Invited Research Article

Research and Trends on Science Teacher Education in England

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Abstract

International comparisons point to a substantial difference in attainment between the highest and the lowest attaining students in science. This gap suggests a need for improved pedagogies which can be addressed through pre- and in-service education. Recent government changes aimed at improving the quality of science education have led to the creation of a number of new routes into teaching and a determined focus on raising the number of physics specialist teachers. The process of allocating teacher training numbers by subject specialism rather than by simply identifying 'science' places has had an impact on the balance of biological and physical sciences. A new system of financial bursaries rewards students with good degrees. While some success has been achieved in increasing pre-service numbers, teachers still do not appear to be getting the in-service training that they need and want.

Key words: science teacher education, pedagogy, curriculum, assessment, professional development, England

I. Introduction

According to a recent analysis of education systems, the UK is ranked sixth best in the world (Pearson, 2012). However, an analysis of international comparisons of student attainment suggests that England has a relatively long tail compared with many other developed countries (Smithers, 2013). That is, the gap between the highest attaining and the lowest is greater than might be expected of an education system that has undergone significant change aimed at raising the quality of teaching and learning over many years.

As in most developed countries, politicians and the media in England are intensely interested in the results of international comparisons especially PISA and TIMSS. An examination of recent PISA study results suggests that between the 2000 and the 2009 series of science tests, England slipped from 4th in the rankings to 16th (DfE, 2011). 'Findings' such as these have been seized on by the press and by politicians as evidence that standards of teaching in science have declined alarmingly and that radical action is needed. Education researchers would argue that the trend in science attainment is not nearly as dramatic as it might appear. Indeed the OECD and others have criticised the government for what they see as misuse of the data for political purposes (Full Fact, 2010). Having said that, there is some legitimate concern that England's position has declined particularly relative to countries such as South Korea and Singapore. This concern has fuelled recent policy initiatives focusing on the science curriculum and on science teacher education.

The countries which make up the United Kingdom have their own education systems which reflect the history and culture of the four nations. Power over education matters in Scotland, Wales and Northern Ireland is devolved and while there are some similarities between the educations systems there are also some significant differences. In this paper we will reflect on recent trends and issues in science teacher education in the largest of the four countries, England.

II. The English Education System

Education is compulsory in England from the age of 5. More than 99% of children receive that education at school with the rest being home-schooled. Recent changes in education policy will mean that the school leaving age will rise from 16 to 17 in 2013 and from 2015 it will rise again to 18. Students must be in some form of education although they will not all have to attend school or college full-time. They could, for example, be on an apprenticeship scheme or be working full-time and studying part-time. These changes reflect a view that students need to be spending longer in education before embarking on their careers. The impacts of these changes on schools have yet to be fully identified.

Throughout most of England, children attend one of around 22,000 primary schools from ages 5–11. From the age of 11 onwards they attend one of 4,000 secondary schools. Beyond the age of 16, students can stay in school for further study or attend other educational institutions such sixth-form colleges or colleges of further education. The number of students aged 16 is about 650,000. Some 7% of pupils attend private ('independent') schools with the figure rising to around 18% for students over the age of 16. There are 164 selective ('Grammar') schools. The great majority of pupils in these schools come from higher socio-economic groups. While the numbers of students are small, the independent and grammar schools are disproportionally represented at the top universities and in the higher echelons of society.

Recent governments have systematically reduced the power of the 174 local authorities in England and Wales. Local education authorities, as they were called, were responsible for the state-funded schools and provided central support such as advisory teachers and teacher centres. The Inner London Education Authority, for example, had three science centres including one at the London Zoo. Over the last decade, schools have been encouraged to become 'academies'. There are around 2,000 academies most of which are secondary schools and they are paid for centrally by the state and are free of local authority control.

III. Curriculum and Assessment in England

The national curriculum, which was introduced in 1989, made a number of subjects, including science, compulsory for all students in state funded schools until the age of 16. In primary schools, which cover Key Stages 1 (ages 5–7) and 2 (ages 7–11) students study science rather than the separate disciplines of biology, chemistry and physics. At Key Stage 3 (ages 11–13) students usually study general science, although the curriculum is divided into the three main disciplines. There are four main strands (with assessment criteria specified in four attainment targets) including three that focus on the content of science: 'Organisms, their behaviour and the environment'; 'Materials, their properties and the earth'; and, 'Energy, forces and space'. Some earth science appears in all three strands. A fourth strand, 'How science works', is taught across all three strands and is intended to introduce students to the processes and methods of science.

