and practice between primary and secondary teachers is key to improving transfer issues, helping pupils to recognise the value of the work they have done at primary school and to see their learning in science in terms of progression rather than repetition.

The last report, by Anne Diack at the Commission for Architecture and the Built Environment (previously at the Department for Children, Schools and Families Innovation Unit), begins by taking a look at some of the key government reports in England over the last ten years that have considered the issue of primary–secondary transfer. It then moves on to look at a number of strategies that have potential to mitigate some of the issues raised, ranging from the use of collaborative learning between primary and secondary students and separate areas for lower secondary pupils within large secondary schools ('schools within schools') to larger-scale changes in school structure. The report concludes that new school structures, such as all-through state schools and federations, can provide a valuable role in smoothing out the transfer from primary to secondary school. It argues for further examination by policy makers of the role and potential of these alternative systems.

It is clear from these reports that there is still work to be done towards understanding and improving the transfer from primary to secondary education, particularly with respect to strengthening progression and continuity in curriculum and, importantly, pedagogy. Specifically the reports call for:

At a national level:

- **A UK-wide review of issues associated with the teaching of science across the primary–secondary interface.** Key to the review would be the need to improve pedagogy, with one of the aims potentially being to develop a common set of pedagogical principles that are flexible enough to accommodate different classroom contexts and teaching outside the classroom.
- **Greater emphasis on ensuring better curriculum continuity between upper primary and lower secondary levels, together with improved support for implementing curriculum change.** The changed approaches to the curriculum and assessment at both Key Stages 2 and 3 in England are an opportunity to improve the interface between primary and secondary levels. Current developments in Wales, Northern Ireland and Scotland (for example the new 3–18 Curriculum for Excellence in Scotland and the removal of the Transfer Test in Northern Ireland) may also provide opportunities for better linkages between these different phases.
- **A review of approaches used in initial teacher training at both primary and secondary level**, with increased focus on pedagogy and on strategies to support curriculum continuity in science. Training programmes need to be of sufficient duration to provide the opportunities required for trainee teachers to develop effective pedagogic practice.

At a regional and local level:

- **More effective links between different schools.** This could be facilitated through additional funding and continuing professional development, for example on the effective use of locally developed bridging units.

For researchers:

- **Further research to update existing knowledge and to explore the impact of new developments.** Much of the research in this area is over 20 years old. New research is therefore needed to explore, for example, to what extent a tabula rasa approach is still adopted by secondary schools and what can be done to minimise repetition. More research is also needed into the impact on transfer of new models for schools, such as all-age school federations and small-scale units within large secondary schools for younger students.

References

Board of Education. The Primary School. Report of the consultative committee on the primary school (Hadow Report). London: HMSO; 1931.

House of Commons Children Schools and Families Committee. Testing and Assessment. Third Report of Session 2007–08. Volume I. London: The Stationery Office; 2008.

Pell T, Galton M, Steward S, Page C, Hargreaves L. Group work at Key Stage 3: solving an attitudinal crisis among young adolescents? Research Papers in Education 2007;22(3):309–32.

Rose J. The Independent Review of the Primary Curriculum: Interim report. London: HMSO; 2008. See www.dcsf.gov.uk/primarycurriculumreview/.

Rose J. Independent Review of the Primary Curriculum: Final report. London: HMSO; 2009. See www.dcsf.gov.uk/primarycurriculumreview/.

Sjøberg S, Schreiner C. How do learners in different cultures relate to science and technology? Asia-Pacific Forum on Science Learning and Teaching 2005;6(2):13. www.ils.uio.no/english/rose/network/countries/norway/eng/nor-sjoberg-apfslt2005.pdf [accessed 9 April 2009].

Tymms P, Bolden D, Merrell C. Science in English primary schools: trends in attainment, attitudes and approaches. Perspectives on Education 1 (Primary Science), 2008;19–41. www.wellcome.ac.uk/perspectives [accessed 9 April 2009].

Moving to secondary school: initial encounters and their effects

Maurice Galton
Faculty of Education, University of Cambridge

Summary

This article begins by looking at the process of transfer through the lens of two competing theoretical perspectives – one favouring continuity, the other discontinuity – and argues that a balance needs to be struck between the two.

It then examines the changes taking place in the period before and after transfer, noting that concerns about work, peer friendships and relationships with teachers tend to continue thereafter and present serious problems for about 12 per cent of the population as they move through secondary school. Data are then presented to show that by the end of Year 7, science and mathematics record the poorest attitude scores. Girls, in particular, show little liking for science. There is limited evidence to suggest that these dips in attitude may be reduced within a three-tier system but this is countered by the negative effects on attainment.

The article then goes on to consider possible solutions to these transfer problems. While acknowledging that improved curriculum continuity can help, it presents evidence suggesting that the main reason for pupils' dissatisfaction with lower secondary school science lies with the impoverished forms of pedagogy that are a feature of most science lessons.

This in turn leads to a number of recommendations. First, for a national debate on the teaching of science, specifically concerned with the transfer stage. The starting-point would be an acknowledgement that this long-term problem has not arisen solely because of the current pressures of testing and target setting. Second, for the setting-up of a number of small-scale initiatives in which teachers in the feeder and transfer schools work together to develop an effective pedagogy across transfer that takes account of contextual factors. Third, for a review of existing science initial teacher education courses, which in the last 50 years have failed to bring about fundamental changes in the way that science is taught.

It would seem reasonable to assume that the pupils' first impressions have a part to play in deciding how they cope at the start of secondary school. Some newcomers will seek to immerse themselves fully in both formal and informal school activities, by seeking, for example, to mix in the playground with both more senior students as well as the leaders among their own peers. Others, of a more reserved nature, will perhaps look for like-minded pupils and seek to join the computer or chess club, where they can take refuge during lunchtimes and breaks. Because research has shown that the earlier experiences in the post-transfer period can have an impact on a pupils' academic performance, causing dips in progress, this process of transfer (sometimes termed transition) from primary to secondary school has been given considerable attention by recent governments.

Continuity: The key to successful transfer

Two main theories have dominated the debate about transfer. The first of these might be described as a ‘matching’ theory, whereby it is argued that transfer works best when the school environment fits the young adolescents’ perceived psychological needs and dispositions. In the USA, this *stage–environment fit* hypothesis was first proposed by Eccles *et al.* (1984; see also Eccles and Midgley, 1989), based on the earlier work of Mitchell (1969) on person–environment fit theories. According to Eccles and her colleagues, a poor fit resulted in dips in both pupils’ attitudes and also their attainment. A key element in the young adolescents’ developmental stage was a desire to make their own decisions about where to go, what to do and whom to do it with. This was coupled with ‘goal aspirations’ or the stirrings within an individual of what he or she would like to do on reaching adulthood. These researchers contrasted the ways in which elementary schools created an environment in the senior part of the school that supported these developmental characteristics, while at secondary school pupils reported more competition, less freedom to make their own decisions, and work that consisted mainly of teacher-dominated classroom discourse where learning was controlled by the teacher. Other work in the USA suggests that there is a link between the onset of puberty and the capacity of pupils to establish the congruence between their *ideal* school environment and the *actual* reality (Miller, 1986). Hence transfer around the ages 11 to 13 is particularly important.

Although not developed as a specific theory, these ideas about person–environment matching were very popular in the UK during the 1970s and in the early 1980s, partly because they supported the notion of a three-tier system in which middle schools acted as a transition between the primary and secondary ethos (Hargreaves and Tickle, 1980). Some local authorities found the concept of a middle school very attractive because it enabled them to convert to comprehensive education using the existing school buildings. Thus it was argued that there was a key period in the development of pupils as they moved from childhood to adolescence that required a special kind of school (Schools Council, 1972), but whether this period took place in the 8–12 or 9–13 age ranges often seemed to depend on the number and size of the available schools in the particular local authority.

The notion of a ‘stage–environment fit’ suggests an approach based on gradual change to match the developmental changes taking place within the young adolescent. This leads to an emphasis on a degree of continuity at transfer, particularly curriculum continuity, including both subject matter and teaching methods (Gorwood, 1986). Indeed, some schools in the late 1970s went further in their desire to make the secondary transfer school appear more like its primary feeders by isolating Year 7 so that, as far as possible, the form teacher took most lessons, children were provided with a separate playground to keep them away from the dangers of mixing with their older peers, and increased use of various pedagogic strategies such as group work was encouraged. Research by Youngman (1978) and Youngman and Lunser (1977) tended to suggest, however, that such dramatic organisational adjustments were not necessarily productive or cost-effective. Their research showed that for 79 per cent of pupils any negative feelings lasted for a relatively short period, irrespective of the type of transfer arrangements in place. Such findings were supported by other research in Northern Ireland (Spelman, 1979) and in Scotland (Dutch and McCall, 1974). More recently, Evangelou *et al.* (2008) have reported that 75 per cent of pupils said they had adjusted well by the end of their first term in the transfer school. The first of the ORACLE (Observational Research and Classroom Learning Evaluation) studies of primary schools between 1975 and 1980 also took up the question of transfer and found that the trauma of transfer (slight apprehension mingled with anticipated excitement) had been forgotten by the middle of the first term. However, in about 12 per cent of pupils were the dips in attainment sustained and relatively serious (Galton and Willcocks, 1983). More recent commentators have put the figure at around 10 per cent (Chedzoy and Burden, 2005).

Transfer as a status passage

An alternative view offers a different perspective on the above research findings. Borrowing from anthropology, it makes use of the concept of 'status passage' (Measor and Woods, 1984). In most societies the move from childhood to adolescence, or indeed any change in status, involves a number of special rites that are designed to initiate an individual into their new roles. Accompanying this change in status there is likely to be a degree of folklore that includes myths about what happens during the induction process. Transfer when viewed in this light bears many of the hallmarks of a status passage. Going to 'big school' marks a point in time when 'grown-ups' such as parents and teachers no longer see pupils as children but as 'young adults'. Initiation into the big school involves a series of rituals to do with new subjects, moving to teachers in different parts of the building rather than spending time in a single classroom, and learning how to cope with different organisational arrangements, such as mastering the procedure for selecting one's lunch from a cafeteria-style self-service menu. Accompanying this change in status are certain myths such as 'the royal flush', whereby new pupils are alleged to have their heads held down the lavatory bowl while another pupil pulls the chain. These myths appear to be global.

As Measor and Woods (1984) point out, viewing the transfer process as a status passage is at odds with the previous notion that the main task of the primary and secondary schools is to ensure that there is as much continuity as possible. These authors point out that if the process of transfer were so managed that the changes before and after the move to the big school were minimal, then pupils would have little evidence to suggest a change in status. In this approach, therefore, the desire for continuity needs to be balanced by an element of discontinuity, which recognises the need in pupils for some 'outward signs' that they are successfully managing the change from childhood to young adolescence. The apprehension mingled with excitement that arises during the transfer process is therefore largely a result of this continuity–discontinuity mix. This can be seen in the way that pupils talk about their hopes and fears during the last few weeks of primary school. They worry about losing existing friends but are looking forward to making new ones. They are looking forward to doing new subjects but worry about whether they can cope with the work. In the same way they look forward to having more teachers but are concerned about whether some will be too strict. In this version of events transfer is full of these kinds of dilemma. Some secondary schools, albeit unintentionally, take the status passage approach to the extreme in that the contrasts with the primary world are sharply defined from day one of the new term. Pupils are put in streams for languages, mathematics and science, they move rooms between classes in most subjects, and are completely immersed into the non-academic school activities such as recreational clubs and various sporting activities. Few schools would appear to regularly review this continuity–discontinuity balance to take account of changing trends in primary and secondary education.

In practice, during the 1970–80 period, the stage–environment approach (seeing primary schools as centres of exciting innovations and secondary schools as dull, formal and hidebound by tradition) was often based on rhetoric rather than reality. Galton *et al.* (1980) demonstrated that most primary classes were not hubs of creativity in which children discovered things for themselves, that pupils did not work for a large part of the time cooperatively in groups, and that these schools were not places where pupils participated in the decision making. Other studies, notably those of Mortimore *et al.* (1988) and Alexander *et al.* (1989), confirmed that this was indeed the case, so that although classroom organisation differed between the primary and secondary school (grouped versus single/paired seating), the forms of instruction were very similar. More recent observational studies (Hargreaves and Galton, 2002; Smith *et al.*, 2004) suggest there has been a reversal in trends in primary schools towards even more direct teaching, partly due to the overcrowding of the primary curriculum but also because of the tendency to teach to the test in Year 6. The effects of this limited pedagogy can be particularly problematic at transfer since it may give rise to anti-learning, anti-school dispositions prior to the move, which are reinforced in Year 7 when, despite expectations of change, classroom practice turns out to be very similar to that experienced in the last year of primary school (Pell *et al.*, 2007).

Synthesising research findings stretching from 1976 to 2005, Galton (2007) has suggested that while the amount of questioning in primary classes has risen, the actual balance between open and closed questions has remained at the ratio of 20 per cent to 80 per cent. Looking at the pattern of teacher statements, those concerned with facts remained roughly the same at around 15 per cent between 1976 and when they were again observed in 1996. By 2005, however, they had doubled to around 30 per cent. Statements of ideas had hardly changed; likewise statements giving directions, with the latter category accounting for roughly 50 per cent of all teacher instructional talk. In a study by Webb and Vulliamy (2006), 18 out of the 45 classrooms visited now had desks or tables arranged in rows. While therefore the patterns of questioning seemed to have remained stable in primary classes, the shift to whole-class interactive teaching seems to have promoted a dominance of teaching as transmission. A similar conclusion was reached by Smith *et al.* (2004), who concluded that much of the teaching in the primary classroom, like that in the first year of secondary school, was interrogative and directive in nature. Viewing the process of transfer as a status passage would suggest that one of the reasons for the persistent decline in attitudes comes about because pupils expect to be taught in different ways after transfer, but this rarely turns out to be the case, particularly in the core subjects of mathematics and science, where the dips in attitude are steepest (Galton, Gray and Rudduck, 2003).

Pupils' concerns before and after transfer

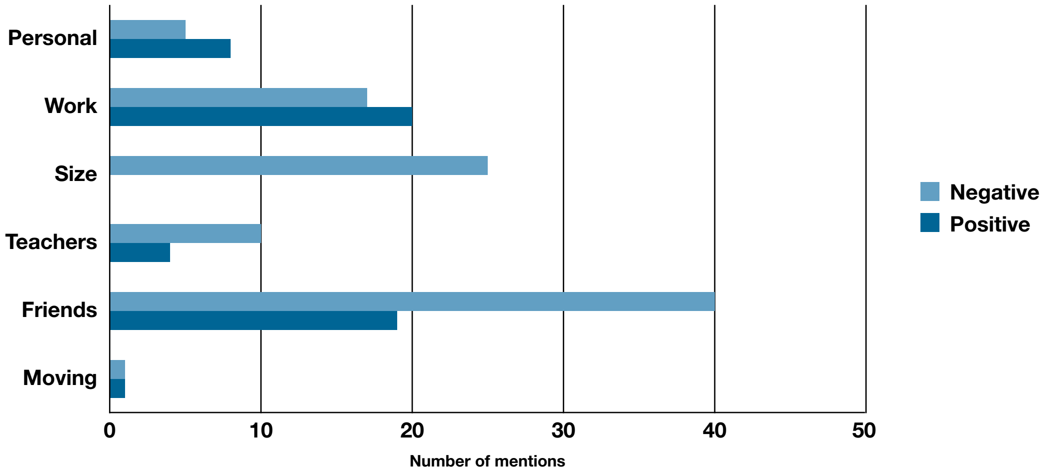
A recent search of the UK literature[1] found 24 studies in which pupils' pre- and post-transfer concerns were identified covering the four decades since 1968. Most of these concerns could be classified under six distinct headings:

1. **Personal adaptability:** Mainly concerns about being the youngest and smallest, and about fitting in with older pupils.
2. **Work:** Coping with different subjects and doing homework on time.
3. **Size:** Getting lost, not using the authorised routes etc.
4. **Teachers:** Adjusting to several teachers (particularly how strict they were).
5. **Friendships:** Making new friends and keeping old ones.
6. **Moving:** Getting to school on time, learning the rules, bringing the right books and equipment, buying school dinners, getting a locker.

In Figures 1 and 2 the relative frequencies of perceptions (both positive and negative) under these six headings are portrayed. The most frequent concerns (i.e. negative perceptions) that are expressed before transfer deal with making new friends and retaining old ones from the primary school. The second most commonly expressed concern relates to the size of the secondary school and of getting lost. Concerns about harder work and coping with homework, the next highest category, are balanced by looking forward to having better facilities such as laboratories for science, a proper drama studio and a dedicated gymnasium for PE.

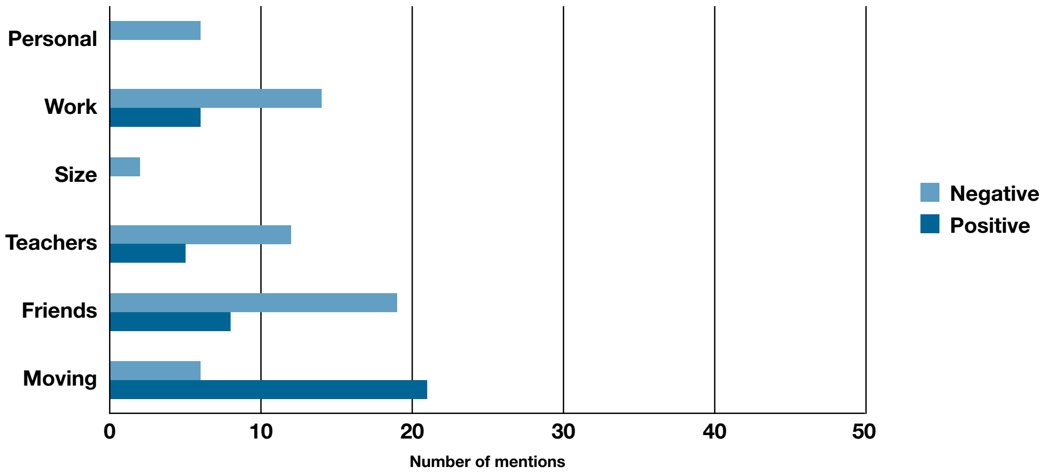
1 I am grateful for the help of my colleague, Ms Jenny Symons, who has carried out an extensive review of transfer studies, on which much of this article is based.

Figure 1: Pupils' pre-transfer perceptions



In Figure 2 the post-transfer perceptions are displayed. Issues relating to the move are now the most frequently mentioned aspect of the transfer but these references are mostly positive. Pupils have learned to find their way around the various buildings, are coping with the school dinner queue, the vagaries of the timetable and getting themselves to school on time. On the negative side, peer relationships and issues to do with work still get most mentions, but these are now closely followed by concerns about various teachers, particularly the way that they apply school rules, including the tendency of some teachers to punish the whole class for an individual's misdemeanour.

Figure 2: Pupils' post-transfer perceptions

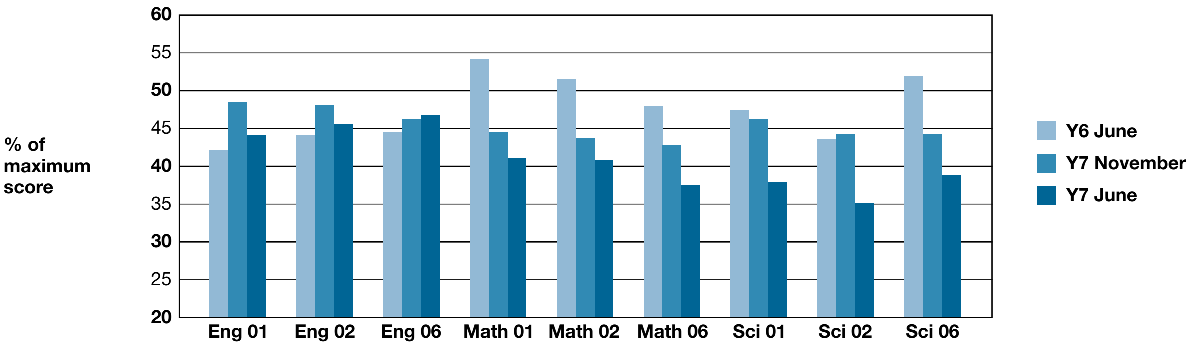


On work-related issues the emphasis tends to have shifted. There are fewer concerns about coping and more expressions of disappointment about the repetitive nature of activities. Concerns about teachers and about the nature of the work appear to be a major determinant of changes in pupils' attitudes over the transfer period.

Changes in pupils’ attitudes during and after transfer

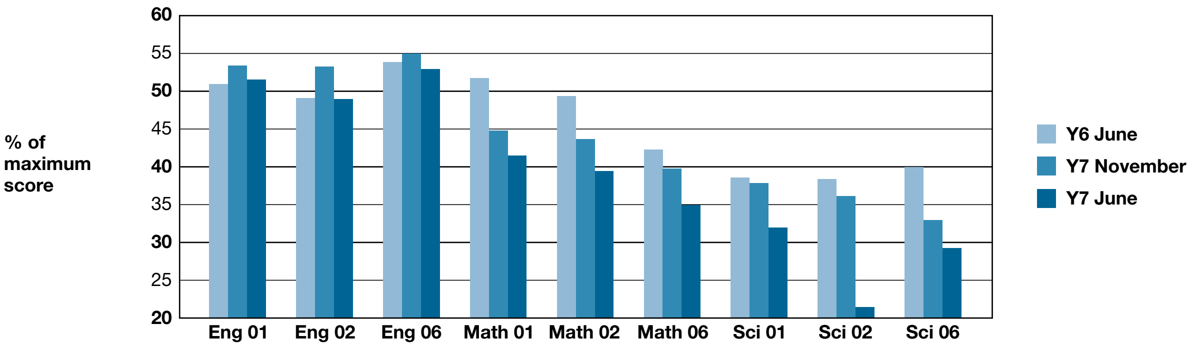
As part of a number of transfer studies carried out at Cambridge since the turn of the millennium, the present writer has collected data on pupils’ attitudes, particularly their liking for English, mathematics and science (Hargreaves and Galton, 2002; Galton *et al.*, 2003, in press). The 2001/02 data were collected from approximately 4500 pupils (1500 girls and 3000 boys), mainly from four local authorities. All show regular dips as pupils move from Year 6 to the end of Year 7. In Figure 3, the boys’ attitudes are displayed. The 2005/06 data come from a new study and therefore do not involve the same schools as used in the two earlier surveys. The data here come from six primaries feeding into three transfer schools in one local authority and involved a further 600 pupils. The intensities of the attitudes have been converted into percentages: for instance, a score of 3 on a scale of 1 to 5 represents 50 per cent. It can be seen that only in three cases does the average score exceed the midpoint of the scale. Two of these are for Year 6 mathematics and one for Year 6 science. For English there are slight improvements in attitudes at the start of Year 7 but thereafter they either decline or, for 2006, show a slight but statistically insignificant gain. In mathematics and science the overall pattern is for attitudes to decline further as pupils move from Year 6 through Year 7.

Figure 3: Boys’ attitudes to core subjects



When the corresponding attitudes for girls are examined, in Figure 4, then the situation for science shows a much sharper decline. Liking for science at the end of primary school is lower than the 40 per cent in all cases and falls throughout Year 7, with the lowest recorded figure of 21.5 per cent in 2002.

Figure 4: Girls’ attitudes to core subjects



The results are in line with similar studies covering the same period. Attitudes declined in all subjects year on year except in English for girls in Year 9. The biggest dips occurred between Years 7 and 8 and Years 9 and 10. Girls had superior attitudes in English, boys in science and mathematics (Miller *et al.*, 1999). Barmby *et al.* (2008), using a questionnaire with Likert rating scales, found that the largest dips between Years 7 and 9 occur with learning science in school (effect size = –1.19) but that the negative effects were reduced when learning was undertaken through doing practical work in science, with a correspondingly smaller effect size of –0.21.

This dip in attitudes towards science at secondary level appears to be a consistent trend spanning several decades and pre-dating the more recent decline at primary level as reported by Osborne *et al.* (2003) and by Tymms *et al.* (2008). Science attitudes have declined on transfer to secondary school and thereon from year to year, with girls having lower scores (Brown, 1976; Doherty and Dawe, 1985; Francis and Greer, 1999). Other studies, mostly from the USA, have produced similar results (Yager and Yager, 1985; Simpson and Oliver, 1985; George, 2000, 2006), although the gender contrasts are not so marked. In Australia, Baird *et al.* (1990) found dips in science attitude at transfer, as did Speering and Rennie (1996), where the decline was sharper for girls. These dips appeared to continue in subsequent years. The continued decline in science attitude scores as pupils move through the lower secondary school therefore appear to be a characteristic of most developed countries around the world, but international comparisons suggest that the trend may be more marked in the UK (Martin *et al.*, 2004, 2008; Bradshaw *et al.*, 2007). Most researchers attribute the dips at transfer to the failure of the actual lessons to meet the high expectations that pupils bring with them at transfer. Viewing the purpose-built laboratories and beguiled by the exciting demonstrations on induction day, pupils assume that secondary school science will largely consist of doing experiments, only to discover very quickly that many of these activities (separating a solid from liquid by filtration or evaporation) have already been done at primary school, don't occupy much lesson time, and require extensive writing up, first in rough books and then again for homework.

Attainment dips in science at transfer

There is less reliable information about changes in pupils' performance in science when moving from primary to secondary school. Where measurements have been made as in the original ORACLE study (Galton *et al.*, 1980) and its subsequent replication (Hargreaves and Galton, 2002), the assessment has focused on literacy and numeracy because standardised versions of tests were readily available. However, Bunyan (1998) and Nicholls and Gardner (1999) have used questions taken from the Year 6 statutory tests in science with Year 7 pupils and also found dips of the order of 5 per cent.

Two- versus three-tier systems

Based on the stage–environment fit theory, some commentators have suggested that a three-tier system might at least slow down the decline in attitudes and lead to eventual improvements in attainment. However, there is little recent comparative evidence in the UK on the differences in performance at different ages of transfer. Galton and Willcocks (1983) and Hargreaves and Galton (2002) found that dips in attainment were greatest when transfer occurred earlier. The fact that dips in attainment do occur at every transfer point, however, raises the question of whether these are cumulative so that pupils entering a three-tier system would be more disadvantaged than their peers who entered a two-tier arrangement. To answer this question fully it would be necessary to track a cohort of children in a three-tier system from their last year in first school at nine years of age until one year after transfer to high school at 14 using as a control a similar group of pupils who experienced a single transfer to a secondary school at 11 years of age. No such longitudinal studies exist.

It is, however, possible to accumulate partial evidence, based on the average levels of academic performance in schools operating different transfer systems, at key milestones such as the Key Stage 2 and 3 national tests, and to use these scores to predict performance at GCSE. Such analysis has to be undertaken at school level and needs to assume relatively stable pyramids so that most of the pupils from the same feeder schools move to the same transfer school. Only the Suffolk Education Authority, with a reasonable mix of two- and three-tier pyramids, has conducted such a detailed analysis in England. It carried out three reviews (Suffolk, 1996, 2001, 2006), of which the latter one provides the more comprehensive analysis.

In the Suffolk (2006) review, results for four cohorts of pupils from 2002 to 2005 were analysed. At Key Stage 1 there were no differences between the two- and three-tier systems but by the end of Key Stage 2, significant differences had occurred in all three statutory assessments. In science, although the proportion of pupils achieving level 4 was very similar (88 per cent in the two-tier schools compared with 85 per cent in the three-tier system), at level 5 the corresponding percentages were 44 per cent and 36 per cent respectively, which was statistically significant. By the end of Key Stage 3, however, this difference had been eliminated, with 74 per cent of pupils gaining level 5 under both arrangements and 43 per cent and 42 per cent obtaining level 6 in the two- and three-tier systems respectively. Overall, therefore, the evidence in the case of science attainment was not conclusive. In the another British study, Boyle and Nelson (2000) compared a national sample of two- and three-tier schools by conducting a statistical analysis of Year 7 progress tests in the summer of 2000 and comparing these results with the same cohorts' scores on the 1999 Key Stage 2 national tests, but this only covered English and mathematics. The findings were not too dissimilar from those in the Suffolk (2006) review.

Symonds (2007) has criticised the findings of the Suffolk (2006) review, which concluded because of the differences in English and mathematics at Key Stage 2 that a two-tier system was to be preferred. Adopting the stage–environment fit approach of Eccles *et al.* (1984), Symonds argues that pupils in the two-tier system have more time to adjust to the new environment than the middle school pupils before taking the Key Stage 2 national tests. Placing such a high-stakes assessment at the end of primary schools gives the two-tier system an extra advantage; this argument is supported by the finding that the middle schools generally make up lost ground by the time of the Key Stage 3 assessments.

America operates various forms of tier arrangements and several studies have examined the effects of transfer at different ages. The most frequently cited is that of Alspaugh and Harting (1995), whose review focused upon reading, mathematics, science and social studies achievement. Comparisons involved two K–4, two K–5, two K–6 and two K–7 schools.[2] These researchers argued that the key factor accounting for dips in attainment was the change from self-contained (with generalist teaching) to departmentalised (with specialist teaching) classrooms that generally occurred at the end of elementary school. No direct information on the magnitude of the dips at different ages was provided but the above finding implies that compared with the teaching arrangements it was of less importance whether the transfer was to a middle, junior high or high school.[3] The 'dips' in reading achievement were the most significant. In a later study, Alspaugh (1998) did, however, find that when pupils transferred to high school at ninth grade the dips in attainment were greater for pupils who had experienced more than one transfer previously This analysis does therefore provide some limited evidence that the effect of frequent transfers may be cumulative.

In addition to these studies there are also two general reviews on transfer that refer to the effect of multiple transfers. Juvonen (2004) reviewed 20 years of relevant literature and analysed existing national and international data. The author found very few studies that had compared schools with different grade configurations. Nearly all of these tended to suggest that young teenagers who made fewer transfers did better. Another review, undertaken by Yecke (2005), concluded that students who transferred at grade eight did better than students who transferred at an earlier grade, and that this improvement was maintained through high school. A Canadian study by Lipps (2005) found, in contrast to the US findings, that changing schools made little difference to the adolescents' academic performance, regardless of school type, but that a three-tier system had less negative emotional and behavioural impact.

Considered as a whole, the North American evidence suggests that delaying the move from elementary school helps to reduce dips at transfer, although there appear to be no specific results for science – except for Rice (1997), who found dips were greatest among more able pupils when transfer to the high school took place at 11 or 12 years of age rather than at 13 or 14.

2 In the US system, pupils enter kindergarten at around 4 or 5 years of age. Thus a K–4 school goes from kindergarten to the end of Grade 4, by which time the pupil is 8 or 9 years old. Similarly pupils will leave the K–5 school at 10 or 11, the K–6 school at 11 or 12 and the K–7 school when they are 12 or 13 years old.

3 In the USA there are a variety of three-tier systems. Students can move from middle to high schools at Grade 7, 8 or 9 and leave at the end of Grade 12 when they are 17 or 18 years of age. Students can also attend a junior high school at Grades 7 or 8, moving to a senior high school at Grade 10.

What can be done to reduce dips in attitudes at transfer and beyond?

Most studies of transfer have found that the 'fresh start' approach still predominates and that Year 7 teachers are often unaware of the contents of the primary syllabus (Galton *et al.*, 1999; Braund and Driver, 2005). According to Pell *et al.* (2007), there appears to be a negative association between attainment and school enjoyment ,suggesting that it is the more able children who are put off by having to repeat work done in the primary school.

One favoured strategy for overcoming this lack of curriculum continuity has been to make use of 'bridging units'. The aim of these units is to enable Year 7 teachers to gain insights into the capabilities of the primary children and to build on these as part of the work that continues in the secondary school during the first weeks after transfer. However, the first of these units, developed by the Qualifications and Curriculum Authority (QCA, 2002) in English and mathematics, met with partial success. An evaluation by Galton *et al.* (2003) found that these units were received with mixed feelings by both primary and secondary teachers. Teachers at primary level said that the need to devote each morning to literacy and numeracy activities in the period up to the national tests meant that the rest of the curriculum was squeezed, so that children missed out on subjects such as art, drama and physical education. There was also little time available for extended investigation. Primary teachers therefore tended to use the time after the May tests to do more imaginative and creative activities. Consequently, there was a certain degree of resentment at having to devote more time to the core subjects, particularly since some of the topics chosen by the QCA had been 'done to death' during Year 6 as part of the National Curriculum. Where primary teachers did do the units, therefore, they tended not to follow their logical order but to pick and choose from various sections, which they thought would be more interesting to the pupils. This made a mockery of the idea of continuity.

For the secondary teachers there were also problems. To begin with, not all transfer schools had distinct catchment areas; some took pupils from up to 15 primary feeder schools. In this situation, the greater proportion of Year 7 pupils might come from three or four schools while others might contribute as few as half a dozen pupils each. Liaison with these latter primary schools would be poor, so that pupils might arrive for the first term after the move having not done any of the bridging units. This presented problems to the teachers who then had to have some pupils doing extra work that others had already done in the main feeder schools.

Moreover there appeared to be uncertainties among teachers as to the purpose of the units. Many teachers saw them as yet another element in the process of social adjustment by giving Year 7 pupils work with which they would have been familiar from primary school, thus providing an easy introduction into academic life in the secondary school. Where this view prevailed, certain consequences followed. First, secondary teachers spent less effort reviewing the work done before transfer, since they did not see the curriculum continuity issue as of vital importance. This in turn produced indifference on the part of the pupils who thought that the teachers were not interested in the work and therefore did not take the tasks set at secondary level seriously. More importantly, because teachers did not see the purpose was to promote curriculum continuity they tended to see the units as a finite piece of work and therefore did not associate what was undertaken with what was to follow subsequently. As one pupil interviewed by Galton *et al.* (2003) responded in relation to a locally produced science bridging unit on the life cycle of the moth:

> Once we'd finished it the teacher put on his white coat and we did the Bunsen burner.

There was also another interesting result that reflects on the continuity versus discontinuity issue and supports the importance of transfer as a status passage. One mathematics teacher reported to Galton *et al.* (2003) that she completed the bridging unit during the first three weeks of the new autumn term. At that point the pupils needed new mathematics exercise books and she gave these out with instructions to her Year 7 set to cover them with paper and write on the front 'Year 7, Set 2 Maths Book'. She recounted that immediately she spoke these words the class cheered loudly. The implication here is fairly clear. The pupils had associated the work done in the bridging unit with work they did in the primary school. It was only when they received their Year 7 maths book that their new status was confirmed; the cheers may have been ones of either relief at finally emerging from their primary school status, or anticipation at the new challenges that they assumed they would now follow.

Nevertheless, there have been more favourable reports of the use of bridging units, particularly when they are jointly constructed within a pyramid and take account of local factors (Suffolk, 2001). This approach has several advantages compared with the weaknesses of the QCA units. First, such units are more likely to provide a meaningful context so that the pupils can study recognisable topics with which they are familiar and that, hopefully, are of interest to them. Investigating the canals in a Midlands town, the characteristics of a coastal region in a school on the Norfolk–Suffolk border, and solving a murder mystery entitled 'Who killed the Chef?', based on a famous city hotel that had been the subject of a TV programme, are all such examples. In the latter case pupils in the primary school used microscopes to identify materials found at the murder scene in order to deduce from the evidence the most likely guilty person. On coming to the secondary school they were introduced to further ideas about chromatography and on then retesting various samples were able to arrive at a new suspect. This is the kind of unit recommended by both Davis and McMahon (2004) and Braund and Driver (2005). According to these latter authors, "too many introductory topics in Year 7 still begin with training in basic laboratory skills" and fail to recognise the previous levels of competence and experience gained at primary school, as one Year 7 pupil explained:

> "You are always experimenting, testing and investigating about the same things [as in primary school] only in secondary school you just have better equipment" (Braund and Driver, 2005, p. 88)

These authors therefore argue that a crucial factor in designing effective bridging units is to ensure that the levels of practical skills and the concepts used are an advance on what was done at primary school, thus building in an element of discontinuity but also of progression, as in the 'Who killed the Chef?' unit described previously. In their own work based on these ideas they report around 87 per cent pupil satisfaction. It is also noticeable that in the best examples schools have tended to use an integrated approach that combines some work in science with different forms of writing and some mathematics calculations. This has the advantage that pupils do not have to do too many units (making them feel, as in the earlier example, that they are still doing primary school work). This approach only appears to work, however, if there is active cooperation between the various departments within the secondary school and it is not just part of an induction programme mainly handled through the personal, social and health education programme. Braund (2007) offers a more ambitious alternative in seeking to identify common topics taught in Years 5 and 6 in primary school and Years 7 and 8 after transfer, so that teachers at each level can make explicit links both forwards and backwards in terms of the concepts taught and the experimental techniques used. Built into these teaching units are pupil self-assessment activities designed to ensure smoother progression.

Bridging units work best, therefore, when there are clearly defined local pyramids so that most of the teachers in the feeder and transfer schools can play a part in their production. An added advantage of developing locally based units is that the discussions will involve not only the curriculum content but also the pedagogy to be used in order to deliver the materials.

Pedagogy: the missing link

Whenever pupils are asked about their views on transfer, the nature of the teaching appears to be a major determinant of the pupils' interest and enjoyment of a subject. Thus mathematics and science often generate little enthusiasm. In both Hargreaves and Galton (2002) and Galton *et al.* (2003), Year 7 pupils ranked both subjects (along with foreign languages) among the least popular. When asked to explain the reasons for this unpopularity nearly three-quarters of all pupils interviewed complained that there was too much writing and too little practical activity in science.

Hargreaves and Galton (2002) observed English, mathematics and science lessons and demonstrated that the patterns of interaction were almost identical before and after transfer. Overall, the proportions of questions and of statements show very little variation between Years 6 and 7. Pre-transfer questions formed 16.2 per cent of all observations while the figure post-transfer was 18.5 per cent. The corresponding figures for statements were 59.2 per cent and 57.3 per cent respectively. Thus over half of these lessons involved teachers talking *at* rather than *with* their pupils.

These categories are broken down further in Table 1, where the different types of question and statement are recorded as a percentage of total questions and statements respectively. It can be seen that in both year groups the balance of questions is almost identical, with open, more challenging questions least frequent. Most statements made are directions, telling pupils what to do either about task procedures or, for example, on some routine behaviour matter. Promoting challenging ideas is the least used category both before and after transfer. Neither is there evidence to suggest that the patterns of classroom interaction differ substantially in the earlier primary years (Alexander, 2000; Moyles *et al.*, 2003), which tends to refute suggestions that classroom practice in Year 6 is largely dictated by the need to prepare pupils for the end-of-year national tests.

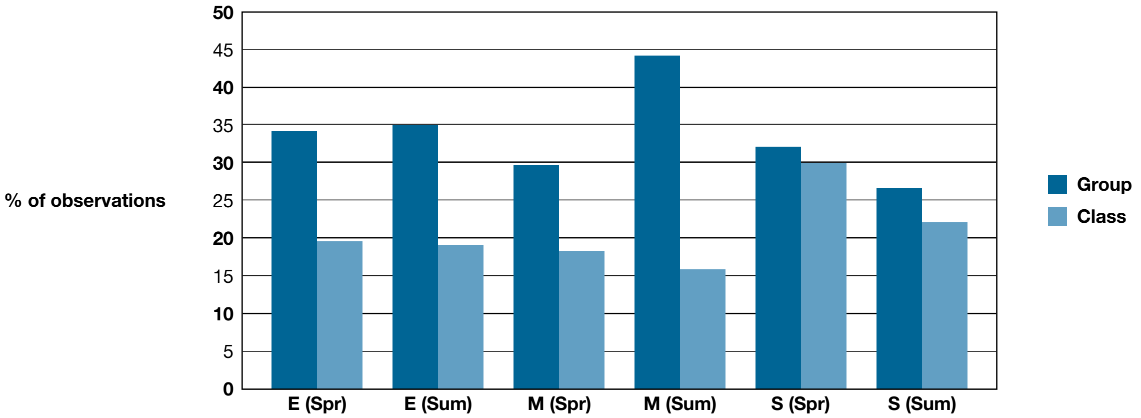
Table 1: Different types of question and statement pre- and post-transfer as a percentage of total questions and statements

	Year 6	Year 7
Questions		
Factual	35.7%	35.6%
Closed	50.0%	51.0%
Open	14.3%	13.4%
Statements		
Facts	13.7%	17.8%
Ideas	4.4%	9.3%
Task directions	45.8%	49.2%
Routine directions	36.1%	23.7%

In a more recent study, the Social Pedagogical Research into Grouping (SPRinG) project (Blatchford *et al.*, 2003), more specific information is available for science in the lower secondary school. In developing the Key Stage 3 National Strategy the then Department for Education and Skills sought to encourage more group work (DfES, 2004). However, in the pilot study of the Key Stage 3 Strategy, Stoll *et al.* (2003) found that whole-class teaching continued to dominate the pedagogy of the core subjects, although when pupils were asked about their preferred way of learning 90 per cent of the sample of Year 8 pupils expressed a preference for working in groups rather than for whole-class teaching. This finding is supported by Pell *et al.* (2007), where a majority of pupils from Year 7 to Year 9 showed a strong liking for working in groups, provided these groups were effective. However, research by Kutnick *et al.* (2005), who surveyed a mix of Year 7 and Year 10 classes, showed that pupil grouping was used infrequently and was rarely determined by the nature of the task. In science, the main factor that decided whether group work would be carried out was the availability of equipment. In other cases the decision to move to group work was often arbitrary. For example, in one instance reported in Kutnick *et al.* (2007) the teacher's rationale for changing from 'class' to 'groups' was "because children appeared to be bored with the class work".

Research studies have shown that for group work to be effective it is necessary to develop the quality of pupils' higher-order thinking, particularly the increased use of explanations as part of the reasoning process (Webb, 1985, 1989). Figure 5 displays the proportions of the aggregated interaction categories (*asking questions*, *offering explanations*, *making suggestions*, *agreeing* and *disagreeing*) in group and whole-class settings, which are associated with the kinds of higher-level cognitive discourse advocated by Webb. The data were collected as part of the SPRinG project (Galton *et al.*, 2009).

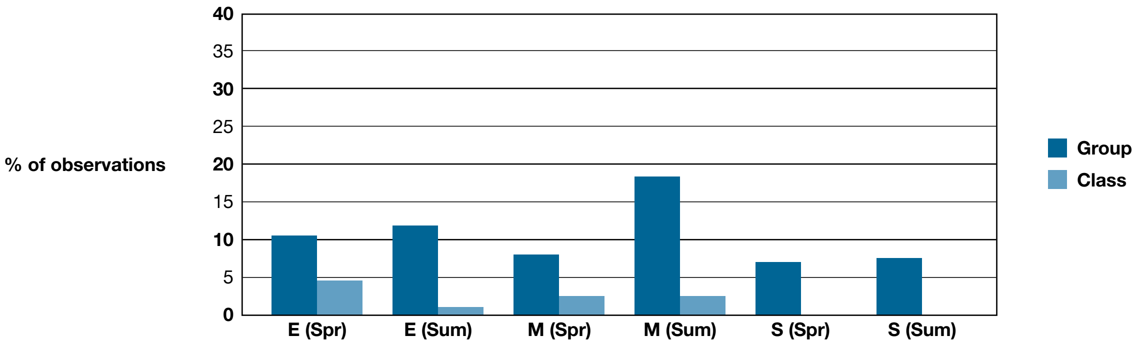
Figure 5: Open dialogue as a percentage of all observations in group vs class settings, in English (E), maths (M) and science (S) in spring (Spr) and summer (Sum) terms



In both English and mathematics in both the spring and summer terms the figures for the groups are superior. However, in science, although pupils in groups outperform those in the whole-class situation, the differences are marginal. In interpreting the data in Figure 5 it should be remembered that the process favours the class rather than the group because of the sampling procedures. During the observation the various categories of pupil behaviour and pupil–adult interaction taking place were coded every 30 seconds. In the group situation two groups were picked at random whereas in the class situation all pupils were included because they belonged to one group, the class.