At Key Stage 4, science is taught as a 'double subject'—i.e. it is equivalent in value to two GCSEs (General Certificates in Secondary Education) and takes up about 20% of teaching time. Physics, chemistry and biology are often taught separately, although the curriculum is coordinated. Students are mainly taught by subject specialists, although a shortage of physics teachers in particular means that this is not always possible. 'Triple Science' is an option in which pupils take three separate GCSEs, in physics, chemistry and biology. Normally only offered to higher attaining pupils, it is an option that has grown quickly in recent years, with strong government backing (Fairbrother and Dillon, 2009). Applied science is a third option that has also grown in recent years. It is generally taken by lower attaining pupils. Applied science struggled to gain acceptance from teachers, parents and employers and the numbers entered each year have been relatively small (Bell and Donnelly, 2007). As Bell and Donnelly point out, 'The relentless association of the word 'vocational' with lower status, and with training for narrow and sub-professional employment is of course a key issue here' (2007, p. 8). The current government has introduced a new draft curriculum for science which is open for public consultation.

Alongside the national curriculum there is a national assessment system. Student attainment up until the age of 14 is measured against a set of eight levels. Descriptors which set out what a pupil operating at each level should know, understand and be able to do are published for each of the attainment targets. The expectation is that most pupils will progress by approximately one level every two years so that by the end of Key Stage 3 they are expected to achieve Level 5 or Level 6. At the end of primary school (Key Stage 2) pupils take national tests in mathematics and English. National testing in science was stopped in 2008 although students are assessed by their teachers at the end of their schooling. In 2012, the teacher assessment of pupils' science attainment reported that 87% achieved the target (Level 4) (compared with 85% in 2011). The increased use of of targets for attainment and attendance has made it easier to compare schools, classes, students and teachers.

IV. The Teaching Force

Teaching in the UK is a graduate profession although the current government has indicated that academies may employ untrained teachers—a controversial policy. The completion of a course of Initial Teacher Training is necessary in order to attain Qualified Teacher Status. The number of routes into teaching has increased in recent years with increasing emphasis on what are termed 'school-based' (as opposed to 'university-based') schemes. One-year postgraduate courses, which have provided the majority of trained secondary teachers are becoming more common at the primary level.

There are almost half a million teachers in state-funded schools in England with a reasonably even split between primary (204,200) and secondary schools (198,800). On average there are nine science teachers in each secondary school. Teaching is predominantly a female profession with around three-quarters of teachers being women. Very few primary teachers have science backgrounds. Having said that, the numbers of graduates in any one subject is not high given the number of subjects in the primary curriculum.

Science teacher training usually prepares students to teach science up to GCSE level and then their own specialist subject (biology, chemistry or physics) post-16 (that is, to students aged 16–19 who may be preparing to take A level examinations which are a prerequisite for university entrance). Most applicants to teacher education courses will have gone through the national curriculum and have been taught across all the sciences until the age of 16. That was not usually the case before the national curriculum was introduced and in the years it took before students who had studied the national curriculum were old enough to apply for pre-service teacher training.

V. Managing the Supply of Science Teachers

The responsibility for managing teacher education and training rests with a government body, the Teaching Agency. Each year approximately 38,000 students are recruited on to teacher training courses. Responsibility for inspecting teacher training lies with the Office for Standards in Education (Ofsted). Ofsted has judged the quality of teacher training in England to be 'good' or better in 90% of institutions.

However, despite the high quality of teacher education which is predominantly organised by universities the current government has made it clear that it favours school-based training schemes (such as school-centred initial teacher training (SCITT), School Direct and Teach First) over university-run courses (such as the Postgraduate Certificate in Education—the PGCE). There are also undergraduate courses—usually designed for trainee primary school teachers—and online courses. It should be pointed out that the PGCE involves students spending 24 weeks in school and 12 weeks in university which leaves little time for in-depth discussion of theories and practices. Whichever course students chose, they gain classroom experience in at least two schools. The House of Commons Education Committee, which has examined issues of recruitment and retention of teachers, commented that:

> We are left in little doubt that partnership between schools and universities is likely to provide the highest-quality initial teacher education, the content of which will involve significant school experience but include theoretical and research elements as well. (HoC EC 2012, pp. 3–4)

Politicians to the right of centre often tend to portray teaching as a craft which does not require a theory-base but which does require subject knowledge. Providers of pre-service teacher education, however, would argue that teaching is a profession, which, similar to medicine, requires a theory-base. This theory-base would include an understanding of how people learn and of the common alternative conceptions children hold (for example, about electricity, forces and the workings of the human body).

One of the innovations brought in by the current Coalition government is School Direct (SD). SD involves schools taking the lead in teacher recruitment and training. There are two routes to this employment-based course one of which involves completing a PGCE and the other (the salaried route) involves spending the vast majority of the year in school.