Figure 6 examines the number of interactions that extended into the next 30-second time unit and so were classified as sustained. These findings confirm previous research on whole-class interactive teaching where there is little extended conversation. In groups, pupils were able to sustain conversations as a consequence of their increasing willingness to offer more explanations and to debate and discuss alternatives, as represented in Figure 5. Science presents the extreme case, in that there were no recorded sustained conversations during whole-class discussion.

Figure 6: Sustained interactions as a percentage of all observations in group vs class settings, in English (E), maths (M) and science (S) in spring (Spr) and summer (Sum) terms



The data recorded in Table 1 and Figures 5 and 6 go some way to explaining why pupils in secondary school find science such a dull subject. The relative lack of open-ended questions and statements of ideas, the emphasis on facts and directions and the lack of sustained conversations all suggest that science lessons provide insufficient intellectual challenge. Asked for explanations for this state of affairs most classroom practitioners cite the restricted, overcrowded Key Stage 3 curriculum, the tyranny of testing and the frequent need to carry out target setting as major impediments (Galton and MacBeath, 2008). Others attribute the cause to the lack of teaching expertise in chemistry and physics and the consequent need for much of the 'balanced' science courses in the lower secondary school to be taught by biologists (Royal Society, 2007). The government's recent decision to scrap the Key Stage 3 tests and to allow more flexibility in choice of content should, on these accounts, do much to improve current pedagogy.

Those familiar with the field of classroom research will be less optimistic. Over the last two decades there have been numerous initiatives by governments in many countries designed to change the way that teachers teach. However, both recent and past history would suggest that attempts to change classroom practice on a large scale have rarely been successful. Yair (2000) estimates that despite various reforms, some well-intentioned, about 80 per cent of US teachers continue with a didactic approach and 15 per cent attempt to change but fail, leaving only 5 per cent who are able to innovate successfully. In the UK the emphasis at primary level in particular has been on attempts to improve classroom dialogue through the use of 'interactive whole-class teaching', but a recent paper from the government-sponsored Innovation Unit concludes that the strategy had resulted "in a rash of lessons and closing plenaries characterised by fast and furious closed questions and superficial answers rather than exploratory discussion and reviewing learning that was the aim" (Cordingley and Bell, 2007, pp. 4–5).

Such examples tend to support the historical analysis of pedagogy since the mid-19th century by Cuban and Tyack (1995), which argues that teaching has always been a *conservative* profession. The study of science teaching some three decades ago confirms this view. In the first major systematic observation study carried out in the UK, Eggleston *et al.* (1976) were able to show that the dominant characteristic of the typical science classroom was, as it still is today, a blend of closed questions, factual statements and task directions. This, it should be remembered, was at a time when specialist subjects were taught throughout most secondary schools, when there was no serious shortage of specialist teachers and when the curriculum was highly innovative with the introduction of the Science 5–13 programme (jointly funded by the Schools Council, the Nuffield Foundation and the then Scottish Education Department), as well as other Nuffield Foundation initiatives with similar enquiry-based objectives.

Alexander (2004), commenting on the rigidity of current practice, argues that too often pedagogical considerations are reduced in official documents to a discussion of teaching methods alone rather than substance and justification, given that pedagogy is also a "morally purposeful activity". He goes on to note that in continental Europe this requires intending teachers to study the wider culture (the philosophy, history, literature and art of the country) to master elements relating to child development and children's learning (psychology, physiology etc.) and to deepen their understanding of the subjects to be taught and the ways of teaching them effectively. Consideration of the latter (the subject disciplines) is often referred to as didactics. Currently in most initial training courses the emphasis is placed almost entirely on didactics. A different approach is taken by Michael Barber (2002), the former head of the Standards Agency, who argues that improvements in pedagogy will come about as a result of "informed professionalism", whereby teachers inform their classroom practice on the basis of research reviews such as latest EPPI (Evidence for Policy and Practice Information) surveys.

This is a reassuring view of the present situation but, unfortunately, one without much foundation. It does not explain why research that is methodologically strong, and that is consistent in its results, the kind that is rated highly in EPPI reviews, appears to hold less attraction for teachers than other offerings, such as 'learning styles', or 'left brain–right brain' training procedures such as 'Brain Gym', for which the research evidence is far less strong or negligible. Furthermore, those like Barber who call for an evidence-based approach to pedagogy often fail to recognise that, as Anderson and Burns (1989) argue:

> Contrary to some people's opinions, evidence does not speak for itself. The translation of evidence into thought and action requires people who understand both the research and the classroom. (Preface)

Alexander (2000) endorses this view, arguing that while there is a component of pedagogy that embodies general principles of teaching, these have to be situated in the context of the individual teacher's classroom, allowing for judgements about the *fitness for purpose* of particular actions within a particular context. This latter kind of knowledge Alexander terms 'craft knowledge'.

Teachers' decision making is not, however, solely based on principled judgements allied to experience. Because teaching is also an emotional as well as a cerebral activity (Hargreaves, 2001), the approaches that teachers *intentionally* choose often become modified during lessons on account of their feelings, particularly fear of losing control of a situation by admitting too many of the pupils' ideas.

Conclusions and recommendations

The problem of transfer is therefore part of a wider problem of finding the means of helping teachers to learn to modify the way that they teach, beginning with the realisation that while external pressures exacerbate the classroom situation the root cause of the reluctance to change practice lies within the individual.

Thus the first recommendation is to **institute a national debate that concentrates specifically on the teaching of science at transfer and agrees (or perhaps restates) a common set of pedagogical principles that are flexible enough to accommodate different classroom contexts (e.g. ability grouping, gender, facilities etc.) and that also addresses the issue of balancing continuity with a degree of discontinuity.** While, previously, there have been several useful reviews on the state of science in English schools, concentration is needed specifically on improving pedagogy across the transfer stage. A useful model for such an enquiry would be that of the Primary Review conducted by Robin Alexander at Cambridge. The aim would be for the pedagogy to dictate the curriculum rather than continue with the current strategy, where the focus is mainly on curriculum continuity.

The second recommendation is about putting these agreed principles into practice. Research shows that teachers need to understand the principles of learning that support pedagogic practice if they are to sustain change; otherwise, they revert to old ways when under pressure. Yet teachers often say they don’t want too much theory when they attend professional development courses. How therefore are key principles to be made relevant and meaningful? Recent small-scale initiatives built around ‘communities of practice’ as described by Chris Watkins (2005) and by Stoll and Louis (2007) here in the UK, and Louis and Marks (1998) in the USA, are examples of possible ways forward. An important result of these developments is regenerating teachers’ sense of their own professionalism. **There will therefore be a need to support a number of small-scale initiatives that allow groups of transfer and their feeder schools to work together in ways that foster communities of practice and that are carefully monitored so that shifts in pedagogy can be assessed and then shared more widely.**

The final recommendation concerns initial teacher education. Most initial teacher training institutions include up-to-date ideas about pedagogic practice in their courses but for various reasons newly qualified teachers tend to adopt the existing practices of their more experienced colleagues in the school. Tutors, while accepting this happens, argue that at some later date these new ideas will be recalled and implemented. The evidence is that this rarely happens; otherwise, more reforms would come to fruition. The present arrangement, dominated by the one-year postgraduate training course, is probably too short and too concentrated to produce the teachers that are needed. **Current approaches used to train science teachers should be reviewed, perhaps adopting a ‘stage development’ model in which student teachers first master some basic survival strategies before returning to the institution to develop more advanced teaching skills.**

This would seem to be the minimum required, since to continue with the present established patterns of classroom discourse is to ensure that the current low level of attitudes towards science will be perpetuated among future cohorts of pupils for many generations to come.

References

Alexander R. Culture and Pedagogy: International comparisons of primary education. Oxford: Blackwell; 2000.

Alexander R. Still no pedagogy? Principle, pragmatism and compliance in primary education. Cambridge Journal of Education 2004;34(1):7–33.

Alexander R, Willcocks J, Kinder K. Changing Primary Practice. London: Falmer Press; 1989.

Alspaugh J. Achievement loss associated with the transition to middle school and high school. Journal of Educational Research 1998;92(1):20–5.

Alspaugh J, Harting R. Transition effects of school grade-level organization on student achievement. Journal of Research and Development in Education 1995;28(3):145–9.

Anderson L, Burns R. Research in Classrooms: The study of teachers, teaching and instruction. Oxford: Pergamon Press; 1989.

Baird J, Gunstone R, Penna C, Fensham P, White R. Researching the balance between cognition and affect in science teaching and learning. Research in Science Education 1990;20(1):11–20.

Barber M. The next stage for large scale reform in England: from good to great. Background Paper presented to the Federal Reserve Bank of Boston 47th Economic Conference, 'Education in the 21st Century: Meeting the challenges of a changing world', 19–21 June 2002.

Barmby P, Kind P, Jones K. Examining secondary school attitudes in secondary science. International Journal of Science Education 2008;30(8):1075–93.

Blatchford P, Kutnick P, Baines E, Galton M. Toward a social pedagogy of classroom group work. International Journal of Educational Research 2003;39:153–72.

Boyle B, Nelson N. Transition from Year 6 to Year 7 in England: Progression or regression? Manchester: Centre for Formative Assessment; 2000.

Bradshaw J, Sturman L, Vappula V, Ager R, Wheater R. Achievement of 15-year olds in England: PISA 2006 National Report (OECD Programme for International Student Assessment). Slough: National Foundation for Educational Research; 2007.

Braund M. 'Bridging work' and its role in improving progression and continuity: an example from science education. British Educational Research Journal 2007;33(6):905–26.

Braund M, Driver M. Pupils' perception of practical science in primary and secondary school: implications for improving progression and continuity of learning. Educational Research 2005;47(1):77–91.

Brown S. Attitude Goals in Secondary School Science. Stirling: University of Stirling; 1976.

Bunyan P. Comparing pupil performance in Key Stages 2 and 3 science SATs. School Science Review 1998;79(289):8–87.

Chedzoy SM, Burden RL. Making the move: assessing student attitudes to primary–secondary transfer. Research in Education 2005;74:22–35.

Cohen J. Power Analysis for the Behavioral Sciences. New Jersey: Lawrence Applebaum Associates; 1988.

Cordingley P, Bell M. Transferring Learning and Taking Innovation to Scale. London: The Innovation Unit; 2007.

Cuban L, Tyack D. Tinkering towards Utopia: A century of public school reform. Cambridge, MA: Harvard University Press; 1995.

Davis D, McMahon K. A smooth trajectory: developing continuity and progression between primary and secondary science education through a jointly planned projectile project. International Journal of Science Education 2004;26(8):1009–21.

Department for Education and Skills. Pedagogy and Practice: Teaching and learning in secondary schools. Unit 10: Group Work. London: DfES; 2004.

Doherty J, Dawe J. The relationship between development maturity and attitude to school science: an exploratory study. Educational Studies 1985;11(2):93–107.

Dutch R, McCall J. Transition to secondary – an experiment in a Scottish comprehensive school. British Journal of Educational Psychology 1974;44(3):282–9.

Eccles J, Adler T, Meece J. Sex differences in achievement: a test of alternate theories. Journal of Personality and Social Psychology 1984;46(1):26–43.

Eccles J, Midgley C. Stage environment fit: developmentally appropriate classrooms for young adolescents. In: R Ames, C Ames (eds). Research on Motivation and Education: Goals and cognition. New York: Academic Press; 1989.

Eggleston J, Galton M, Jones M. Processes and Products of Science Teaching. London: MacMillan for the Schools Council; 1976.

Evangelou M, Taggart B, Sylva K, Melhuish E, Sammons P, Siraj-Blatchford I. What Makes a Successful Transition from Primary to Secondary School? Effective Pre-school, Primary and Secondary Education 3–14 Project (EPPSE 3–14) Research Report DCSF-RR019. Annersley, Notts: Department for Children, Schools and Families; 2008.

Francis L, Greer J. Measuring attitude towards science among secondary school students: the affective domain. Research in Science and Technological Education 1999;17(2):219–26.

Galton M. Learning and Teaching in the Primary Classroom. London: Sage Publications; 2007.

Galton M, Gray J, Rudduck J. The Impact of School Transitions and Transfers on Pupil Progress and Attainment. Research Report RR131. Nottingham: DfEE Publications; 1999.

Galton M, Gray J, Rudduck J. Transfer and Transitions in the Middle Years of Schooling (7–14): Continuities and discontinuities in learning. Research Report RR443. Nottingham: DfEE Publications; 2003.

Galton M, Hargreaves L, Pell T. Group work and whole class teaching with 11 to 14 year olds compared. Cambridge Journal of Education 2009;39(1):113–34.

Galton M, MacBeath J. Teachers under Pressure? London: Sage Publications; 2008.

Galton M, Simon B, Croll P. Inside the Primary Classroom. London: Routledge and Kegan Paul; 1980.

Galton M, Stewart S, Hargreaves L, Pell T, Page C. Motivating Students in the Secondary School. London: Sage Publications; in press.

Galton M, Willcocks J (eds). Moving from the Primary School. London: Routledge and Kegan Paul; 1983.

George R. Measuring change in students' attitudes to science over time: an application of latent variable growth modelling. Journal of Science Education and Technology 2000;9(3):213–25.

George R. A cross domain analysis of change in students' attitudes towards science and attitudes about the utility of science. International Journal of Science Education 2006;28(6):571–89.

Gorwood B. School Transfer and Curriculum Continuity. London: Croom Helm; 1986.

Hargreaves A. Emotional geographies of teaching. Teachers College Record 2001;103(6):1056–80.

Hargreaves L, Galton M. Moving from the Primary Classroom: 20 years on. London: Routledge; 2002.
Hargreaves A, Tickle L (eds). Middle Schools: Origins, ideology and practice. London: Harper & Row; 1980.
Juvonen J. Focus on the Wonder Years: Challenges facing the American middle school. Santa Monica: RAND Education; 2004.
Kutnick P, Blatchford P, Clark H, MacIntyre H, Baines E. Teachers' understandings of the relationship between within-class (pupil) grouping and learning in secondary schools. Educational Research 2005;47(1):1–24.
Kutnick P, Hodgkinson S, Sebba J, Humphreys S, Galton M, Steward S, Blatchford P, Bains E. Pupil Grouping Strategies and Practices at Key Stage 2 and 3. Research Report 796. Nottingham: DfES Publications; 2007.
Lipps G. Making the Transition: The impact of moving from elementary to secondary school on adolescents' academic achievement and psychological adjustment. Family and Labor Studies Division, Analytical Studies Branch, Statistics Canada; 2005.
Louis K, Marks H. Does professional community affect the classroom? Teachers' work and student experiences in restructured schools. American Journal of Education 1998;106(40):532–75.
Martin M, Mullis I, Gonzalez E, Chrostowski M. TIMSS 2003 International Science Report. Boston: TIMSS and PIRLS International Study Centre, Lynch School of Education, Boston College; 2004.
Martin M, Mullis I, Foy P. TIMSS 2007 International Science Report. Boston: TIMSS and PIRLS International Study Centre, Lynch School of Education, Boston College; 2008.
Measor L, Woods P. Changing Schools: Pupils perspectives on transfer to a Comprehensive. Milton Keynes: Open University Press; 1984.
Miller C. Puberty and person–environment fit in the classroom. Paper presented at the meeting of the American Educational Research Association, San Francisco, April 1986.
Miller D, Parkhouse P, Eagle R, Evans T. Pupils and the core subjects: a study of the attitudes of some pupils aged 11–16. Paper presented to the British Educational Research Association Annual Conference, University of Sussex at Brighton, 2–5 September 1999.
Mitchell J. Education's challenge to psychology: the prediction of behaviour from person–environment interactions. Review of Educational Research 1969;39:695–721.
Mortimore P, Sammons P, Stoll LD, Ecob R. School Matters: The junior years. Wells: Open Books; 1988.
Moyles J, Hargreaves L, Merry R, Paterson F, Esarte-Sarries V. Interactive Teaching in the Primary School. Maidenhead: Open University Press; 2003.
Nicholls G, Gardner J. Pupils in Transition: Moving between Key Stages. London: Routledge; 1999.
Osborne J, Simon S, Collins S. Attitudes towards science: a review of the literature and its implications. International Journal of Science Education 2003;25(9):1049–79.
Pell T, Galton M, Steward S, Page C, Hargreaves L. Group work at Key Stage 3: Solving an attitudinal crisis among young adolescents? Research Papers in Education 2007;22(3):309–32.
Qualifications and Curriculum Authority. Transition Units (English and mathematics). London: QCA; 2002.
Rice J. Explaining the negative impact of the transition from middle to high school on student performance in mathematics and science: an examination of school discontinuity and student background variables. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, 24–8 March 1997.
Royal Society. The UK's Science and Mathematics Teaching Workforce: A 'state of the nation' report, 2007. London: The Royal Society; 2007.
Schools Council. Education in the Middle Years. Working paper no. 2. London: Evans-Methuen; 1972.
Simpson R, Oliver J. Attitudes towards science and achievement motivation profiles of male and female students in grade six through ten. Science Education 1985;69:511–26.
Smith F, Hardman F, Wall K, Mroz M. Interactive whole class teaching in the National Literacy and Numeracy Strategies. British Educational Research Journal 2004;30(3):395–412.
Speering W, Rennie L. Students' perceptions about science: the impact of transition from primary to secondary school. Research in Science Education 1996;26(3):283–98.
Spelman B. Pupil Adaptation to Secondary School. Publication no. 18. Belfast: Northern Ireland Council for Educational Research; 1979.
Stoll L, Louis K (eds). Professional Learning Communities: Divergence, depth and difficulties. Maidenhead: Open University Press; 2007.
Stoll L, Stobart G, Martin S, Freeman S, Freedman E, Sammons P, Smees R. Preparing for Change: Evaluation of the implementation of the Key Stage 3 Pilot Strategy. Final Report. London: Department for Education and Skills; 2003.
Suffolk Education Department. A Report of an Investigation into What Happens When Pupils Transfer into Their Next Schools at the Ages of 9, 11 and 13. Ipswich: Inspection and Advice Division, Suffolk County Council; 1996.
Suffolk Education Department. Transfer Review 2001. Ipswich: Suffolk County Council; 2002.
Suffolk County Council. School Organisation Review. Ipswich: Suffolk County Council Children and Young People's Services; 2006. www.suffolk.gov.uk/sor [accessed 14 April 2009].
Symonds J. The ambiguities of comparing transfer 'effects' between two and three tier systems: suggestions for improving declines in attitudes and achievement: a review of the literature. Research Papers. National Middle Schools Forum; 2007.
Tymms P, Bolden D, Merrell C. Science in English primary schools: trends in attainment, attitudes and approaches. Perspectives on Education 1 (Primary Science), 2008;19–41. www.wellcome.ac.uk/perspectives [accessed 9 April 2009].
Watkins C. Classrooms as Learning Communities: What's in it for schools? London: Routledge; 2005.
Webb N. Student interaction and learning in small groups: a research summary. In: R Slavin, S Sharan, S Kagan, R Hertz-Lazarowitz, N Webb, R Schmuck (eds). Learning to Cooperate, Cooperating to Learn. New York: Plenum Press; 1985. pp. 147–72.
Webb N. Peer interaction and learning in small groups. International Journal of Educational Research 1989;13:21–39.
Webb R, Vulliamy G. Coming full circle? The impact of New Labour's education policies on primary school teachers' work. London: Association of Teachers and Lecturers; 2006.
Yager R, Yager S. Changes in perception of science for third, seventh and eleventh grade students. Journal of Research in Science Teaching 1985;22(4):347–58.
Yair G. Educational battlefields in America: the tug of war over students' engagement with instruction. Sociology of Education 2000;73(2):247–69.
Yecke C. Mayhem in the middle: how middle schools have failed America – and how to make them work. Compact Guides to Education Solutions. Washington, Thomas B Fordham Institute; 2005.
Youngman M. Six reactions to school transfer. British Journal of Educational Psychology 1978;48(4):280–9.
Youngman M, Lunzer E. Adjustment to Secondary School. Nottingham: School of Education; 1977.

About the author

Professor Maurice Galton, a former Dean of Education at the University of Leicester, is now a Senior Research Fellow in the Faculty of Education, University of Cambridge. He has conducted numerous large and small-scale evaluations, using a combination of systematic observation and case study methods. He is best known for his longitudinal studies of primary classrooms, which have covered teacher and pupil styles, the use of cooperative group work and transfer to secondary school. He has regularly acted as a consultant for the Hong Kong Education Department, most recently in an evaluation concerning the effectiveness of class size reductions in primary school. Currently he is a visiting professor at the Hong Kong Institute of Education.

E mg266@cam.ac.uk

Progression and continuity in learning science at transfer from primary to secondary school

Martin Braund
Senior Lecturer in Science Education, Centre for Innovation and Research in Science Education, University of York

Summary

The problems of disjunction in pupils' learning at transfer from primary to secondary school have been recognised for over half a century. Teaching provision either side of transfer has often been inconsistent with a spirally arranged curriculum that assumes continuity and progression in learning but does not take enough account of the curriculum content of primary schools or pupils' previous experiences and achievements. Pupils in primary schools look forward to doing science in secondary school but their enthusiasm is soon blunted by needless repetition of work without additional challenge, an environment that does not celebrate their work and contexts for learning that seem irrelevant to their everyday lives.

Key points

- There is evidence of significant regression from Key Stage 2 to Key Stage 3 in pupils' performance in national tests in science that does not occur in English or mathematics. Regression is also evident in studies based on retests using the same questions in Key Stage 3 as in Key Stage 2.
- Explanations for post-transfer regression in science during Key Stage 3 are consistent in the literature from the UK and overseas and fall into four main areas: repetition of primary work, a change in the environment and culture for learning science, achievements from primary school not being recognised or valued at Key Stage 3, and a lack of trust in transferred information on learning and achievement.
- There is evidence that many secondary schools adopt a 'tabula rasa' (clean slate) approach to teaching science as a result of a lack of knowledge of and trust in pupils' experiences of primary science.
- Secondary teachers may not be aware of the extent to which pupils entering their schools are already conversant with, understand and can apply key language and terminology in science.
- Bridging units are one way of addressing the differences in pedagogy and curriculum either side of transfer, though some writers caution that using them destroys a sense of *discontinuity* that pupils look forward to when they move to secondary school.
- Other criticisms of using bridging units are: the breakdown of school clusters as a result of the free market results in lack of coherence; primary teachers want to do other things following Key Stage 2 SATs; pupils look forward to doing new work and want to leave their primary experiences behind; and work done in primary school is rarely referred to in sufficient depth after pupils have transferred.
- Lengthy bridging projects may be counterproductive as they impact negatively pupils' attitudes following transfer.
- There is evidence that, if planned with clear progression linked to investigation in everyday contexts and with consistent teaching approaches at each side of transfer, bridging work is enjoyed by pupils and helps them transfer to secondary science.
- There is some evidence that using bridging work reduces post-transfer regression in science (effect size = 0.2).
- Training in using bridging work is important to ensure that teachers plan for and use the right amount of progression, particularly in the variables investigated in practical work each side of transfer.
- Bridging work is most successful when it is part of a coordinated programme of transfer measures that includes teachers sharing their practice through meetings, exchange of assessed work and co-observation of each other's teaching.
- Co-observation and co-teaching work best when they involve professional dialogue between teachers that improves an awareness of each other's practice and teaching styles.
- Meetings to compare pupils' assessed work are most productive when they avoid arguments about lack of equivalence of National Curriculum levels either side of transfer.

Introduction

In life we go through moments of transition resulting in relative disruption or even dysfunction: a new job, getting married or divorced, moving house and so on. Some of these may involve setbacks as well as being points from which we move on. The educational life of the child contains several points of transition: from pre-school to formal schooling, from infant to junior phases, from primary to secondary school, from secondary school to sixth form or work and then into further and/or higher education. When these transitions coincide with a physical shift in location of learning from one school or institution to another we refer to them as 'transfers' (Galton, Gray and Rudduck, 1999). From the child's view transfers are particularly significant because they represent shifting phases of significant amounts of time in their lives at the moments they are experienced.

Before compulsory schooling for all became a reality in the UK there was already an awareness of the problems that disjunction between one phase of schooling and another might mean for pupils' learning. In *The Primary School*, one of the two publications generally known as the Hadow Report that preceded and shaped the 1944 Education Act, the following appeared:

> …there should be no sharp edges between infant, junior and post-junior stages, and transition from one stage to the succeeding stage should be as smooth and gradual as possible. (Board of Education, 1931, p. 70)

The fact that similar hopes were being expressed over 50 years later in the period leading up to the design and implementation of the National Curriculum in the mid-1980s (Department of Education and Science/Welsh Office, 1985) and are still today (Estyn, 2008; Evangelou *et al.*, 2008; Ofsted, 2008) is, perhaps, evidence of one of British education's greatest failures. As far as the National Curriculum was concerned, the introduction of science as a compulsory subject into all primary schools from 1989 presented a new set of responsibilities:

> The development of science in primary schools imposes an added responsibility on the schools to which the pupils transfer: they have to ensure, if the goal of making science from 5 to 16 a continuum is to be realised, that pupils' early start is neither ignored nor undervalued but rather reinforced and exploited in their subsequent work. Suitable arrangements for ensuring continuity and progression are therefore essential. (Department of Education and Science/Welsh Office, 1985, para. 32, p. 11)

Against this background the National Curriculum 'experiment' proceeded. The age-related design for learning with its key stages and repeated content areas owes much to the spiral curriculum envisaged by Bruner (1960). Bruner realised that construction of knowledge relies on a continual process through which learners develop complexity of thinking by integrating new experiences, observations and knowledge with what they already know and have experienced. According to Bruner, the child already has mental templates for interpreting the world, so new experiences are matched against these and templates develop and change to accommodate new ways of thinking (Bruner, 1966).

With such a spirally conceived curriculum came the expectation that teaching should be planned well, especially at stages involving transfer from one school to another, to avoid needless repetition of work and so that pupils' previous achievements might be recognised and progressed accordingly. But why should this be seen as particularly important in science rather than in subjects such as mathematics, history or geography? It may be that subject content, key ideas and skills in science are seen as having to be progressively developed rather than compartmentalised into study at different ages. As for other subjects, for example, history has different periods, geography has regions and mathematics has processes of numerical manipulation and abstraction. In these subjects it is perhaps easier to allocate content to different programmes (and so ages) of study, though of course overarching subject attributes such as chronological awareness and interrogation of primary sources in history, geographical enquiry and measurement and data handling in mathematics all require careful planning for continuity and progression.

For pupils entering their new senior schools new experiences and different topics are exciting prospects, and science is one of the subjects most pupils to look forward to (Jarman, 1990; Griffiths and Jones, 1994; Schagen and Kerr, 1999; Morrison, 2000; Hargreaves and Galton, 2002; Ofsted, 2002; Galton, Gray and Rudduck, 2003). In secondary school you are now studying the Tudors and not Romans and South America not England. But in science – it is forces, and energy, and living things, and materials – *yet again*. That this is natural, because curriculum designers and teachers have thought to progress learning of the 'big ideas' of science in a gradual way, according to a spiral-constructivist approach, is lost on young minds ready and eager to learn and experience new things. The science laboratory and much practical work are what pupils look forward to most in secondary school science (Jarman, 1993; Braund and Driver, 2005; Braund and Hames, 2005), and these aspirations are easier for secondary schools to satisfy than content-related ones (Jarman, 1997; Braund, 2007). Even when pupils transfer from ICT-rich environments in primary schools to relatively poor ICT provision in secondary schools, it is practical work rather than ICT that holds the key to pupils' maintaining positive attitudes to science (Beauchamp and Parkinson, 2008). There are, however, concerns that the quality of the learning experience suffers in an 'anything goes as long as it keeps them busy' approach to practical work in the first years of secondary school and that clear learning objectives are sacrificed in an attempt to make every lesson a practical one (Abrahams and Millar, 2008).

The scope and structure of the review

This review concentrates on learning of science, though recognising that it can never ignore or be isolated from broader social and cognitive issues relevant to and affecting learning in many subjects.

The review begins by critically examining evidence for regression in science learning experienced by many pupils after transferring to secondary school and some of the reasons for this. Rather than attempting to address many common approaches to the problems, it concentrates on the contributions of bridging work and of teachers sharing reflections on practice to improving progression and continuity of science teaching and learning. The review draws mainly on the literature relevant to the UK but some work from other countries is used where it illuminates efforts made here. The majority of studies on primary–secondary transfer in science have been based in England and Northern Ireland but findings are relevant to all parts of the UK. The Scottish system diverges most from that of the other home nations in that pupils transfer from primary schools at 12 rather than at 11 and science is not represented as a distinct curriculum subject until age 14. Nevertheless, the societal and sociocultural differences that impact education in Scotland, including transitions and transfers, are more similar to other counties of the UK than they are different (HM Inspectors of Schools, 1999; Raffe *et al.*, 1999).

The evidence for post-transfer regression in school science

If progression lines in the programmes of study and associated assessment schemes of the National Curriculum worked as they should, and assuming performance target levels set for the ends of different stages are realistic, we could assume that disjunctions represented by transfers between schools would not last very long – impact on progression as evidenced by pupils' advances in performance would be small. So a comparison of pupils' performance on national tests taken at the end of Key Stage 2 (age 11) and at the end of Key Stage 3 (age 14), three years later, should show an advance (or at least consistency) in the numbers of pupils achieving the target level for their age group – in other words that there were signs of progression. For science this has clearly not been the case, and this has been used as evidence by Ofsted to pronounce that "standards in Key Stage 3 do not yet reflect the great strides made by primary science…up to a third of pupils have not progressed beyond the expected level for 11 year olds" (Ofsted, 2000, p. 1). Table 1 (see Braund, 2008, p. 24) compares percentages of pupils who achieved the expected target level at the end of Key Stage 2 (level 4 or above) with the percentages of the *same population* of pupils three years later when they had reached the end of Key Stage 3. The figures confirm that the pattern identified by Ofsted continues. In English and mathematics the same pupils do not show anything like as severe a regression in performance. Indeed, in recent years (from 2005) there are signs that in English and mathematics the 'regression gap' has closed and more pupils are now achieving target level in Key Stage 3 than did so in Key Stage 2, while science remains in regression.

Table 1: Pupils achieving target levels in National Curriculum tests at the end of Key Stage 2 (age 11) and end of Key Stage 3 (age 14)

	Percentage of pupils at or above target level in end of Key Stage 2 tests				Percentage of pupils at or above target level in end of Key Stage 3 tests		
	English	Mathematics	Science		English	Mathematics	Science
2000	75	72	85	**2003**	68	70	68
2001	75	71	87	**2004**	68	70	68
2002	75	71	86	**2005**	74	74	70
2003	75	73	87	**2006**	73	77	72
2004	78	74	86	**2007**	74	76	73

(Braund, 2008, p. 24)

It could be claimed that comparing test results for different subjects gives a false picture because tests in science cannot be robustly compared with those in mathematics or English at either Key Stage. Several authors report that teachers (mainly in secondary schools) often regard SATs at Key Stage 2 as simple memory tests and that intensive revision periods artificially inflate pupils' performance (Jarman, 1993; Kaur, 1998; Nicholls and Gardner, 1999; Nott and Wellington, 1999; Schagen and Kerr, 1999; Galton, Morrison and Pell, 2000; Gray, Hussey and Schagen, 2003; Braund, 2008).

A further criticism is that tests at Key Stage 3 are based on a programme of study that draws on much more demanding and abstract concepts requiring more than the simple descriptions and basic pattern recognition required at Key Stage 2. On the other hand, we should remember that tests have changed radically at both Key Stages since 2002 and now include a significant proportion of questions (about 40 per cent at each Key Stage) that require application of procedural knowledge and understanding such as about variables for investigation, recognition of patterns and relationships, strategies for measurement, and interpretation of graphs and tables. It could be argued that procedural understanding should be more substantial, less ephemeral and less prone to inflation through revision. But, although according to data in Table 1 there has been a slight closing of the regression gap in science since 2005, the basic trend and negative comparisons with performance in English and mathematics continue. One could claim that conceptual leaps from one stage to another exist in mathematics and yet the same populations of pupils do not show as much regression and indeed, since 2004, there is evidence of advance in numbers in mathematics who reach the Key Stage 3 target compared with numbers who reached target for Key Stage 2.

Stronger evidence challenging the test comparison critique comes from retests administered in secondary schools using the same questions from national test papers taken at the end of the primary phase. It could be argued that regression in retests is natural to expect because primary pupils were primed to take tests and secondary pupils' greater knowledge might make them more likely to read too much into questions. Even so, even greater amounts of regression than those seen in comparisons of national test results have been noticed. For example, Doyle and Herrington cite a study by Nicholls where 65 per cent of pupils who were retested immediately following transfer regressed, though this recovered to 25 per cent when the same questions were used again at the end of the first term in secondary school (Doyle and Herrington, 1998). Even when questions selected for the retest examine procedural aspects, such as recognition of experimental variables and manipulation of data, which are less susceptible to inflation through revision than content-related questions, regression (over 50 per cent) in a retest used six weeks following transfer has been noted (Braund, 2007, p. 919).

Before moving to explanations for post-transfer regression in science, it is worth examining some of the research comparing primary and secondary classrooms. In 1976 Galton described teaching and learning in classrooms in primary, middle and secondary schools in studies that were part of the ORACLE project (Observational Research and Classroom Learning Evaluation; Galton, Simon and Croll, 1980). ORACLE research was repeated 20 years later. Lessons in English, mathematics and science were observed in primary schools, the same pupils being seen again some months after they had transferred to their secondary schools. Galton measured pupils' on-task behaviour in lessons, allocating pupils to different 'pupil personae' (Hargreaves and Galton, 2002). He found the numbers of pupils showing high levels of on-task behaviour (in effect a measure of concentration) declined in science following transfer. In mathematics and English on-task behaviour actually increased slightly. Since these pupils did not show particular dislike for science before or after transfer, findings were explained in terms of probable boredom, perhaps connected with repetition of work covered before in primary school or a perception that activities were just uninteresting compared with previous experiences in primary schools.

Accounting for post-transfer regression in school science

In the late 1980s and early 1990s, Ruth Jarman carried out a series of studies of primary–secondary transfer in science, seminal in this field of research in science education. Jarman analysed open, written responses from 1767 pupils from primary schools across Northern Ireland (8 per cent of the school population at that age), comparing their views of primary and secondary science and their aspirations and anxieties about transfer related to learning science (Jarman, 1993). Additionally, she researched teachers' views on transfer issues at the time of the introduction of the Northern Ireland curriculum (Jarman, 1990) and conducted a six-year longitudinal study of the views of teachers who had responsibility for Key Stage 3 science in 50 schools. Much of what we know and understand about primary–secondary transfer, as it affects pupils learning science and issues such as regression in pupils' performance, comes from Jarman's work, but there are other notable studies in the UK that have made important contributions. Schagen and Kerr (1999) carried out a telephone survey of 114 schools across 11 LEAs and interviewed teachers and pupils in 17 primary schools and ten secondary schools. Nicholls and Gardner (1999), drawing on previous work in Northern Ireland, reviewed aspects of practical experience and the difficulties of planning and progressing science work across transfer. Doyle and Herrington (1998) carried out action research in a cluster of schools attempting to improve liaison and transfer schemes for science. Pointon (2000) carried out a small-scale study involving interviews of pupils post-transfer, and Morrison (2000) analysed email communication from 100 pupils in secondary schools who contacted Year 5 and Year 6 pupils in the primary schools that they had attended to tell them about how they were finding secondary work. From these and other studies it is possible to identify four continuing and consistent themes accounting for and influencing pupils' performance in and attitudes to science following transfer to secondary school:

1. **Repetition:** Pupils may repeat work done at primary school, often without sufficient increase in challenge, sometimes in the same context and using identical procedures (Secondary Science Curriculum Review, 1987; Jarman, 1990; House of Commons Education Committee, 1995; Galton *et al.*, 1999; Morrison, 2000).
2. **The environment and culture of learning:** Teaching environments, teaching styles and teachers' language are often very different in secondary schools compared with primary schools. The use of collaborative group work and display of pupils' work is less than in primary classrooms. This represents a change in learning culture to which pupils have difficulty adjusting (Pointon, 2000; Hargreaves and Galton, 2002; Moore, 2008).
3. **Valuing previous learning:** Teachers in secondary schools often fail to make use of, or refer to, pupils' previous science learning experiences. Information supplied by primary schools on their pupils' previous attainments is rarely used effectively to plan curriculum experiences in the secondary school (Doyle and Herrington, 1998; Nicholls and Gardner, 1999; Schagen and Kerr, 1999). This makes it difficult for teachers to respond to the individual learning needs of pupils that have arisen because of different prior experiences and achievements.

4. **Trust in assessment:** Teachers in secondary schools distrust the assessed levels of performance gained by pupils in national tests in science, taken by all pupils in England (and previously Wales), at the end of primary school. As discussed earlier, teachers in secondary schools often claim these levels have been artificially inflated by intensive revision for these tests (Bunyan, 1998; Schagen and Kerr, 1999). This may be used by secondary teachers as justification for 'starting from scratch' when planning new learning (Nott and Wellington, 1999).

These themes accounting for post-transfer regression in science are not unique to the UK. Studies elsewhere have identified similar problems, e.g. in the USA (Anderson *et al.*, 2000), Australia (Scharf and Schibeci, 1990) and in Finland (Pietarinen, 2000). These themes are not solely the invention of academics nor mere products of research. For example, Braund collected teachers' explanations for post-transfer regression in science at training days, conferences and through internet surveys and found that the same themes were used by teachers to explain post-transfer regression from primary to secondary phases as well as for transfer from secondary to tertiary education (Braund, 2008, pp. 52–6).

In these surveys, teachers were asked whether they thought National Curriculum levels represented equivalent levels of skill, knowledge and understanding across the primary–secondary transfer as was intended in the design of the National Curriculum (Department of Education and Science/Welsh Office, 1988). Teachers were more inclined to accept equivalence of levels for practical work (Sc1) than they were for science as a whole, confirming findings from other studies (Jarman, 1997; Peacock, 1999).

Repetition of work without additional challenge or reason, as perceived by pupils, is one of the most consistent and crucial factors explaining post-transfer regression in science. For example, Jarman found many pupils claimed that much of their primary work, even exactly the same experiments, was repeated in secondary school science lessons. If repetition is reinforcement that develops both conceptual and procedural learning, supporting Bruner's 'spiral curriculum', then some revisiting of topics might be justifiable. But the problem is that some repetition occurs because teachers are unaware of, ignore or denigrate pupils' previous achievements. In their extensive survey carried out for the National Foundation for Educational Research, Schagen and Kerr found that several heads of science in secondary schools said that, despite science having been taught as a National Curriculum subject for several years, they would assume that pupils entering Year 7 would have little or highly variable knowledge and experience of science and so they would adopt a 'tabula rasa' (clean slate) approach (Schagen and Kerr, 1999, pp. 37–8). The same assumption about starting from scratch has been noted in other studies of secondary science teachers' opinions of primary science (Jarman, 1993; Nott and Wellington, 1999), but there is no evidence to show whether these attitudes have changed in the last 20 years. A question emerging from these findings is, then, how do pupils react to repetition? Do they learn to tolerate it or does it quickly erode the generally positive attitudes that they have to science at the start of secondary school? The demotivating effect that repetition can have is shown starkly by this comment, from Morrison's email study, sent from a Year 7 pupil to Year 6 pupils in her old primary school:

> "I used to like science, but here we started from scratch" (Morrison, 2000 p. 47)

In a study of 144 16-year-olds' recollections of and attitudes to school science by Osborne and Collins (2001), one of the most negative comments about experiences of school science centred on the needless repetition of work. According to Osborne and Collins, pupils viewed repetition negatively in two ways:

1. From the point of view of repeated tests to prove the same point, e.g. colour changes of indicators with acids/alkalis. According to Osborne and Collins this is repetition to persuade pupils of the validity of a worldview but without addressing why it matters.
2. Repetition of topics without increasing depth from primary to secondary school and from lower to upper school. There is excitement of meeting new things in Year 7 (atoms, molecules and electrons) but boredom and demotivation through repetition of this content knowledge in subsequent years.

Thus it seems that repetition remains a key issue not just at transfers but in year-to-year and topic-to-topic transitions, and that it has long-lasting impact on pupils' attitudes.

Finally, it is worth considering what research has to say about the issue of language in science across the Key Stage 2–3 transfer, as this has a bearing on the extent to which pupils' previous experiences are valued and built on (point three in the list of aspects accounting for post-transfer regression). In 1999, Graham Peacock presented results from a study commissioned by the Qualifications and Curriculum Authority (QCA). In his study, Peacock (1999) asked teachers from three clusters of primary and secondary schools in three different Local Education Authorities what concepts, terms and words associated with plants and changes of state they would expect their pupils to know and understand. As expected, he found an increase in numbers and complexity of terms used from Key Stage 1 to Key Stage 2, but there was a *marked decrease* from Key Stage 2 to Key Stage 3. There were a striking number of cases where more teachers in primary schools expected an understanding of terms such as melting and boiling point, evaporate and molecule than their secondary counterparts receiving pupils a few months later. Regression in language is not unique to science. It was evident in English lessons in the ORACLE study (Galton *et al.*, 1999). Words in science, however, are important vehicles for conceptual understanding and Peacock's findings are yet another example of how much progress made in primary science is underappreciated by secondary schools.

Addressing curricular and pedagogical discontinuities at transfer

In 1998 the Centre for Study of Comprehensive Schools issued questionnaires at its regional conferences to establish what was commonly done to address post-transfer regression. The results were analysed by Galton and presented in an influential report to the Department for Education and Skills (Galton *et al.*, 1999, pp. 22–8). Galton summarised efforts to improve transfer as what have come to be known as 'bridges' to smooth primary–secondary transfer. The first 'bridge' deals with administrative actions such as transfer of data and communication with parents, the second with social efforts such as open and induction days, buddying and peer mentoring, and the third and fourth bridges address continuity (or discontinuity) of curriculum content and pedagogy (teaching styles). Strategies associated with the third and fourth 'bridges' typically include co-observations of teaching, improving teachers' knowledge of content taught each side of transfer, shared assessment of pupils' work and jointly planned teaching. This part of the review concerns the last of these.

A common approach is to plan and provide work that pupils start at the end of primary school and complete in secondary school. Schemes in this area are variously described as transition units (Department for Education and Skills, 2002), link projects (Davies and McMahon, 2004) and bridging units (QCA, 2000; Braund, 2002). As with other actions on transfer, work has been most prolific in English and mathematics where units of work have been made available to schools in England by the Qualifications and Curriculum Authority and the Department for Education and Skills (QCA, 2000; DfES, 2002, 2003). In science no such units have been available and so it has been left to groups of schools, often working in conjunction with local authorities and/or in collaboration with higher education institutions, to devise these materials. The aims for bridging work (referring to English) were identified by the DfES as follows:

- Pupils experience a lesson structure they are familiar with and understand.
- There is a consistency in teaching approach that helps pupils respond to new people (i.e. classmates and new teachers) in new surroundings.
- Pupils build on their early successes and demonstrate what they know, understand and can do in the context of the work they did in Year 6.
- Teachers are better informed about pupils' strengths and weaknesses and can use the lessons to confirm their assessments and plan teaching programmes that meet the needs of their pupils.
- There is greater continuity and progression and less repetition of work. (DfES, 2002, p. 3)

Some writers caution against using work that might seem, to pupils after transfer, to be simplistic, babyish or too rooted in primary experience. For pupils, the move from primary school is an important marker of growing up and so there is the notion of *discontinuity* of experience that is natural and is what pupils look forward to and thrive on (Derricott, 1985; Stringer, 2003). The discontinuity idea appears to represent a block to bridging work. Additionally, Galton's research has criticised the use of bridging units in mathematics and science on the basis that:

1. The breakdown of school ‘pyramids’, where well-defined groups of primary school pupils are transferred to one secondary school, means that not all pupils entering secondary school science classes will have covered the primary part of the bridging unit.
2. Primary teachers and their pupils are not very enthusiastic about the use of these materials after the stresses of national tests carried out in the last term of primary school and the revision period that preceded them.
3. Primary teachers may be unwilling or lack time to mark work and provide comments that would provide the amount of detail to allow secondary teachers to develop and progress the topic according to pupils’ individual needs.
4. Some pupils claim they rarely see the work that has been transferred, or that primary work is only referred to at a superficial level and then the secondary teacher returns to ‘business as usual’.
5. Pupils entering secondary school expect and look forward to doing new things. They want to leave their primary experience behind.