VI. Issues in Science Teacher Education

1. Subject Knowledge

Good subject knowledge is essential for science teachers in secondary schools. However, good teaching involves a number of other factors including the ability to translate high-level subject knowledge into knowledge that school students can understand. Possessing a high quality degree in a subject does not automatically mean that someone will be a good teacher. The degree of importance of subject knowledge to science teachers has been the cause of some debate for several years.

The Wellcome Trust commissioned a study of how PGCE science students improved their subject knowledge during their training. The report's authors outlined what they saw as the key issue:

> Few trainee teachers will have studied all three science subjects to A-level (Institute of Physics, 2002). Many may have only studied one science to A-level and for these trainees their study of other sciences will have been limited to GCSE. Although the Training and Development Agency (TDA, 2010) requirement is that trainees are prepared to teach across the sciences to Key Stage 3 and in their specialism at GCSE onwards, studies by Lock and Soares (2005), Lock, Soares and Foster (2009) and the House of Commons Children, Schools and Families Committee (2010) report that schools require many NQTs to be competent to teach all sciences to GCSE level. This places a considerable demand on trainees developing their subject knowledge and ways of transforming this knowledge into effective teaching during a one-year ITT course. Even in teaching their subject specialism, trainee teachers need pedagogical content knowledge to transform good subject matter knowledge into effective lessons (Van Driel, De Jong and Verloop, 2002; Kind, 2009). (Lock et al., 2011, p. 5)

Subject knowledge enhancement (SKE) courses are available to students accepted on to courses of initial teacher education, and are taken prior to starting their ITT course. Courses in chemistry and physics (but not biology) are available. They normally last two weeks but some can be spread over a longer period of time and can be taken online rather than face-to-face.

The House of Commons Education Committee chose teacher recruitment, training and retention for in-depth study in mid-2011. Their report, which goes into some depth, is entitled 'Great teachers: attracting, training and retaining the best'. The cross-party committee took evidence in writing and in person from a large number of informants. The issue of subject knowledge and its importance to teachers was one that they discuss in some detail:

> We heard considerable debate around the level of subject knowledge required by teachers, and how this equated to both their academic background and their skill in the classroom. Evidence from around the world suggests that degree class can be a useful 'initial sieve', prior to teacher training, to ensure that graduates have strong subject knowledge and solid academic credentials. Moreover, setting a high academic bar sends a clear signal that this is a difficult profession to enter, thus raising its status. For example, South Korean teachers are generally recruited from the top 5% of the graduate cohort, those in Finland from the top 10%, and in Singapore and Hong Kong from the top 30%. All four of those countries are ranked significantly above the OECD average for students' reading and mathematics, where the UK is around the average for both.
> (HoC EC, 2012, p. 15)

The extent to which subject knowledge should be used to select potential trainee teachers is one that has been around for some years. In England institutions which provide initial teacher education courses are encouraged to select students with good degree classifications. The HoC

Education Committee found evidence that this position was contested and not supported by significant evidence:

> Despite the policies suggested by that international evidence, witnesses to our inquiry—whilst generally minded that, in the words of one organisation, "the better qualified the teaching profession is the more effective it will be"—were sceptical that degree class equated to ability in the classroom. Ofsted said it knew of "no firm evidence to support the view that those with the highest degree classifications make the best teachers", a statement supported by Keele University which argued that "some the highest-quality teachers" it had produced "have had degrees at 2.2 or lower". That opinion was backed up by teachers attending a private seminar with the Committee to launch the inquiry, all of whom were outstanding practitioners and several of whom had lower class degrees.
> (HoC EC, 2012, p. 15)

Debate about this issue continues to take place and there is no sight of any resolution in the near future. The challenge of improving teachers' subject and pedagogic content knowledge in school has been tentatively examined by Childs and McNicholl (2007) and, more recently, by McNicholl, Childs and Burn (2013).

2. Increasing the Number of Physics Teachers

For many years, the numbers of specialist physics teachers in schools was significantly lower than specialist chemists and biologists. The government sets targets for the number of teachers trained each year. Until recently, the government allocated target numbers for 'Science'. King's College London, for example, was allocated 75 'science' places in 2009. However, a recent change has seen targets being set for biology, chemistry and physics places. It was generally the case that applicants for biology PGCE courses had a broader and stronger set of qualifications before going to university and better degree results than applicants for chemistry and physics. So, in a typical year, King's would take 38 biology PGCE students, 20 chemistry students and 17 physics students. With the implementation of targets for each science, the situation is very different with 15 biology PGCE students, 25 chemistry PGCE students, 14 physics PGCE students and 16 physics with mathematics PGCE students (a total of 70 students). This shift from equity between biological sciences and physical scientists has a number of impacts which are beginning to be felt in courses across England. One of these impacts is a possible lowering of the overall quality of students training to be science teachers.

As a result of the recent changes, the allocation of places to universities is increasingly complex. The allocation for King's in 2013–14 is 14 biology PGCE students plus one SD Training Programme (SDTP) place, 25 chemistry PGCE students, 1 salaried SD place and 4 SDTP places; 15 physics PGCE students plus 1 salaried SD place and 4 SDTP places; and, 10 physics with mathematics PGCE places giving a total of 74 places.

While increasing the diversity of routes into teaching might meet the needs of a larger proportion of the population, this is not the prime reason why School Direct has been introduced. The current government wishes to give schools greater input into the selection and training of teachers.

3. Increasing the Quality of Science Teachers

There has been a shortage of secondary science teachers for many years. Attempts to increase recruitment have involved fairs, advertising campaigns and financial inducements. The current government replaced the relatively modest bursary scheme which had been in existence for some years with a new set which reflect the desire to increase the number of physics and chemistry teachers in particular. The scheme also reflects the belief in the supreme value of subject knowledge for which the degree classification of the undergraduate degree is used as an indicator. So, for example, someone accepted onto a physics PGCE course who has a first class degree would be awarded a bursary of £20,000. Students with second class degrees get less—£15,000 for an upper second class degree and £12,000 for a lower second-class degree. Students with a third class degree do not get any bursary. Biology students, however, who are not in such short supply, receive £9,000 if they have a first class degree and £5,000 if they have an upper second class degree.

There is no bursary for biology students with lower degree classifications. To give some idea of the impact of the bursaries, according to figures provided to the House of Commons Education Committee, in 2009–10, 62% of trainees had a 2.1 or above in their first degree, and 30% had a 2.2 (HoC Education Committee, 2012, p. 11). The bursary payments may not be as generous as they first appear: The current government brought in legislation to allow universities to raise their fees up to a limit of £9,000/year soon after being elected—and students may use their bursaries to pay the fees that most institutions now charge for the PGCE. Again, the House of Commons Education Committee has some cogent observations about the bursary scheme:

> Defining the qualities associated with outstanding teaching is a complex exercise. We support the Government's new bursary scheme, which offers financial incentives for trainees with higher class degrees: we trust that this will attract more people to consider the profession, but caution that this approach alone will not do the job. Whilst strong subject knowledge is vital, particularly at secondary level, greater effort is needed to identify which additional personal qualities make candidates well-suited to teaching. (HoC EC, 2012, p. 3)

There is a danger that the discourse of subject knowledge will distract those involved in supporting and organising teacher education from addressing other issues such as the personal characteristics of applicants, the quality of mentoring that they receive in school and how to cram all the necessary knowledge, skills, understanding and experience into a 36-week course. For most science teachers, the PGCE is the time when they receive the most professional development and when they, consequently, make the most progress in terms of becoming a teacher.

VII. Continuous Professional Development

Teacher education has been described as operating on a clockwork mouse model—teachers are wound up at the start of their career and then left to run down. Their degree of contentment is suggested by research carried out by Moor *et al.* (2006) who found that 37% of their sample of 726 of heads of science department rated their overall level of satisfaction on a 5-point scale as '4' or '5' ('very' satisfied). 26% rated their overall level of satisfaction as '1' ('very dissatisfied') or '2' (p. 183). These figures were very similar to those of science teachers (n=2,684) (p. 183). In effect this might suggest that one in four heads of department has high levels of dissatisfaction and that, on average (taking the figure of nine science teachers per department mentioned above), there are two teachers in each science department who feel the same way. This would appear to be a substantial fraction of the science teaching force.

The impact of the national curriculum and its assessment on the teaching professional was, and continues to be, profound and this has impacts on the inservice teacher education that teachers need. Helsby and Knight noted that:

> The changes in the formal structures of in-service education and support for teachers (inset) which have accompanied the educational 'reforms' of recent years, have seriously restricted the opportunities for personal, professional development. (1997, p. 149)

In their eyes, professional development had become 'heavily managed from the centre within tight budgetary constraints' (ibid. p. 149). For many teachers, opportunities for professional development in general, for example, Master's degrees or one-day courses, seem scarcer now than they were twenty years ago.