(Summarised by reference to: Galton, 2002; Galton, Gray and Rudduck, 2003; Galton, Hargreaves and Pell, 2003.)

Experiences of bridging in Australia (Scharf and Schibeci, 1990) and in Scotland (Dutch and McCall, 1975) show that lengthy projects (involving a term or more of transition work) have a negative impact on pupils’ attitudes at transfer. In Australia, this was particularly true for low-achieving girls, who ended up showing marked declines in attitudes compared with similar pupils who had not been involved in bridging work.

Recognising these issues and that Year 6 teachers have a packed timetable of activities they wish to pursue in the weeks following national tests (Galton, Hargreaves and Pell, 2003), research and development teams at the University of York designed, implemented and evaluated bridging ‘units’ in science (Braund, 2008). Four design criteria, each based to some extent on evidence of what works, were set for the units:

1. Investigations in each unit were framed in industrial and commercial contexts likely to appeal to pupils of this age (tasting and investigating ‘fizzy drinks’ and making ‘bread’). The York team’s previous experience with context-based approaches in science education (e.g. Salters’ Science [Campbell *et al.*, 1990]) and a recent meta-analysis of research on the use of such contexts (Bennett, Hogarth and Lubben, 2003) indicated that they are motivating and have a positive impact on pupils’ attitudes to science.
2. Teaching in Years 6 and 7 was carefully designed to promote continuity in approach. For example, lessons were planned around a three-part structure (starter activity, main activity and concluding phase) and common teaching strategies were encouraged in each phase, e.g. the use of a poster to help pupils plan investigations, concept cartoons (Keogh and Naylor, 1999) to prompt group discussions and letters from fictitious companies to prompt discussion about variables investigated.
3. Practical work was designed to progress from Year 6 to Year 7 in terms of context and procedural and conceptual demand.
4. Previous studies have shown that pupils expect to use more sophisticated equipment when they arrive in secondary school (Jarman, 1993; Braund and Driver, 2005). The investigations in Year 7 were, therefore, designed to allow pupils to use a wider range of different apparatus than is commonly available in primary schools.

Thus the York bridging units provided what has been called *planned discontinuity* (Derricott, 1985; Gorwood, 1994). For example, there was planned ‘discontinuity’ of experience with equipment and in being in a laboratory but ‘continuity’ in teaching approaches used at each Key Stage. In the York work, progression was planned to provide sufficiently challenging new work in Key Stage 3. In the case of the ‘Bread’ unit, there were opportunities to use ICTs rarely available in primary schools. For example, carbon dioxide evolved from reacting yeast mixtures was passed though lime water (calcium hydroxide) and a light sensor was used to measure the optical density as the solution turned ‘milky’ (with the progressive formation of calcium carbonate).

Evaluating bridging work – does it make a difference?
A common criticism of projects on transfers and transitions is that few of them have been evaluated in any depth, even though substantial sums of money have been spent on them (Galton, Gray and Rudduck, 1999; Peacock, 1999; Hall *et al.*, 2001; Ofsted, 2002, 2008; Galton, Hargreaves and Pell, 2003; Estyn, 2008). This was not the case at York, where research on the impact of bridging was built into the project design (Braund, 2007; 2008). Data were collected from pupils and teachers in 27 primary and ten secondary schools that used bridging work, using questionnaires, telephone and group interviews. Additionally, retests of pupils' performance on selected items from national tests at Key Stage 2 were carried out with 270 pupils in two high schools, one that had been involved in bridging work and one that had not. Contrary to Galton's predictions, there was an overwhelmingly positive reaction from pupils to bridging work. Eighty-eight per cent of responses in primary and secondary schools were positive. This level was much higher than the 30 per cent reported for another bridging project in England that also used context-led approaches to investigative work carried out either side of transfer (Davies and McMahon, 2004). The strongest themes emerging from analysis of pupils' responses evident in both Year 6 and Year 7 were:

- that bridging work gives a sense of comfort and familiarity at the start of the secondary science course
- that bridging work improves confidence in Year 7 as a result of experience of practical technique or previous knowledge gained in the work done at primary school
- that the work was not merely a repetition in Year 7 of primary experience but was complementary and covered new ground.

One of Galton's critiques of bridging work is that pupils might see Year 7 work as mere repetition of topics and procedures already covered and that this runs against what they are looking forward to in secondary science (Galton, 2002). Although comments about repetition were not the most frequent, pupils in both years did make specific but positive references to it, for example:

> I feel that it's better doing it more than once because you will find out different stuff. Not the same stuff you found out this time…different stuff, what the coke was made from or something.

In Davies and McMahon's 2004 study, 25 per cent of Year 7 pupils thought of work as mere repetition of Year 6. In the York project the equivalent figure was much lower at only 8 per cent. The reasons for this are not clear but may have been associated with clearer descriptions in the York bridging units of the different tasks to be used either side of transfer and efforts to preserve discontinuity of experience. The use of planning posters, included to ensure continuity in the teaching, seemed to have struck a chord with the pupils at both ages and was mentioned specifically by about half of the pupils interviewed at each age (12 pupils in Year 6 and 16 pupils in Year 7).

Primary teachers were very positive about bridging work in science. Contrary to Galton's claim that primary teachers would be largely unenthusiastic about teaching bridging work, there were no negative comments concerning the validity or usefulness of bridging work. Responses showed general acceptance of the work as a sound foundation and preparation for further study. For some primary teachers (five of the 21 teaching 'Fizzy Drinks' and eight of the 17 teaching 'Bread'), however, this acceptance was qualified by concerns that work might not be continued in, or sufficiently valued by, secondary schools.

Most Key Stage 3 coordinators felt bridging work had been of value and said their pupils enjoyed carrying it out, although their comments were less enthusiastic than those of their primary colleagues. Coordinators in two schools thought their pupils were bored by the work. Interestingly, this was not corroborated by comments made by pupils in these schools when groups of pupils were interviewed.

Retests of pupils who had transferred to secondary school using selected questions from national tests taken before, at the end of Key Stage 2, showed positive gains for those who had been taught using the bridging unit compared with those who had not. Although both sets of pupils regressed, as was expected from previous studies mentioned earlier, this was less marked for the 'bridging group'. The overall effect size was small (0.19) but compared favourably with other, longer interventions at this age such as in reading and spelling (Lipsey and Wilson, 1993) and with previous research in science (Nicholls and Gardner, 1999). When analysed by question type, however, the results showed that the differences between the two groups were due mainly to better performance, for the bridging group, on questions about planning investigations and recognition of experimental variables (effect size = 0.29). Since the ability to identify and comment on relationships between experimental variables and patterns and evidence supporting conclusions was a major part of the design and so intended to be an important part of the teaching, this result raised some concerns (Braund, 2007). Results seemed to show that these abilities were not advanced as much as the planning of investigations was. It could be that schools ignored advice about the procedural progression. There was some support for this found when pupils were interviewed. Fewer pupils in Year 7 than in Year 6 could make statements that related patterns of experimental outcomes with what had been changed and measured (Braund and Hames, 2005). It seems that care is needed in dissemination and training before teachers get to use these bridging units so that they more clearly appreciate the progression lines on which teaching is based.

Evaluation showed there are key benefits for teachers and pupils in primary and secondary schools from using science bridging work, if it is designed carefully and taught well. Where bridging was least successful this was most likely to have been when schools were half-hearted about doing it, thought the work was too demanding and time-consuming, or thought their pupils would benefit more from doing something else. Schools (both primary and secondary) gained most when the key messages about science teaching embedded in the units, concentrating on reliability of findings, using common and recognisable teaching strategies and language, and recognising procedural progression were taken on board. Best practice in secondary schools had much to do with how well bridging work was integrated with other efforts to improve transfer in science, such as co-observation of each other's teaching, meetings to compare standards of work, induction visits and so on. Thus a bridging unit is best as part of a complex of strategies that impact pupils' learning and so raise standards in Key Stage 3.

Sharing practice

There is consensus in the literature that transfer projects that have worked best and had longest-lasting impact have involved teachers' cooperation and co-working where sharing and understanding each others' practice play a key role. This applies equally to projects addressing general, social aspects of primary–secondary transfer and those focused on specific subjects like science (Jarman, 1990; Suffolk Education Department, 1996, 2002a, 2002b; Doyle and Herrington, 1998; Hall *et al.*, 2001; Ryan, 2002; Bishop and Denley, 2003). Cooperation aimed at establishing better understanding of each other's teaching methods and styles links with the third and fourth of Galton's 'bridges', addressing curriculum and pedagogy. In a review of several Key Stage 2–3 transfer projects in science, Bishop and Denley asserted:

> It is teachers collaborating, sharing and reflecting jointly on experiences of teaching and learning science that is most likely to lead to pedagogical change and a consequent harmonisation of approaches. (2003, p. 9)

Sharing practice between schools and teachers to develop cross-phase understanding of teaching and learning science most commonly involves teachers in co-planning work (including bridging work discussed before), observation of each other's teaching, co-teaching of each other's classes and the exchange and analysis of assessed work.

Co-planning

At the simplest level, just viewing each other's schemes of work at joint meetings of teachers allows conversations about what is learned at adjacent Key Stages. Some suggestions for jointly planned work, however, seem overambitious. For example, in their book on primary–secondary transition, Nicholls and Gardner suggest that Year 6 and Year 7 teachers should jointly agree the content to be taught in each year and plan their teaching programmes accordingly (1999, p. 69) – surely beyond what is practical.

As a follow-up to bridging work developed at York, teams of teachers from primary and secondary schools were assembled to identify topics where repetition of practical experiences might occur and to produce ‘progression steps’ that would lead to more clearly dovetailed teaching. A key question emerged in these meetings: ‘If this is what is most appropriately taught and experienced at Key Stage 2, how would the same topic and similar practical work be taught at Key Stage 3 so that tasks are challenging enough and not merely seen as repetition by pupils?’ Thus the idea was to show primary and secondary teachers how procedures and knowledge gained by primary pupils can be recognised, built on and developed. The team established the concept of a ‘Scientific Enquiry Progression Task’. Four tasks were produced as examples for teachers who could then go on to replicate the process in their own schools, devising tasks in whatever topic they might wish to develop and progress each side of transfer. The process still requires a degree of cooperation and agreement between primary and secondary teachers but has the advantage that tasks are not so time-consuming as bridging work and are more likely to dovetail with existing teaching (see Braund, 2008, pp. 99–112).

Co-observation of teaching

According to a systematic review of international research on the impact of collaborative continuing professional development for teachers, an essential element of successful transfer schemes is that they provide for co-observation of teaching. Schemes with lowest impact lack this (Cordingley *et al.*, 2003). In a survey of transfer projects shortly after the introduction of the National Curriculum in 1989, it was found that personal contacts, cross-phase visits and observations were all valued more highly by teachers than meetings to discuss documentation, schemes of work or assessment (Lee, Harris and Dickson, 1995). With the introduction of the Key Stage 3 Strategy in 2000, with its emphasis on Key Stage 2–3 transfer, observations of teaching in primary schools by secondary teachers grew rapidly. However, perhaps as a result of priorities for developing literacy and numeracy at the time, observations were confined mainly to English and mathematics (Ofsted, 2002). In 2002, the science part of the Key Stage 3 Strategy provided funding for observation of primary science by secondary teachers. However, since most of the funding went to secondary schools, it seemed that unless secondary schools donated funding, primary teachers were left out of the equation and rarely got to see teaching in secondary schools. This situation was addressed by project teams at York, who allocated funds directly to primary schools. Over four years, teachers from both phases observed each other’s lessons using a framework to promote reflection on matters of differing pedagogy, assessment and learning styles (Braund, 2008, pp. 128–34). In the design of the observation framework it was important to avoid teachers confusing this purpose for observation with others they may have encountered, e.g. for assessment, appraisal and inspection (Cosh, 1999; Ofsted, 2002).

The extent to which teachers actually played a participant role during observation was a matter of personal choice. Woods’s view is that good ethnographic study relies on participant observation, as there is no substitute to understanding the experiences of others unless “you can have a go yourself” (Woods, 1986, p. 33). For example, in many cases teachers chose to talk with pupils so that they could see how learning related to the planned objectives for the lesson. It was advised, however, that quality participant observation relies on being unobtrusive. The role was therefore one of a friendly *participant observer* with an interest in the teaching and learning taking place, not of being an extra or assistant teacher.

Examples of outcomes from these co-observations are reported by Braund (2008, pp. 133–4) and show that, in many cases, teachers were able to reflect on subtle yet important differences in pedagogical approaches. This gave hope that, despite the efforts in time and cost in setting up this type of teacher interchange, these actions may be crucial to understanding each other’s classrooms as the basis for successful transfer projects in science.

Co-teaching
Although rarer than co-observation of teaching, the benefits of teaching in each others' schools and classrooms has been seen in transfer work, notably in Suffolk schools. It is claimed that this was particularly because standards of work, behaviour, organisation and achievements were witnessed and experienced by teachers at first hand. Where this has been in addition to other liaison such as meetings, bridging and looking at assessed work, it is claimed benefits have been huge (Suffolk Education Department, 1996). In the work at York, even teachers who had been involved in many curriculum initiatives before gained new and important insights on progression and continuity (Braund, 2008, pp. 134–6).

Exchange and analysis of assessed work
Assessment has traditionally been one of the thorniest problems of Key Stage 2–3 transfer. Providing assessment information that is meaningful, and getting secondary teachers to make use of it when it is, are recurring difficulties at all transfers. Problems are not just products of legislation such as the National Curriculum. For example, in a study of transfer practices at ages nine and 13 in the Isle of Wight in the early 1980s, it was found that communication between schools about assessment lacked focus and that transfer of pupils' grades did little to help them make progress (Stillman and Maychell, 1984). One might expect that, with all the efforts that have been made on transition and transfer over the last quarter of a century since this survey took place, the situation might have improved. A number of surveys have identified specific problems:

- Key Stage 3 teachers distrust the levels of attainment that pupils have been assessed at in primary schools.
- Despite national and regional arrangements, the quantity and quality of assessment information transferred and reaching science departments in secondary schools has been inconsistent (Peacock, 1999; Ofsted, 2002).
- Assessment information transferred to the secondary school is often ignored or is not detailed enough to guide effective lesson planning that takes account of pupils' individual abilities (Lee, Harris and Dickson, 1995; Nicholls and Gardner, 1999; Schagen and Kerr, 1999). This might result in poorer differentiation of teaching.
- Portfolios or examples of pupils' work are infrequently made available to secondary schools. While portfolios have been common practice in English/literacy, they have been rarer in science, as a study in Worcestershire showed (see Peacock, 1999). Where this did happen (in one-fifth of studies in Worcestershire schools) work was rarely used or referred to by the receiving teachers. Consequently, pupils felt their efforts and achievements in primary science were not valued.

With these criticisms in mind, the York team provided a diagnostic, formative transfer system that recorded individual pupils' progress in terms of procedural knowledge and understanding involving peer assessment along the lines suggested by Black and Wiliam (1998). Even though the system was designed by primary and secondary teachers and records were transferred, at some cost, directly into the hands of the secondary teachers who received pupils in September, the system was unsuccessful. A trimmed-down version was used the following year and, although secondary school teachers preferred using it, there were complaints that it did not provide the level of detail needed to help pupils progress in Year 7. It seems there is a gap between the views expressed by some secondary teachers, bemoaning the quality of transferred assessment in helping them to plan and teach for progression, and what they are prepared to do with this level of information when they actually get it. Too much information is unusable and too little is not useful. This conundrum remains a key issue in transition work but is not one that teams at York were able to solve. This is not to say that diagnostic and formative transfer records are not worth using. It is interesting to speculate that the original scheme might find more acceptance today, as schools have gained more experience in using formative assessment approaches that involve pupils as peer reviewers. Advances in using these methods of assessment have been noted in findings of school inspections (Ofsted, 2006, para. 226, p. 55), though more noticeably for English and mathematics than for science.

Finally, it is worth noting some of the issues that arise in liaison meetings used to compare samples of work across Key Stage 2–3 transfer. According to the literature, considering samples of pupils' work is something that commonly features in liaison meetings between primary and secondary teachers (Stillman and Maychell, 1984; Galton, Gray and Rudduck, 2003). It even seems that teachers are disappointed when such exercises are not included at these meetings (Suffolk Education Department, 1996). Unfortunately, meetings often result in unproductive haranguing when teachers refuse to accept each other's judgements based on National Curriculum levels (Suffolk Education Department, 1996), partly because of the reasons discussed earlier. At York, project teams ran meetings that collected anonymised pupils' work in adjacent year groups at either side of transfer (i.e. from Years 5 and 6 and from Years 7 and 8). Pupils' assessed work featured reports of practical work and investigations and was assessed using non-National Curriculum criteria. Braund (2008, pp. 122–3) claims some benefit from using this approach compared to the more common comparisons of assessments using only National Curriculum levels.

Conclusion

It seems clear from studies reviewed here that pupils' progress in and their attitudes to school science following transfer are rarely maintained, let alone progressed. That this is more to do with teaching than pupils' inherent dislike of science was shown in a recent Australian study where pupils' perceptions of science in society hardly changed across transition whereas their attitudes to school science declined markedly, particularly where there were fewer practical activities, excessive writing demands and rushed topic teaching (Logan and Skamp, 2008). It seems that the seeds of discontent impacting the numbers of pupils who maintain an interest in science sufficient for them to want to continue with advanced studies or choose careers in science and technology are sown early in secondary schools. This is particularly important when we consider that most scientists make up their minds to pursue the subject before they are 14 – in many cases their motivation can be traced back before the age of 12 (Royal Society, 2006).

From the 1960s until the late 1980s the different organisation of curriculum content in primary and secondary schools (such as the integration of subjects in primary schools but separate subject teaching in secondary schools) and the sectors' divergent teaching styles produced an obvious disjunction for pupils entering secondary education. As new curricula were adopted, the organisation of primary schools became more like that of secondary schools as subject teaching took over from integrated topic work, at least in the more senior years of primary schools (Hargreaves and Galton, 2002). Now, convergence between primary and secondary schools is taking a new form, away from subject-based work in primary and secondary schools and towards more integration, offering increased hopes for improving continuity of science teaching for pupils following transfer. In 2007, Northern Ireland introduced a revised curriculum, rolled out for Years 1 and 5, in which science moves from being a discrete subject to a contributory element, along with history, geography and technology, of a learning area called the 'world around us' (Primary Science Review, 2007, p. 11). In Wales, integration of science is not so noticeable, though increased emphasis on contextualisation and how to teach rather than on what to teach is prominent (Department for Education, Lifelong Learning and Skills, 2007). In Scotland there has been a national debate on education resulting in publication of *A Curriculum for Excellence* (Scottish Government, 2008). At the heart of this debate is the aim of a seamless structure for 3–18 learning that de-clutters content, encourages integration and *supports meaningful transitional practices*. In England too, *Curriculum 2008* opens the door to increased collaboration between subjects at Key Stage 3 and the chance to focus on overarching themes affecting learning that are described in common for all subjects (QCA, 2007).

One of the key determinants of decline in pupils' motivation is pupils feeling that the science they did in primary schools was somehow of a lower grade, unimportant and now a poor basis for further study. One way to reduce pupils' impressions that secondary science is a boring series of repeats of what they think they have already covered before is to encourage teachers to make explicit links both forwards and backwards, as suggested by Jarman (1997) and Braund (2008), so that pupils can more readily appreciate what they have done before and will do in the future, and to recognise this as progression rather than repetition. Jarman sees secondary teachers as either 'resumptionists', most likely to repeat work because they doubt pupils' understanding or levels of competence, or as 'recognitionists', more likely to value collaborative efforts with primary colleagues (Jarman, 1997). The main aim of improving primary–secondary transfer, therefore, is to increase the number of recognitionists and reduce the number of resumptionists.

Recommendations

For schools

There are four conditions that, if put in place, would be most likely to improve post-transfer progression and continuity for pupils learning science.

Condition 1: Learning environment

There should be a learning environment in secondary schools that takes on board best practice of primary schools without seeking to replicate it. Actions could include providing colourful displays relevant to pupils, celebrating work carried out in the first few weeks in the new school, encouraging paired and group discussions and using older pupils to act as working partners.

Condition 2: Assessment

Assessment at both sides of transfer should be focused on and involve individuals, pairs or groups of pupils, drawing on the best practices of formative and diagnostic assessment (e.g. as recognised by Black and Wiliam, 1998; Black *et al.*, 2002). Pupils should have oral feedback from their teachers about their work as regularly as they did at primary school.

Condition 3: Progression in learning

There should be recognition that learning science is progressive, building on foundations laid before. This means recognising that the learning journey began some time ago and that it is natural to revisit areas of knowledge to make our thinking better, so that we can have a more complete understanding of the world. The skills and procedures of science are a common toolkit that is expanded as pupils learn and can do more. Teachers must talk to pupils about what they have done before and value their efforts, and help them to look forward to the next steps in their learning.

Condition 4: Liaison and collaboration

There should be school policies that allow regular high-quality sharing of pedagogy and practice either side of transfers. This means more than just liaison or moderation meetings and induction days. Liaison ought to involve two-way teacher exchanges requiring observation and reflection on each other's practices.

For policy makers and researchers

a. The initial training of primary and secondary teachers should devote more time to understanding the evidence for and possible solutions to the problems of science at transfers and transitions between Key Stages. Examples of strategies to improve primary–secondary transfers in science should be included in university-based training and experienced in school practice wherever possible.
b. Courses in the professional development and in-service training of science teachers and managers of science, such as at the National and regional Science Learning Centres, should include elements that inform on and consider strategies to address post-transfer regression in science.
c. Funding should be made available that allows more collaboration between primary and secondary teachers to develop co-planned work and to observe each other's teaching of science. This will require training teachers on effective co-observation and reflection so that they can better understand differences and similarities in their practice.
d. Research and development is needed to explore new ways in which transferred pupil assessment data can be used to provide better-differentiated science lessons in the first year of secondary school, so that teachers take more account of pupils' previous achievements.
e. As most research on this is 20 years old, new research is needed to explore to what extent science teachers and heads of science in secondary schools believe learning should 'start from scratch' and, if they do, why this might be and what can be done to minimise repeated work.
f. Research is required that tracks pupils as they progress from Key Stage 2 through the whole of Key Stage 3 to determine how their experiences affect their attitudes to school science and in relation to other subjects of the curriculum. This is especially important in the current climate of radical curriculum change at Key Stage 3.

References

Abrahams I, Millar R. Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. International Journal of Science Education 2008;30(14):1945–69.

Anderson LW, Jacobs J, Schramm S, Splittberger F. School transitions: beginning of the end or a new beginning? International Journal of Educational Research 2000;33:325–39.

Beauchamp G, Parkinson J. Pupils' attitudes towards science as they transfer from an ICT-rich primary school to a secondary school with fewer ICT resources: does ICT matter? Education and Information Technologies 2008;13(2):103–18.

Bennett J, Hogarth S, Lubben F. A systematic review of the effects of context-based and science-technology-society (STS) approaches in the teaching of secondary science. In: Research Evidence in Education Library. London: EPPI-Centre, Social Science Research Unit, Institute of Education; 2003.

Bishop K, Denley P. Primary–secondary transfer: innovative projects to ease transition. Education in Science 2003;202:8–10.

Black P, Wiliam D. Inside the Black Box. London: King's College, Department of Educational Studies; 1998.

Black P, Harrison C, Lee C, Marshall B, Wiliam D. Working Inside the Black Box: Assessment for learning in the classroom. London: King's College, Department of Education and Professional Studies; 2002.

Board of Education. The Primary School. Report of the consultative committee on the primary school (Hadow Report). London: HMSO; 1931.

Braund M. STAYing the course: smoothing the transfer from Key Stage 2 to Key Stage 3. Education in Science 2002;197:28–9.

Braund M. 'Bridging work' and its role in improving progression and continuity: an example from science education. British Educational Research Journal 2007;33(6):905–26.

Braund M. Starting Science…Again? London: Sage; 2008.

Braund M, Driver M. Pupils' perceptions of practical science in primary and secondary school: implications for improving progression and continuity of learning. Educational Research 2005;47(1):77–91.

Braund M, Hames V. Improving progression and continuity from primary to secondary science: pupils' reactions to bridging work. International Journal of Science Education 2005;27(7):781–801.

Bruner J. The Process of Education. Cambridge, MA: Harvard University Press; 1960.

Bruner J. Toward a Theory of Instruction. Cambridge, MA: Belkapp Press; 1966.

Bunyan P. Comparing pupil performance in Key Stages 2 and 3 science SATs. School Science Review 1998;79(289):85–7.

Campbell B, Lazonby J, Millar R, Smith S. Science, the Salters' Approach: Books 1–4. Oxford: Heinemann; 1990.

Cordingley P, Bell M, Rundell B, Evans D. The impact of collaborative CPD on classroom teaching and learning. In: Research Evidence in Education Library. London: EPPI-Centre, Social Science Research Unit, Institute of Education; 2003.

Cosh J. Peer observation: a reflective model. ELT Journal 1999;53(1):22–7.

Davies D, McMahon K. A smooth trajectory: developing continuity and progression between primary and secondary science education through a jointly-planned projectiles project. International Journal of Science Education 2004;26(8):1009–21.

Department of Education and Science/Welsh Office. Science 5–16: A statement of policy. London: HMSO; 1985.

Department of Education and Science/Welsh Office. National Curriculum: Task Group on Assessment and Testing: A report. London: HMSO; 1988.

Department for Education and Skills. English Transition Units. London: DfES; 2002.

Department for Education and Skills. Mathematics Transition Units – 2003 Edition. London: DfES; 2003.

Department for Education, Lifelong Learning and Skills. Science in the National Curriculum in Wales. Cardiff: Welsh Assembly Government; 2007.

Derricott R (ed.). Curriculum Continuity: Primary to secondary. Windsor: National Foundation for Educational Research–Nelson; 1985.

Doyle L, Herrington N. Learning progression across the primary/secondary divide. All-in Success (Journal of the Centre for the Study of Comprehensive Schools) 1998;9(2):9–12.

Dutch R, McCall J. Transition to secondary – an experiment in a Scottish comprehensive school. British Journal of Educational Psychology 1974;44(3):282–9.

Estyn (Her Majesty's Inspectorate for Education and Training in Wales). The Impact of Transition Plans: An evaluation of the use of transition plans by primary–secondary school partnerships to improve the quality of learning and standards. Cardiff: Estyn; 2008. www.estyn.gov.uk/ThematicReports/0608_impact_of_transition_plans.pdf [accessed 9 April 2009].

Evangelou M, Taggart B, Sylva K, Melhuish E, Sammons P, Siraj-Blatchford I. What Makes a Successful Transition to Secondary School? London: Department for Children, Schools and Families; 2008. www.dcsf.gov.uk/research/data/uploadfiles/DCSF-RR019.pdf. [accessed 9 April 2009].

Galton M. Continuity and progression in science teaching at Key Stages 2 and 3. Cambridge Journal of Education 2002;32(2):250–65.

Galton M, Simon B, Croll P. Inside the Primary Classroom. London: Routledge; 1980.

Galton M, Gray J, Rudduck J. The Impact of School Transitions and Transfers on Pupil Progress and Attainment. Research Report RR 131. London: Department for Education and Employment; 1999.

Galton M, Morrison I, Pell T. Transfer and transition in English schools: reviewing the evidence. International Journal of Educational Research 2000;33:341–63.

Galton M, Gray G, Rudduck J. Transfer and Transitions in the Middle Years of Schooling, 7–14: Continuities and discontinuities in learning. Nottingham: Department for Education and Skills; 2003.

Galton M, Hargreaves L, Pell T. Progress in the middle years of schooling: continuities and discontinuities at transfer. Education 3–13 2003;31(2):9–18.

Gorwood B. Primary–secondary transfer after the National Curriculum. In: R Moon, AS Mayes (eds). Teaching and Learning in the Secondary School. London: Routledge; 1994.

Gray J, Hussey S, Schagen I. The primary side of the transfer divide: heads' perceptions and pupil progress, In: Galton, Gray and Rudduck (2003).

Griffiths J, Jones L. And you have to dissect frogs! Forum 1994;36(3):83–4.

Hall I, Lin M, Smith P, Todd L. Beacon Council Research – Round 3 Theme Report. Transition in Education: Transition Between Key Stages in Schools. Newcastle: Department of Education, University of Newcastle-upon-Tyne; 2001.

Hargreaves L, Galton M. Transfer from the Primary Classroom: 20 years on. London: Routledge and Falmer; 2002.

HM Inspectors of Schools. Improving Science Education 5–14. Edinburgh: Scottish Executive Education Department; 1999.

House of Commons Education Committee. Fourth Report: Science and Technology in Schools. London: HMSO; 1995.
Jarman R. Primary science–secondary science continuity: a new ERA? School Science Review 1990;71(257):19–29.
Jarman R. Real experiments with bunsen burners: pupils' perceptions of the similarities and differences between primary science and secondary science. School Science Review 1993;74(268):19–29.
Jarman R. Fine in theory: a study of primary–secondary continuity in science, prior and subsequent to the introduction of the Northern Ireland Curriculum. Educational Research 1997;39(3):291–310.
Kaur B. Primary/secondary liaison in science and value added from Key Stage 2 to 3: a case study. Education in Science 1998;179:9–11.
Keogh B, Naylor S. Concept cartoons, teaching and learning in science: an evaluation. International Journal of Science Education 1999;21(4):431–46.
Lee B, Harris S, Dickson P. Continuity and Progression 5–16: Developments in schools. Slough: National Foundation for Educational Research–Nelson; 1995.
Lipsey MW, Wilson DB. The efficacy of psychological, educational and behavioral treatment: confirmation from meta-analysis. American Psychologist 1993;48(12):1181–209.
Logan M, Skamp K. Engaging students in science across the primary secondary interface: listening to the students' voice. Research in Science Education 2008;38:501–27.
Moore C. Bridging the divide: part 1. In: Braund (2008).
Morrison I. School's great – apart from the lessons: sustaining the excitement of learning post transfer. Improving Schools 2000;3(1):46–9.
Nicholls G, Gardner J. Pupils in Transition Moving between Key Stages. London: Routledge; 1999.
Nott M, Wellington J. The state we're in: issues in key stage 3 and 4 science. School Science Review 1999;81(294):13–8.
Ofsted. Progress in Key Stage 3 Science. London: Ofsted; 2000.
Ofsted. Changing Schools: An evaluation of effectiveness of transfer arrangements at age 11. London: Ofsted; 2002.
Ofsted. The Annual Report of Her Majesty's Chief Inspector of Schools 2005/6. London: The Stationery Office; 2006.
Ofsted. Evaluation of the Primary and Secondary Strategies. London: Ofsted; 2008.
Osborne J, Collins S. Pupils' views of the role and value of the science curriculum: a focus-group study. International Journal of Science Education 2001;23(5):441–67.
Peacock G. Continuity and progression between key stages in science. Paper presented to the conference of the British Educational Research Association, University of Sussex, 2–5 September 1999.
Pietarinen J. Transfer to and study at secondary school in Finnish school culture: developing schools on the basis of pupils' experiences. International Journal of Educational Research 2000;33:383–400.
Pointon P. Students' views of environments for learning from primary to secondary school. International Journal of Educational Research 2000;33:375–82.
Primary Science Review. All change or small change? Primary Science Review 2007;100:9–13.
Qualifications and Curriculum Authority. Bridging Units in Mathematics: Algebra introducing symbols. Sudbury, Suffolk: QCA Publications; 2000.
Qualifications and Curriculum Authority. The New Secondary Curriculum: What has changed and why? London: QCA; 2007.
Raffe D, Brannen K, Croxford L, Martin C. Comparing England, Scotland, Wales and Northern Ireland: the case for 'home internationals' in comparative research. Comparative Education 1999;35(1):9–25.
Royal Society. Taking a leading role – scientists survey. London: The Royal Society; 2006. www.royalsoc.ac.uk/page.asp?id=2903 [accessed 9 April 2009].
Ryan M. Tackling the Key Stage 2 to 3 transition problems – a bridging project. School Science Review 2002;84(306):69–75.
Schagen S, Kerr D. Bridging The Gap? The National Curriculum and progression from primary to secondary school. Slough: Nuffield Foundation for Educational Research; 1999.
Scharf PF, Schibeci RA. The influence of a 'transition science' unit on student attitudes, Research in Science and Technological Education 1990;8:79–88.
Scottish Government. Curriculum for Excellence: Building the Curriculum 3 – A framework for learning and teaching. Edinburgh: The Scottish Government; 2008. www.ltscotland.org.uk/Images/building_the_curriculum_3_jms2_tcm4-489454.pdf [accessed 9 April 2009].
Secondary Science Curriculum Review. Better Science: Building primary–secondary links. London: Heinemann; 1987.
Stillman A, Maychell K. School to School: LEA and teacher involvement in educational continuity. Windsor: Nuffield Foundation for Educational Research–Nelson; 1984.
Stringer J. 'We've all done this before.' Primary Science Review 2003;80:4–6.
Suffolk Education Department. A Report of an Investigation into What Happens When Pupils Transfer into Their Next Schools at the Ages of 9, 11 and 13. Ipswich: Inspection and Advice Division, Suffolk County Council; 1996.
Suffolk Education Department (2002a). Transfer Review 2001 – Summary. Ipswich: Suffolk County Council; 2002.
Suffolk Education Department (2002b). Transfer Review 2001 Annex C – Summary of the findings for science. Ipswich: Suffolk County Council; 2002.
Woods P. Inside Schools. Ethnography in educational research. London: Routledge; 1986.

About the author

Martin Braund is Deputy Director of Undergraduate Programmes in Educational Studies at the University of York and leads Master's courses in Science Education and Science Education and Leadership. His research interests include learning in primary and secondary science, biology education, museums and informal learning, teacher education and professional development of teachers, and discussions and critical thinking/argumentation in science. He has directed a number of research projects, including the STAY (Science Transition AstraZeneca York) project, which looked at ways to improve transition from Key Stage 2 to Key Stage 3 for pupils learning science.

Martin joined the University of York in 2001, having spent 18 years teaching science in secondary schools. He has also worked as an advisory teacher for science and assessment and spent seven years teaching science and environmental biology to intending primary teachers at Bretton Hall College, University of Leeds.

Martin is also Adjunct Professor in the Faculty of Education and Social Sciences at the Cape Peninsula University of Technology in South Africa, where his work involves research and capacity building, mainly in science education and teacher education.

E mb40@york.ac.uk

A smoother path: managing the challenge of school transfer

Anne Diack
Commission for Architecture and the Built Environment, London

Summary

We live in an age of great scientific discovery: developments in cloning, in investigating matter, in understanding the history of Mars. But is this excitement reflected in science education in schools? How are school students performing? What do they think about science? At a time when science (as well as technology) is being seen as increasingly important in order to address global challenges, are students being inspired about science throughout their time in primary and secondary schools? What is being done to ensure that they move smoothly from one phase to another and maybe to taking science up as a career? And, in an age when scientific discovery will impact increasingly on all our lives, are school students being encouraged at all stages of their education to realise that we all have to understand science now?

The subject of this paper is the issue of transfer between the primary and secondary phases of science education and what might be done to contribute to an 'all-through schooling' approach. The reports and policies referred to relate primarily to England, although many of the points raised may apply equally to Scotland, Wales and Northern Ireland.[1] To understand fully the issues relating to transfer, the paper begins by taking a brief look at wider attitudes to science education, including the findings of some international studies.

In this paper, the term 'transfer' is used to refer to the move from different institutions, such as when a pupil moves from a primary to a secondary. The term 'transition' is used to refer to moves within the same institution, such as moving between lower and upper secondary school.

Global perspectives

Science competencies for tomorrow's world

TIMSS (Trends in International Mathematics and Science Study) is an international research project that takes place every four years and provides data about trends in mathematics and science achievement and attitudes over time. The study looks at the knowledge, skills and attitudes of pupils aged 9–10 and 13–14. It is therefore particularly relevant to any consideration of issues surrounding the transfer from primary to secondary school. The latest survey was carried out in 2007. It involved approximately 425 000 pupils in 59 countries, with the UK participation from England and Scotland.[2]

When the findings of the 2007 survey are compared with earlier studies, some findings emerge that are of concern. In terms of overall *performance* in science, the survey found that England was one of the highest-performing countries at both primary and secondary levels. Students also showed a high degree of self-confidence in learning science at both stages. Despite these encouraging findings, however, *attitudinal* data showed that the percentage of pupils aged 9–10 in England with highly positive attitudes to science had actually declined. The last time comparable data had been gathered was in 1995, when 72 per cent of pupils had highly positive attitudes to science. In 2007, this had dropped to 59 per cent – a decline of 13 percentage points. Moreover, this percentage of English primary school pupils in the 2007 survey who had highly positive attitudes to science was lower than in other countries that were scoring at a higher or similar level on the *performance* scale.

At secondary level, the decline in positive attitudes was even greater. In 2007, 55 per cent of pupils in England were found to have highly positive attitudes to science. Although this was comparable to other countries that scored high on the *performance* scale, it had dropped by 21 percentage points since 1999, when 76 per cent of secondary pupils were found to have highly positive attitudes to science.

1 A table showing how Key Stages in England compare to the other education systems across the UK can be found on page 56.
2 More detail available at www.nfer.ac.uk/research-areas/timss/timss_home.cfm.

England does not seem to be alone in this. At both primary and secondary levels, these declines in positive attitudes to science were also experienced by some other countries scoring highly on the performance scale, such as Singapore, suggesting that declining attitudes to school science are not just a UK phenomenon. Interestingly, in terms of the *importance* of science, 7 per cent more secondary pupils in England placed a high value on science in 2007 than in 2003, perhaps reflecting the often-repeated phrase "science is important, but not for me" (for example, Jenkins and Nelson, 2005).

Similar attitudinal trends can also be seen from the latest Organisation for Economic Co-operation and Development (OECD)[3] Programme for International Student Assessment (PISA) survey, which looks at the knowledge and skills of 15-year-olds.[4]

PISA surveys have been carried out every three years since 2000, with a different subject focus each time. The focus for the first survey, in 2000, was reading. The second survey, in 2003, focused on mathematics and the latest survey, in 2006, focused on science. Based on tests carried out among 400 000 students in 57 countries, including the UK, the 2006 survey looked at school students' scientific literacy.[5] This included abilities to comprehend and tackle scientific problems, as well as attitudes towards, and engagement with, school science.

As with TIMSS 2007, the UK scored above the OECD average for PISA 2006 and was in the top third of the countries surveyed. However, while a large number of school students thought that science was important (for example, 93 per cent of all students reported that science was important for understanding the natural world, and 92 per cent said that advances in science and technology usually improved people's living conditions), only 57 per cent said that science was very relevant to them personally. And while 67 per cent enjoyed acquiring new knowledge in science, only a minority aspired to a career involving science: 37 per cent said they would like to work in a career involving science and 21 per cent said they would like to spend their life doing advanced science.

Notwithstanding the global credit crunch, which, at the time of writing, is dominating the headlines and looks set to continue for some considerable time, student attitudes to science will be crucial to the economic potential of countries in the future. These findings from TIMSS and PISA suggest that science will not necessarily be the career of choice for a large number of students. Moreover, developments in science are impacting increasingly on all of our lives and scientific literacy is a crucial aspect of informed citizenship for everyone today. Seen within this context, any decline in attitudes resulting from, or exacerbated by, the transfer from primary to secondary school is clearly something that needs to be addressed.

Insights from science education in Europe

In January 2008, a report on science education in Europe was published by the Nuffield Foundation – an organisation long respected for the pioneering work it has carried out in science education. This drew attention to the importance of two particular factors that impact on the questions raised in the opening paragraph of this report (Osborne and Dillon, 2008).

3 The OECD has been one of the world's largest and most reliable sources of comparable statistics, with economic and social data for over 40 years. There are 30 core member countries, including the UK, with another 100 sharing expertise and exchanging views.

4 PISA is an internationally standardised assessment, developed by participating countries for 15-year-olds in schools to assesses how far they have acquired some of the knowledge and skills that are essential for full participation in society. Reading, mathematical and scientific literacy are covered both in terms of content of the school curriculum, and also knowledge and skills needed in adult life. Full results for PISA 2006 are available at www.oecd.org/document/2/0,3343,en_32252351_32236191_39718850_1_1_1_1,00.html [accessed 7 April 2008].

5 The PISA programme defines 'scientific literacy' as being the extent to which an individual:
- possesses scientific knowledge and uses that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues
- understands the characteristic features of science as a form of human knowledge and enquiry
- shows awareness of how science and technology shape our material, intellectual and cultural environments
- engages in science-related issues and with the ideas of science, as a reflective citizen.

The first is the fact that declining attitudes towards school science begin at an earlier stage than when students are making actual subject and career choices. Research shows that student interest in science at age nine is high, with no gender difference (Haworth *et al.*, 2007, cited in Osborne and Dillon, 2008). However, interest is much lower by the time students have reached age 14 (Osborne *et al.*, 2003). This suggests that programmes and activities aimed at improving student attitudes towards school science and encouraging young people to pursue science qualifications and careers need to start much earlier than at age 14.

Written evidence presented by Jonathan Osborne to the House of Commons Select Committee on Science and Technology (Royal Society, 2006; Tai *et al.*, 2006; Lindahl, 2007; all cited in Osborne, 2007) similarly quotes research, including data from the Royal Society and the US National Educational Longitudinal Study, which suggests that interest in science as a subject of study is engendered in students before the age of 14. In the Royal Society survey, just over a quarter of respondents (28 per cent) first started thinking about a career in science, technology, engineering or mathematics (STEM) before the age of 11, and a further third (35 per cent) between the ages of 12 and 14 – a total of 63 per cent. Such findings again highlight the importance of the primary–secondary transfer period in influencing young people's attitudes to school science.

A second factor to which the Nuffield report draws attention is something raised by the eminent learning theorist J D Bransford[6] – the extent to which influences outside the school impact on children. The Nuffield report highlights the data Bransford presents on the amount of time that learners spend in school settings relative to other activities, making the point that we currently know little about the factors that lead children under the age of 14 to be interested in science or not, and that it may well be worth considering the time outside the classroom as well as that inside when deliberating about how to develop science education (Bransford, 2006).

Drawing these factors together with other data, the authors of the Nuffield report argue that science education should offer a varied pedagogy, opportunities to engage with the material world, a vision of what science can provide from a creative perspective, formal and informal contexts for learning, and also, crucially, continuity:

> What is required is a continuum of educational experiences of science from an early age. (Osborne and Dillon, 2008, p. 19)

Although these findings and recommendations are not specific to primary–secondary transfer, they highlight the fact that transfer does not take place in isolation and are therefore important to consider when looking at ways of reducing dips in attitudes relating to the move between primary and secondary. It seems clear that a "continuum of educational experiences" is crucially important in ensuring that the population as a whole is enthusiastic about, and engaged with, science and has sufficient scientific literacy to ensure that people can make informed choices about scientific matters that affect their lives. It is also vitally important for providing the country with a future supply of career scientists.

The local context

In their book *Transfer from the Primary Classroom*, Hargreaves and Galton (2002) make the point that unlike any other education system, in England and Wales the majority of pupils take part in experiences that are anxiety-producing and time-consuming on a frequent basis. While most individuals do not move five times during their education (from nursery to infant school, infant school to junior school, junior school to middle or secondary school, middle school to secondary or upper school, secondary school to college, possibly sixth form college), the number of possible moves illustrates the point. As highlighted in the other reports in this publication, moving institutions between the primary and secondary phases has the potential to throw up particular challenges. To understand fully how these might be practically addressed, it is helpful to reflect back on some of the research that has unpacked the challenges brought about by the organisational structures of the education system.

6 J D Bransford is former co-chair of the Committee on Developments of the Science of Learning, convened under the auspices of the National Research Council, part of the US National Academies.

Transfer from the primary classroom

In the late 1990s the then Department for Education and Skills (DfES; now the Department for Children, Schools and Families, DCSF), commissioned a seminal report into transfer and transition (Galton *et al.*, 1999). The report noted that some of the early studies on transfer had considered social and emotional aspects, including teacher perception, rather than concentrating on the continuity of learning. Among the studies covered were ones that focused on the impact of adjustment and social background (Nisbet and Entwistle, 1969), the development of pupils' self-identities (Measor and Woods, 1984) and friendships, teacher–pupil relationships and teacher perception (Beynon, 1985). As a result, Galton *et al.* suggested that the programmes developed by schools in the 1980s and 1990s "may have concentrated on the social aspects of transfer at the cost of establishing commitments to, and sound foundations for, academic learning" (1999, p. 11).

The DfES report also noted that some pupils who did well in science examinations said that they did not enjoy the subject, and that many of the tasks in the year after transfer required pupils to perform at lower attainment levels than had been achieved in the science tests at the end of Key Stage 2. Similar findings also emerged from a study of design and technology projects in Years 6 and 7, which showed a much higher proportion of time being spent listening to the teacher after transfer and less time spent on discussion (Stables, 1995). The DfES report also drew on the replication of the large-scale Observation Research and Classroom Learning Evaluation project (ORACLE),[7] which found that following transfer from primary to secondary school, the proportion of pupils fully engaged in science fell from 60 per cent to 34 per cent. These findings contrasted with English and mathematics, in which the proportion of pupils fully engaged remained close to 60 per cent before and after transfer for both subjects.[8]

What was striking about the report was that that despite a decade of what was generally considered to be increasingly successful primary science, at the end of Key Stage 3 when the pupils were 14, they had not made the kind of progress in science that would have been expected given the standards they had reached at the age of 11. This reflected data from the 1996/97 *Annual Report of Her Majesty's Chief Inspector of Schools*, which showed that in 50 per cent of all secondary schools in England pupils were making unsatisfactory progress between the end of primary school and the early stages of the first year in secondary school (Ofsted, 1998).

The DfES report authors concluded that despite improvements in communications and liaison, problems between primary and secondary schools still persisted, and that although one of the aims of the National Curriculum in England and Wales had been to ensure continuity between the various Key Stages, few teachers felt that these links were working satisfactorily. In addition, increased parental choice meant geographical ties to particular schools were no longer as close, making it more difficult to provide continuity; secondary teachers still had assumptions rather than detailed knowledge about what was happening in primary schools; and where there had been attempts to improve continuity in the curriculum, these had not been properly evaluated.

When the National Curriculum was first introduced into schools in England and Wales in the late 1980s, the initial introductory materials were an opportunity to demonstrate the excellent practical science work that was already being undertaken in some primary classrooms – particularly with younger children – and to ensure that this high-quality practical work reached a far greater number of pupils. The formal introduction of science into the primary sector has been considered to have been a success, but there have been some issues. Systematically embedding teaching and learning techniques as well as content across different phases of the education system was not straightforward, as the replication of the ORACLE study mentioned earlier showed. The ORACLE authors also noted that generalisations about what happens in primary schools by secondary schools and vice versa can have particular consequences for pupils who are 'hard to reach' or 'at risk' either individually or as part of a group, who may be ignored or targeted (Catterall, 1998).

7 The ORACLE project followed a cohort of pupils in feeder primary schools and then after transfer for one year between 1975 and 1980. It was replicated 20 years later.

8 'Fully engaged' meant they were on task for 75 per cent of the individual observations made of their behaviour.

In summary, the 1999 DfES report was very important in highlighting many of the issues associated with primary–secondary transfer, particularly in terms of impact on learning. Braund has suggested that the report was behind the government's move to introduce a secondary strategy for schools in England (Braund and Driver, 2002). This may be overstating the case, but what it did do was draw the attention of policy makers more sharply to the issues facing pupils at transfer, and it was used as a rationale for many other projects.

Bridging the gap

In the 1999 DfES report, Galton, Gray and Rudduck identified five main categories of activity that schools employ to bridge the transfer process: bureaucracy, social activity, the curriculum, pedagogy and the management of learning. They argued that while attention had been given to the social and bureaucratic aspects of transfer, rather less attention has been paid to the learning dimensions. They also suggested that unless the traditional structures of schooling were altered to allow teachers to be more responsive to individual pupils, ideas such as transferring data electronically, increasing the number of liaison visits between schools, holding summer schools or setting up joint projects in the final term before transfer would be unlikely *per se* to relieve the problems in pupil progress at transfer. Moreover, their view was that schools had done a good job in making the social aspects of the move less stressful, but had not addressed the issue of being able to deal with different teaching methods and the expectations of students.

These arguments have since been used as a rationale for a number of projects, including the Science Transition AstraZeneca York (STAY) project, in which teachers and academic science educators developed 'bridging units' that could be started in primary schools and continued in secondary schools. As discussed in detail in the other two reports in this publication, bridging units have not been without their critics. Factors such as increased parental choice (and more recently allocation by lottery in a few parts of the country) have affected the links between primary and secondary schools. In addition, some schools may have pupils from a large number of primary schools, making it difficult to ensure that all the incoming pupils will necessarily have covered the same bridging work. These and other arguments are countered by the STAY project researchers: while acknowledging that improvements could still be made, they cite their evaluation of the bridging unit work showing that such work is valued by pupils, who like knowing that the teachers from upper primary and lower secondary are using similar approaches. They also argue that both sets of teachers value a common approach to lesson plans and approaches (Braund *et al.*, 2003; Braund and Hames, 2005).

In 2003, Galton *et al.* produced another research report for the then DfES, which found that schools in England were now paying more attention to curriculum and pedagogic issues at transfer, rather than just concentrating on social issues, and that secondary teachers were better informed about the Key Stage 2 Programmes of Study because of the increasing number of visits between institutions. However, the report also found that many teachers held over-optimistic views of primary practice:

> The reality is that for many pupils much of Year 6, in the run up to the (statutory) tests, consists largely of revision with an emphasis on whole class direct instruction. This squeeze on the curriculum and the restricted range of pedagogy employed in Y6 has implications for teaching at the lower end of the secondary school. (Galton *et al.*, 2003, p. ii)

In mathematics, and more especially in science, it appeared that pupils who made most progress after transfer did not express very positive attitudes to these subjects. Only in English were attitude and attainment positively correlated, with pupils stating that in Year 7 (the first year of secondary school) English had more variety and was more interesting. In science, in contrast, pupils spent much of their time copying out details of experiments or writing out instructions under the teacher's guidance; able pupils said they were easily bored by these lessons. Because of the extensive amount of revision in Year 6, pupils could also be quite distant from the kind of activities that might have been engaging their early scientific imagination. More positively, the researchers did find enthusiasm among learners for programmes that were developing study skills, engaging them as 'professional learners' and developing their problem-solving skills. As these programmes can be generic, they can alleviate the context-dependency of bridging materials.

In January 2008 a report from the Effective Pre-school, Primary and Secondary Education 3–14 Project (EPPSE 3–14) was published, drawing on some of the data from this major longitudinal study into the effects of pre-school education and later schooling (Evangelou *et al.*, 2008). The report used a sample drawn from children and families in the wider EPPSE project[9] and gives the most recent comprehensive large-scale picture of what is working at points of transfer and transition. Echoing the five bridges that Galton *et al.* had identified in 1999, there was evidence of considerable efforts being made to ensure that the social process of transition was being well managed. Information booklets about the secondary schools, open days and talks by secondary teachers were taking place, as were visits to secondary schools for whole primary classes or for families, where they could see examples of work and sample lessons. Some schools structured the first day of Year 7 so that the primary children were the only pupils at their new school and could experience the new space and facilities without other pupils around.

Some schools used 'bridging materials', with the same workbooks used in Years 6 and 7. There was some sharing of information on the skills and understanding pupils had achieved and on the style of lessons, for example, through the visits of Year 7 teachers to Year 6 classrooms to watch lessons and talk to individual pupils, with secondary school teachers initiating most of the contact. A minority (17 per cent) of the parents mentioned that their child had been assigned an older pupil as a mentor in secondary school.

The authors concluded that, to promote curriculum interest and continuity:

> Children need to understand what is expected of them in secondary school, be prepared for the level and style of work, and be challenged to build on progress at primary school. This helps to ensure a growing interest in school and work. Teachers reported wanting more information and a better understanding of the different approaches to teaching between primary and secondary schools. Parents also want to see schools better preparing their children for the work expected of them in secondary school. (Evangelou *et al.*, 2008, p. 56)

The continuity challenge

It is clear from the preceding section that the current picture regarding transfer presents the education system with some challenges. Although some of the 'bridges' identified in the seminal 1999 DfES report have been addressed in some areas, the picture is not uniform. Moreover, the recent interim report from the Primary Curriculum Review by Sir Jim Rose notes that there is little evidence on the comparative effectiveness of most of these strategies – although, as set out in the 'Engaging parents and carers' section below, an approach that engages all parties seems to be most effective (Rose, 2008). The context in which pupils are learning is changing rapidly, with other dynamics coming into play that may offer additional opportunities over and above those already uncovered in these research reviews. The following subsections highlight some of these opportunities.

Information and communications technology (ICT)

With new technologies being developed at a rapid rate, ICT can play an important part in supporting the transition points in a pupil's school career, helping to mitigate the impact of moving between different educational phases and institutions. High-quality materials that can support teaching and learning are increasingly available via technology, such as searchable DVDs of David Attenborough's wildlife TV series and interactive games teaching young children how to treat animals, conduct virtual experiments or understand periodic tables through new and dramatic formats. These materials are available anytime, anywhere and crucially for any age. Bransford (2006), among others, has already reminded us of the amount of time children and young people spend outside schools, often accessing materials that are not bounded by age or stage in the way that the school curriculum has been. Access to such materials and other ICT materials and technologies offers the chance to personalise approaches to learning. The work led by Lord Carter for 'Digital Britain', launched in late 2008,[10] seeks to address issues of inclusion, and to lead

9 1190 children from the total EPPSE sample made a transition at the end of the 2005/06 academic year and were approached. Responses were received from 550 children (a 46 per cent response rate) and 569 parents (a 48 per cent response rate) from across England drawn from six local authorities (a shire county, an inner London borough, a Midlands/metropolitan region, an East Anglia area and two authorities in the North East). Children were recruited to balance region, gender, socioeconomic status and ethnicity. A wide range of other data, already available from the main EPPSE study, was also used.

10 More information available at www.culture.gov.uk/what_we_do/broadcasting/5631.aspx.

to a drive to ensure that all children and young people have access to high-speed broadband, which will further extend the role technology could play in supporting pupils as they transfer between institutions.

Pupil involvement

Another approach that has been tried to address the problems of transfer comes from social interaction between pupils and the well-established body of research on the power of collaborative activity in learning (Howe and Mercer, 2007). When carefully structured, this type of activity has been shown to impact on the learning of those pupils who are the 'experts' as well as the 'novice' learner. Morrison (2005) conducted a small study in which Year 8 pupils worked with primary pupils.[11] The findings showed that the Year 8 pupils' attitudes towards learning and behaviour had improved as a result of the project, with some of the pupils commenting on the way the processes had made them reflect on their own behaviour in school and how having to explain scientific concepts and answer questions on topics had helped their own understanding. The primary teachers were also very positive about the project as it enabled them to have extra help in their classes and their pupils enjoyed working with the older students. The secondary teachers felt that their pupils improved their scientific knowledge, their social skills and their self-esteem. Clearly it is important to ensure that the 'expert pupils' are accurate in any explanation they give younger pupils – but a careful structuring of materials could support this kind of activity and mitigate risks of inaccurate information being shared.

Work in Scotland by Topping *et al.* (2008) has also found that collaborative group work across the primary–secondary transfer can have enduring effects on attainment and attitudes for the primary pupils, even two years later in secondary school.

An enquiry-based approach to learning

In 2007, the Department for Children, Schools and Families (DCSF) published a report based on a small-scale investigation into why some pupils who have done well at Key Stage 2 are unable to maintain their progress when they transfer to secondary school (DCSF, 2007). In terms of science, the study concluded that there need to be more opportunities in lower secondary school both for investigative work and for pupils to use a wider range of writing styles. The need for more investigative work was also echoed in a report by Ofsted, *Success in Science* (2008). Drawing on visits to 90 primary and 105 secondary schools between 2004 and 2007 and on the outcomes of subject conferences organised by Ofsted and work that Her Majesty's Inspectors (HMI) had done with national educational organisations, the report found that the schools with the highest or most rapidly improving standards were the ones that ensured that scientific enquiry was at the core of their work in science – where pupils were given the opportunity to pose questions and to design and carry out investigations for themselves. HMI found that teaching and learning were "at least satisfactory" in almost all of the schools visited. However, although this was a generally positive report, HMI found there were "recurring weaknesses, particularly in planning and assessment".

Among the findings was the fact that too often, in planning science activities, teachers did not take sufficient account of what pupils had already learned in previous Key Stages and did not give them clear advice on how to improve their work further. As a result, Ofsted found that "pupils lost interest and made insufficient progress". In too many primary and secondary schools, teachers were also found to be "mainly concerned with meeting narrow test and examination requirements and course specifications". This led them to adopt methodologies that "did not meet the needs of all pupils or promote independent learning". In Ofsted's view, throughout schooling, "the most stimulating teaching and most enthusiastic learning" occur when teachers are encouraging pupils to come up with their own ideas and suggestions and, while consulting with their teacher, to plan, conduct, record and evaluate their own investigations.

The report also found that, although many teachers are competent at using ICT and often employ resources such as PowerPoint themselves in their lessons, pupils do not get enough opportunities to use ICT in science lessons.

11 Year 8 pupils were chosen because some studies had shown that there was a potential drop-off in interest and increase in anti-work cultures at this age if pupils were bored and restless (for example Galton *et al.*, 2003).

Among the recommendations made by the report are the following that are particularly relevant to the subject of this paper:

- policy makers should “broaden the test requirements at Key Stages 1 and 2 [now just Key Stage 2] to give greater weight to assessing pupils’ understanding of how science works”
- policy makers should also “promote the sharing of good practice between phases and sectors to ensure more effective transition for pupils between key stages”
- secondary schools should “collaborate with associated schools to ensure continuity and coherence in pupils’ science education as they move from one key stage to the next”
- primary schools should “ensure that a focus on meeting test requirements does not detract from the breadth and balance of the science curriculum” (Oftsed, 2008, p. 6).

The new Key Stage 3 curriculum in England provides extensive opportunities for enquiry and investigation and encourages the use of a wide range of resources, including those found outside classrooms, such as Engaging Places and other resources[12] being developed by CABE (the Commission for Architecture and the Built Environment) and other organisations. The Opening Minds curriculum run by the RSA (Royal Society for the encouragement of Arts, Manufactures and Commerce) has been developing a new kind of curriculum based on competencies. Started in 2000, Opening Minds[13] aims to help schools to give young people ‘real-world’ skills or competencies via a broad framework through which schools can deliver the content of the National Curriculum in a creative and flexible way. The five sets of competencies cover citizenship, learning, managing information, managing situations and relating to people. Opening Minds is now being used in more than 200 schools across the country. According to the RSA, schools involved report that their students are more engaged, more independent as learners, have developed real-world skills and have higher self-esteem. In 2008, the RSA opened a new academy[14] that is the first school to be designed around the principles of Opening Minds.

Using assessment to promote learning

In Ofsted’s *Success in Science* report, good formative assessment is seen as crucial to success:

> When pupils receive regular feedback on how well they are progressing and clear advice on how they can improve further, they are able to focus their energies effectively. The resulting growth in self-confidence contributes to further progress. Where they take responsibility for self- and peer-assessment, their learning becomes more focused. (2008, p. 4)

Over the last few years there has been a drive to ensure that ‘assessment for learning’ (AfL) is used across the education system, with similar generic processes being followed across different content areas. Given the large evidence base on the benefits of formative assessment (for example by Black and Wiliam, 1998), this should provide a potentially effective mode of ensuring smooth progression at the point of transfer from primary to secondary school.

Engaging parents and carers

In June 2008, the Teaching and Learning Research Programme (TLRP) published a report of research carried out by Pamela Greenhough, Martin Hughes and colleagues, which examined the potential for home–school knowledge exchange to provide support for the primary–secondary transfer process (TLRP, 2008). In the schools where knowledge exchange programmes had been implemented, pupils made significantly greater progress in literacy from Years 6 to 7 than in the comparison schools (greater progress was also found in mathematics, but these results were not statistically significant). While attitudes to learning became less positive across all schools during this period, it was less marked in the knowledge exchange schools. The research also highlighted the importance of targeting pupils who are likely to need extra support at the point of transfer. Research from the National Strategies programme, cited by Sir Jim Rose in the interim report of his review of primary education (Rose, 2008), indicates that transfer occurs most smoothly when schools work together with local authorities, parents and pupils to establish what issues need to be addressed.

12 See www.engagingplaces.org.uk and, for other resources, www.cabe.org.uk.
13 See www.openingminds.org.uk.
14 See www.thersa.org/projects/education-legacy/rsa-academy---tipton.

Changing structures

In addition to the strategies already outlined, structural developments are also emerging that may help to address some of the challenges associated with transfer.

All-age or all-through schools

Schools that cater for pupils through all stages of their compulsory education are more common in the private sector and have long been promoted as a positive experience for pupils being privately educated. There is however, increasing interest in using similar models for schools in the state sector.

The Consortium of All Through Schooling[15] was developed from some of the early work of the DfES Innovation Unit.[16] The Unit originally brought together a number of school headteachers to consider issues involved in working in cross-phase education. As a result of this work, five themes were identified that were considered to be important in maximising the opportunities to improve pupil outcomes, namely leadership and management, curriculum, resources, ethos and community.

In the group's view, the collaboration and continuity that result from working in an all-age institution may well lead to raised attainment by the pupils. The main strengths of all-age schools in this respect were felt to be:

- the more settled environment for pupils and the creation of a learning ethos right across the school
- a strong sense of the school community with positive core values that are consistent throughout a pupil's school career
- improved teaching as teachers share expertise across the phases
- the opportunity to develop personalised learning portfolios and to use common assessment frameworks and other data about pupils more effectively
- improved pastoral care that can offer a joined-up strategy for special and behavioural needs across the phases
- strengthened links with parents through the greater continuity
- enhanced opportunities for staff retention and development – for example, creating roles such as 'Head of Learning and Pedagogy' with responsibilities right across the school
- some flexibility in areas such as curriculum design and delivery as well as school management
- sharing of resources and economies of scale
- improved continuity for multi-agency involvement across the phases – particularly for full-service or extended schools
- economies of scale, such as with ICT, leading to the release of some resources to be targeted at learning
- wider access to community facilities, and increased opportunities for local community to benefit from and support the work of the school.

In addition, the work from the Sorrell Foundation on school design demonstrates the importance of pupils being able to identify positively with their school – and being attached to a single institution throughout schooling may lead to a strong commitment to the school's 'brand' (Sorrell and Sorrell, 2005).

The Consortium of All Through Schooling (CATS) now exists as a separate entity and the movement is growing, with 120 members already. More all-age academies are planned, including a new one for Nottingham – which, with 3500 pupils, will eventually be the largest in the country. However, there are no national figures on how many schools are moving in this direction, because there is no requirement to report it. There are also no set formulas for how these schools should develop. Each one has to create its own model to respond to the particular local community context.

15 See www.allthroughschooling.org.

16 See www.innovation-unit.co.uk. The Consortium was incubated by the Innovation Unit when the Unit was part of the Department for Education and Skills. The Unit became independent of the Department in 2006 and is now a self-funded independent company.

St Matthew Academy[17] opened in late 2008 in south London. The Principal, Monica Cross, believes it offers the opportunity to eradicate the traditional dip in schooling and makes the point that her school will allow gifted younger children to join older ones in lessons that will stimulate and stretch them (Wilce, 2008). This may again help to address some of the transition, behaviour and learning issues that are seen elsewhere. Hilary Macaulay, of West London Academy, Northolt,[18] an all-through school that has been open for three years, similarly believes there is no such thing as transition in her Academy.[19]

In Nottingham, David Harris – previously Principal of Serlby Park, a 3–18 Business and Enterprise Learning Community that was formed from the integration of a secondary, a junior and an infant school in north Nottinghamshire – has said that addressing the issue of dips in performance as pupils move through school was one of the drivers for developing the single unit. Examples of efforts to reduce transfer issues include form tutors from different year groups working together on joint projects and the fact that all Year 7 pupils follow a cross-curricular timetable for the first two periods each day, taught by the form teacher. These cross-curricular lessons are carefully planned to address generic thinking skills and methods of learning in a way that helps to smooth the transition between the primary and secondary phases.

Owing to the relatively short time that state sector all-age schools have been in existence, evidence on their benefits is still limited. However, the indications from the case studies above seem to imply that the all-age school environment is likely to reduce barriers to learning and support better progression in all subjects. Members of CATS also draw on experience from elsewhere, such as the highly successful education system in Finland (the top performer in the PISA 2006 study referred to earlier), where pupils go to a single comprehensive school from 7 to 16.

So what can the rest of the education system learn from the experience of the heads who are working in all-through schools? Based on interviews with headteachers in four all-age schools, a report published in 2007 by the National College for School Leadership highlights some of the challenges and opportunities of leading and managing an all-age school and makes several recommendations that could equally apply to other primary and secondary schools (Swidenbank, 2007). For example:

- …base [the Year 7 curriculum] around a traditional primary model, for example, having 'home teachers' who teach the Year 7 students the majority of the time or introducing curriculum models based around themes such as those outlined in the RSA Opening Minds projects.
- Set up tracking and assessment systems that go across the two phases.
- Develop opportunities for joint planning and team teaching across the two phases.
- Set up joint monitoring systems such as 'book looks', work sampling, standardisation of writing or art work.
- Set up buddying systems for students and staff across the age range.
- Collapse timetables occasionally and allow for flexibility. (Swidenbank, 2007, p. 3)

Federations

There are still only a small number of all-age schools. Nevertheless, anecdotal evidence[20] suggests that there is a desire in many other schools to collaborate in some form or another and that this is increasing. Some of this collaboration is in phase-specific groups, as in the secondary schools in the Harris Federation in south London, which has eight academies. Other instances work across the age range and may open up possibilities for different kinds of movement and transition point, such as moving to secondary education when a child is ready rather than automatically at age 11.

17 See www.stmatthewacademy.co.uk.
18 See www.westlondonacademy.co.uk.
19 See 'The Risk Takers' supplement in the *Guardian*, 23 May 2006.
20 Data collated by the author in her role as one of the Directors of the Innovation Unit.

A ‘federation’ consists of a group of at least two and maybe more schools working as partners, with some elements of shared governance, in order to raise standards. The 2002 Education Act made provision for schools to be able to work together to create informal or formal collective agreements. The act of federating offers schools a chance to exchange practice, each learning from the others’ best practice and drawing on the highest-performing aspects of each school. Evidence from other kinds of collaboration between schools (such as the Leading Edge Partnership Programme originally established by the Innovation Unit in 2003) has already shown that that all schools can benefit from a wider range of teaching expertise and a shared commitment with other institutions to raise quality.

Any type of school can agree to work together, including further education institutions, independent schools, academies and city technology colleges. However, only maintained schools can form a federation under a single governing body. This is known as a ‘hard’ federation and is the more formal arrangement. It would be possible for a formal federation such as this to collaborate with other maintained or non-maintained schools in a more informal way at the same time. Moreover, there is also the possibility of groups of schools working with other providers of children’s services such as health and social services.

In terms of alleviating transfer issues, federations can offer many of the benefits of all-age schooling for their pupils, but they clearly place other demands on school leaders and governors to ensure that the managerial dimensions run smoothly. Liz Talmadge, Headteacher of a federation of schools covering the 2–19 age range, has spoken about how staff decided to teach most pupils in Year 7 as though they were still in a primary class, and gave them a single tutor for all subjects apart from science, physical education and languages.[21] The school, which originally combined two struggling secondary schools and a local primary school, has now become very popular, with Year 7 being oversubscribed.

So, do federations generally work? The DCSF funded 37 federations at a cost of £16 million for the period 2003–07, and evaluated them at various stages of the process. In relation to transfer, around three-quarters of the sample had listed improving the move from primary to secondary as one of their aims, and of these schools, three-quarters thought that it had been achieved satisfactorily. Although there was no significant impact on performance at Key Stage 2 or Key Stage 3, at GCSE significantly more pupils from the federations (2.3 percentage points) gained five A–G grades compared with other schools not on the federation programme, and the score for the value that the school and teachers had added was four points higher. The vast majority of heads and governors felt that the federations were successful, with a quarter rating them as them as “very successful”.

Smaller units

In February 2008, Channel 4 broadcast a *Dispatches* documentary entitled *The Children Left Behind*,[22] which investigated whether the size, design and organisation of comprehensive schools might play a role in the fact that up to 300 000 young people each year were leaving secondary school with fewer than five GCSEs at grades A*–C (including English and maths). Drawing on research carried out at the University of Bristol by James Wetz, the programme highlighted the fact that many of the children who left school with no qualifications were doing well in their education at the age of 10 or 11; the turning point came as they joined their secondary schools (Wetz, 2006). Was the large size of the comprehensive schools that pupils moved to after being in smaller primary schools part of the problem? The programme’s contention was that it could be and suggested that one way to address this issue might be to create smaller ‘schools within schools’, where younger students are separated from other age groups. The small school movement has been gathering momentum in the USA, with organisations such as the Bill and Melinda Gates Foundation funding their development. In the UK, Mossbourne Academy in Hackney has a mini-school for Year 7 pupils, which is separated from the rest of the year groups. The Academy has the best ‘value added’ scores in the country for Key Stage 3.

---

21 See ‘The Risk Takers’ supplement in the Guardian, 23 May 2006.

22 *Dispatches: The Children Left Behind.* Broadcast on Channel 4 on 11 February 2008. See www.channel4.com/news/articles/dispatches/the+children+left+behind/1537047.

Conclusions and recommendations

Recent advice from the Specialist Schools and Academies Trust[23] supports many of the processes mentioned above, including buddying systems, 'schools within schools' for younger secondary students, collaborative projects between primary and secondary schools, reciprocal visits between schools by teachers and pupils, secondary teachers giving lessons to primary pupils, joint governance (as in federated schools), and all-through schools. A forthcoming National Foundation for Educational Research study on transition will augment the knowledge we have about effective ways of managing the transfer process between primary and secondary schools by looking at the common issues faced by pupils generally and at particular stages; are there particular issues for pupils who may need extra support, what seems to work well and what constitutes effective policy and practice in this area?

In advance of this, we can say there are some areas that seem particularly fruitful and would be worth further examination by policy makers:

- better engagement of parents in all young people's learning, particularly at points of change and for those children who may need extra support
- the use of a portfolio or passport of a pupil's work (perhaps an e-portfolio) to help secondary teachers to gain more information on the experiences and abilities in science of their new students; this could also include activities carried out outside school
- better alignment of teaching and assessment approaches across the phases, such as the use of carefully structured collaborative learning approaches, investigations and problem solving, and assessment for learning
- the creation of smaller-scale units within large comprehensive schools for first-year secondary students
- further evaluation of the federation and all-age school approaches, which appear to offer the chance for many of the 'bumps' that occur at transfer to be smoothed out, as well as providing an opportunity for pupils to identify with a single institution or associated group of institutions throughout their school career.

23 See www.ssatrust.org.uk/article.aspa?PageId=1533&NodeId=53.

References

Beynon J. Initial Encounters in the Secondary School. Lewes: Falmer Press; 1985.

Black P, Wiliam D. Inside the Black Box: Raising standards through classroom assessment. London: King's College; 1998.

Bransford JD. Toward a 21st century learning theory: Some emerging thoughts. Paper presented at the Annual Conference of the National Association for Research in Science Teaching, San Francisco, California, 2006.

Braund M, Driver M. Moving to the big school: what do pupils think about science practical work pre- and post-transfer? Paper presented to the British Educational Research Association Annual Conference, 2002.

Braund M, Driver M, Crompton Z. Improving post-transfer progression in science: the effective use of 'bridging work' in schools in the UK. Paper presented at the European Science Education Research Association conference, 2003. www1.phys.uu.nl/esera2003/programme/pdf/024S.pdf [accessed 7 April 2009].

Braund M, Hames V. Improving progression and continuity from primary to secondary science: pupils' reactions to bridging work. International Journal of Science Education 2005;27(7):781–801.

Catterall J. Risk and resilience in student transitions to high school. American Journal of Education 1998;106:302–33.

Department for Children, Schools and Families. Getting Back on Track: Pupils who make slow progress in English, mathematics and science at Key Stage 3. London: Department for Children, Schools and Families; 2007.

Evangelou M, Taggart B, Sylva K, Melhuish E, Sammons P, Siraj-Blatchford I. What Makes a Successful Transition to Secondary School? London: Department for Children, Schools and Families; 2008.

Galton M, Gray J, Rudduck J. The Impact of School Transitions and Transfers on Pupil Progress and Attainment. London: Department for Education and Skills; 1999.

Galton M, Gray J, Rudduck J, Berry M, Demetriou H, Edwards J, Goalen P, Hargreaves L, Hussey S, Pell T, Schagen I, Charles M. Transfer and Transitions in the Middle Years of Schooling (7–14): Continuities and discontinuities in learning. Research Report RR443. London: Department for Education and Skills; 2003.

Hargreaves L, Galton M. Transfer from the Primary Classroom: 20 years on. London: Routledge; 2002.

Haworth CMA, Dale P, Plomin R. A twin study into the genetic and environmental influences on academic performance in science in nine-year-old boys and girls. International Journal of Science Education 2007;30(8):1003–25.

Howe C, Mercer N. Children's Social development: Peer interaction and classroom learning. Primary Review Research Survey 2/1b. Cambridge: University of Cambridge Faculty of Education; 2007.

Jenkins E, Nelson NW. Important but not for me: students' attitudes towards secondary school science in England. Research in Science and Technological Education 2005;23(1):41–57.

Lindahl B. A longitudinal study of students' attitudes towards science and choice of career. Paper presented at the 80th National Association of Research in Science Teaching International Conference at New Orleans, Louisiana, 2007.

Measor L, Woods P. Changing Schools. Milton Keynes: Open University Press; 1984.

Morrison L. Involvement in primary transfer. School Science Review 2005;87(318):75–82.

Nisbet JD, Entwistle NJ. The Transition to Secondary School. London: London University Press; 1969.

Ofsted. Annual Report of Her Majesty's Chief Inspector of Schools: standards and quality in education 1996/97. London: HMSO; 1998.

Ofsted. Success in Science. London: Ofsted; 2008.

Osborne J. Memorandum 70: Submission from Jonathan Osborne, King's College London. House of Commons Select Committee on Science and Technology; 2007. www.publications.parliament.uk/pa/cm200607/cmselect/cmsctech/903/903we75.htm [accessed 7 April 2009].

Osborne J, Dillon J. Science Education in Europe: Critical reflections. A report to the Nuffield Foundation. London: King's College London; 2008.

Osborne JF, Simon S, Collins S. Attitudes towards science: a review of the literature and its implications. International Journal of Science Education 2003;25:1049–79.

Rose J. The Independent Review of the Primary Curriculum: Interim report. London: HMSO; 2008. See http://publications.teachernet.gov.uk.

Royal Society. Taking a Leading Role. London: The Royal Society; 2006.

Sorrell J, Sorrell F. Joinedupdesignforschools. London: Merrell; 2005.

Stables K. Discontinuity in transition: pupils' experience of technology in year 6 and year 7. International Journal of Technology and Design Education 1995;5:157–69.

Swidenbank H. The Challenges and Opportunities of Leading and Managing an All-age School. Research Associate Summary Report. Nottingham: National College for School Leadership; 2007.

Tai RH, Qi Liu C, Maltese AV, Fan X. Planning early for careers in science. Science 2006;312:1143–5.

Teaching and Learning Research Programme. Supporting Primary-secondary Transfer through Home-school Knowledge Exchange. TLRP Research Briefing Number 45. London: TLRP; 2008. www.tlrp.org/pub/documents/45HughesRBfinal.pdf [accessed 7 April 2009].

Topping KJ, Thurston A, Tolmie A, Christie D, Murray P, Karagiannidou E. Group Work: Transition into secondary. Education Analytical Services, Scottish Government; 2008. www.scotland.gov.uk/Publications/2008/02/04144018/0 [accessed 7 April 2009].

Wetz J. Holding Children in Mind over Time. Bristol: Bristol Education Initiative; 2006.

Wilce H. An academy for all ages: why all through schools are booming. Independent 2008 2 October.

About the author

Anne Diack is Head of Education at the Commission for Architecture and the Built Environment – the government's adviser on architecture, urban design and public space. From 2002 to 2008 she was a Director of the Department for Children, Schools and Families Innovation Unit. She has been a member of the National Education Research Forum, an education researcher and a teacher trainer. She has also been a BBC producer for the Open University, covering education, arts and cognitive psychology in the UK and worldwide, and Research Manager for BBC Education Policy. This work was commissioned before she took up her present post and the views expressed here are her own.

Glossary

*Items marked with * are taken or adapted from Braund (2008).*

Academies (previously known as 'City academies') – Comprehensive schools in England established by sponsors from business, faith or voluntary groups working in partnership with central government and local education partners. Sponsors and the Department for Children, Schools and Families (DCSF; previously the Department for Education and Skills, DfES) provide the capital costs for the Academy. Running costs are met by DCSF.

All-through schools (also known as 'all-age schools')[1] – There are two main all-age models:

- All-age school federation (also see 'federation') – two or more schools that share a degree of governance and pedagogical programmes, but remain funded as separate institutions. They may or may not share one site/campus.
- All-age school – one school comprising all or multiple phases, with one governing body and funded as a single institution. It often occupies a single site/campus or is combining its previously separate institutional sites into a new build.

Bridges – A term used to describe types of strategy or activity to support transfer from primary to secondary school. In their report for the Department for Education and Skills, Galton, Grey and Rudduck (1999) identified five main bridges: the bureaucratic bridge, the social bridge, the curriculum bridge, the pedagogy bridge and the management of learning bridge. The 'social bridge', for example, focuses on developing social links between pupils and parents/carers and their new school before and after transfer.

Bridging* – The term given to a programme of planned/shared learning, where topics are started in one phase or school and completed in the next one.

Clusters (of schools)* – A generic term applied to grouping schools on the basis of location or intake arrangements – see also 'family of schools' and 'pyramid (of schools).'

Comprehensive schools* – Introduced in the late 1950s and the 1960s as all-ability alternatives to grammar and secondary modern schools (see 'eleven-plus'). Most schools in England, Wales and Scotland are of this type. Admissions policies must be equitable and avoid selection of pupils on the basis of their abilities.

Eleven-plus (11+)* – Psychometric tests used to score a population of pupils at age 11 to select those who will go to grammar schools. Introduced in the 1950s and now only used in a few areas of England (also see 'Transfer Test').

Every Child Matters* – Legislation introduced by the UK government to integrate policy and approaches on social, family and healthcare with educational services.

Family of schools* – Usually considered to be one secondary school and its feeder primary schools, but could also refer to schools sharing the same religious background; hence families of Roman Catholic or Church of England schools.

Feeder schools* – These are primary schools that send pupils to a particular secondary or middle school at transfer. In England, the number of feeder schools will depend on factors such as the geographical location of the school, its agreed maximum intake (pupil spaces available) and whether it is denominational or religiously endowed.

1 Definition taken from Innovation Unit (2006).

(School) Federation – A federation is a group of schools, often cross-phase, that agree to work together, for example to share curriculum teaching, ICT, sports facilities or budgets.[2]

Grammar schools – State-funded schools that are allowed by law to select all their pupils on the grounds of academic ability. There are no state grammar schools in Scotland or Wales.

Key Stages* – The National Curriculum introduced into England and Wales in 1989, and to Northern Ireland in 1991, divided statutory ages of schooling into four Key Stages. See p. 56 for more detail.

Local Authorities (LEAs or LAs)* – Regional bodies responsible for local organisation of education services in UK countries. In Northern Ireland these are currently known as Education and Library Boards.

Middle schools* – Schools that have transfer ages different from the usual age 11. The age ranges of these schools are most commonly 8– or 9–13 or 11–14. These schools were common in some areas of the UK in the 1970s and 1980s. They are now being phased out.

ORACLE – Observational Research and Classroom Learning Evaluation carried out during a five-year period beginning in 1975, the ORACLE project described teaching and learning in classrooms in primary, middle and secondary schools. This research was then repeated 20 years later.

Pyramid (of schools)* – This usually refers to a structure whereby one large secondary school takes pupils from a number of middle schools who each in turn take pupils from a number of primary schools – hence the shape is like a pyramid. This arrangement is now rare in England.

SATs* – Standard attainment tests are used nationally in England to assess the whole population of pupils in state schools in English, mathematics and science at age 11 (previously also at ages 7 and 14). Data are published as numbers of pupils attaining target levels of the National Curriculum. Schools' results are compared with regional (LA) and national averages and used to construct league tables comparing schools.

Science Learning Centres – A national network of centres offering professional development to those involved in science education, including secondary science teachers, primary teachers, science technicians and those teaching citizenship. There are nine regional centres across England and one UK-wide National Centre in York.

Specialist schools* – Comprehensive schools that have raised funds matched by government and have been awarded 'specialist school status' in a particular area of expertise such as science, mathematics, the arts and so on. Specialist schools must offer the full range of National Curriculum teaching and are expected to coordinate with other schools in the area, for example to offer training.

STAY* – Science Transition AstraZeneca York project, which researched, developed and evaluated science bridging work.

'Transfer' (and 'transition') – These terms are often used interchangeably to describe major changes in a young person's education, for example from primary to secondary school or secondary school to university. Some authors also use the term 'transition' to describe more minor changes, such as from one year to another within a school or even from one topic to another within a subject. The reports in this publication restrict their use of the term 'transfer' to refer to changes between schools.

Transfer Test – The name given to the recently abolished 'eleven-plus' test in Northern Ireland. The last year of testing was 2008. Some Northern Irish grammar schools are now introducing private entrance tests.

'Transition' – See 'transfer'.

2 Definition adapted from Innovation Unit (2005).

References

Braund M. Starting Science…Again? Making progress in science learning. London: Sage Publications; 2008.
Galton M, Gray J, Rudduck J. The Impact of School Transitions and Transfers on Pupil Progress and Attainment. Research Report RR 131. London: Department for Education and Employment; 1999.
Innovation Unit. An Introduction to School Federations. London: Department for Education and Skills; 2005.
Innovation Unit. All-age Schooling: A resource. London: Department for Education and Skills; 2006.

Overview of UK curriculum stages, compulsory assessments and qualifications

Please note that the table highlights a limited selection of the wide range of qualifications available and is not intended to be comprehensive. (Notes on following page.)

	Age	ENGLAND			WALES			SCOTLAND		NORTHERN IRELAND[7]	
		National Curriculum for England			National Curriculum for Wales			3–18 Curriculum for Excellence[4]		Northern Ireland Curriculum	
NURSERY AND PRIMARY EDUCATION	3–4	Early years (Foundation)			Foundation Phase – combines the previous Early Years and Key Stage 1 (Years 1–3)						
	4–5		Teacher assessment			Teacher assessment		P1	National assessment in reading, writing and mathematics. Marked internally, with pupils tested 'when ready' at teachers' discretion. Also Scottish Survey of Achievement (SSA)[5]	Foundation Stage (Years 1–2)	Annual teacher assessment focusing on cross-curricular and other skills as well as areas of learning and use of diagnostic assessment (Years 4–7) based on aspects of reading and mathematics. Reports for parents
	5–6	Key Stage 1 (Years 1–3)						P2			
	6–7							P3		Key Stage 1 (Years 3–4)	
	7–8		National tests (English and mathematics) marked in school and used to inform teacher assessment			Teacher assessment		P4			
	8–9	Key stage 2 (Years 4–6)			Key stage 2 (Years 4–6)			P5		Key Stage 2 (Years 5–7)	Summative record of achievement at end of Key Stage 2
	9–10							P6			
	10-11		National tests in English, mathematics and science.[1] Marked externally. Schools' results published nationally			Teacher assessment plus formative assessment of skills progression supported by some optional assessment materials; results private		P7			
SECONDARY AND FURTHER EDUCATION	11–12	Key Stage 3 (Years 7			Key Stage 3 (Years 7–9)			S1	As above	Key Stage 3 (Years 8–10)	Annual teacher assessment (as above) and reports for parents
	12–13							S2			
	13–14		Teacher assessment			Teacher assessment		S3			
	14–15	Key Stage 4 (Years 10–11)	14–19 Diplomas[2]		Key Stage 4 (Years 10–11)	Welsh Baccalaureate[3]		S4	Qualifications at several levels in the Scottish Credit and Qualifications Framework (SCQF), including Access, Standard Grade, Higher and Advanced Higher. Also a new Baccalaureate[6]	Key Stage 4 (Years 11–12)	
	15–16			GCSEs			GCSEs	S5			GCSEs and summative record of achievement
	16–17	Post-16 (Years 12–13)		AS and A levels	Post-16 (Years 12–13)		AS and A levels	S6		Post-16 (Years 13–14)	AS and A levels and summative record of achievement
	17–18							S7			

Notes to Overview of UK curriculum stages, compulsory assessments and qualifications

1 Single-level tests are also being piloted in English reading, English writing and mathematics (but not science) at Key Stage 2. These are not age-specific but are intended to be taken when a teacher thinks a pupil has reached the next National Curriculum level.

2 The new diplomas will cover 17 subjects, or lines of learning, including science and engineering. They are intended to combine theoretical and applied learning in a work-related context. By 2013 all students will be entitled to study for one of the diplomas.

3 The Welsh Baccalaureate combines personal development skills (for example work-related skills and personal and social education) with existing qualifications such as GCSEs, A levels and NVQs (National Vocational Qualifications) to make one wider award. The qualification is offered at Foundation, Intermediate and Advanced levels. Intermediate and Advanced levels are already available across Wales. Foundation level will be introduced from September 2009.

4 The new 3–18 Curriculum for Excellence will be in place from 2009/10. A consultation on future arrangements for National Qualifications was carried out in 2008. New qualifications will be in place from 2012/13. This table shows the existing assessment system.

5 The Scottish Survey of Achievement (SSA) is an annual national survey of pupil attainment between the ages of 5 and 14. Attainment of a random sample of pupils in a representative sample of schools is measured in years P3, P5, P7 and S2.

6 A new science baccalaureate is being introduced in Scotland (first awards will be made in 2010). The qualification is aimed at students studying two science subjects and mathematics at Higher level and one science at Advanced Higher level, and will include an interdisciplinary project to be taken in year S6.

7 The assessment system in Northern Ireland is under review. This table shows the new assessment system currently being introduced.