Professional bodies and learned societies, such as the Royal Society, have noted the impact of the national curriculum on aspects of science learning, such as the amount of practical work done in schools and the subsequent needs for training science teachers. A report from one of the Royal Society's working groups noted that since 1990 there have been many changes in science education including (Royal Society, 1997: 1): 'an increase in the amount of pupil investigation, particularly where pupils follow up their own ideas'; 'the continuing developments in science equipment, particularly Information Technology'; 'an increased emphasis on matching learning demands to pupils' prior attainment has also resulted in teachers developing alternative strategies for teaching particular topics' and a 'continuing search for more relevant practical work linked to real life applications'.

The issue of the lack of effective science teacher professional development has been around for many years. The HoC Education Committee has tried to address the problem:

> Amongst other barriers to recruitment and retention of the best teachers, we believe that the lack of opportunities for (and structure to) professional development and career progression for teachers are in need of urgent remedy. Therefore, we recommend that the Government consult on the quality, range, scope and content of a high-level strategy for teachers' professional development, and with an aim of introducing an entitlement for all teaching staff as soon as feasible. (HoC EC, 2012, p. 4)

All state-funded schools timetable five non-teaching days each year which may be used for staff development (In-service Education and Training or INSET). CPD (Continuing Professional Development) is not mandatory. Access to CPD appears to have declined in recent years although the data are not robust. The rise in the number of academies has presented some opportunities for clusters of schools to work together and one outcome has been an increase in the amount of professional development available to teachers:

> At academies in the Harris Federation, for example, teachers work an extra five days (or equivalent, at evenings or weekends) per year, specifically for CPD, and are paid accordingly. This is a model which might be replicated by other such networks of schools, whether formal (in the case of the Harris Federation) or more ad hoc. In addition, the federation runs a number of CPD events of its own, including for support staff. (HoC EC, 2012, p. 39)

This is not a new issue. A survey of teachers' needs and wants (Dillon *et al.*, 2000) concluded that there was a concern among science teachers about how they could develop personally and professionally throughout their careers. The lack of a system of continuous, personal professional development resulted in a severe disjuncture between teachers' initial, pre-service training and their subsequent development; something which continues to mark teaching out from other professions, notably medicine and engineering.

The survey confirmed what had been suspected about the professional development of science teachers by policy makers and academics for some time. Although there was some evidence of good practice—particularly effective local authority support, for example, the paucity of provision was seen as a major factor in the recruitment and retention of science teachers. Evidence from the survey and the associated focus groups suggested that schools did not have adequate funding to support their staff in the long-term, classroom-focussed coaching that characterised successful programmes such as Cognitive Acceleration through Science Education—a two-year programme of professional development which involved the whole science department in training in a new pedagogy based on a Piagetian view of child development.

Even in science departments that had undergone CASE training there was evidence that some teachers benefited more from the professional development than others (Adey *et al.*, 1995). In short, the study indicated that science teachers, in common with all other teachers, lacked an established, well-defined structure of further training, accreditation and recognition. There was a distinct lack of a path of progression for teachers to systematically acquire further professional training that drew on anything more than restricted local networks and the voluntary interests and commitments of those who engaged with the work or activities of the Association for Science Education (ASE).

Teachers relied on local networks of informal contacts, either in-school or between schools, and a number of school-based training days which, because of their whole-school nature, rarely dealt with subject-specific issues. Schools and local education authorities rarely co-ordinated the dates of professional development days thus denying any opportunity for science teachers to meet and share common problems, issues and strategies.

Another problem identified in the study was that the implementation of the National Curriculum coincided with a substantial devolution of resources to schools resulting in a lack of any system-wide priorities at local or national level. HMI, the schools' inspectorate had commented as early as 1992 that:

> Teachers attended a range of courses but with many schools receiving devolved INSET funding, much of the INSET has been school-based ... Overall, however, the systematic identification and prioritisation of INSET needs, both individual and departmental, was not sufficiently common. (HMI, 1992: X)

The greater devolution of resources to schools in subsequent years, a major education policy, had not made the situation any better than it was in the early 1990s.

The survey formed the basis of the Council for Science and Technology's publication, *Science Teachers: A report on supporting and developing the profession of science teaching in primary and secondary schools* (CST, 2000a). This report was designed to advise the government on how to improve science teaching in schools (CST, 2000b). The authors of the CST report argued that:

> there is considerable scope for securing a step change in science teachers' performance and hence in the science education of their pupils, by creating a pro-CPD culture, one in which a life time of professional learning is very much the norm. (CST, 2000a: 4–5)

The report recommended that the 'subject related CPD of individual teachers should be treated distinctly from other CPD requirements concerning whole school issues, matters of administration and national initiatives' (CST, 2000a: 29). The report also recommended that a 'core set of quality assured products and services is needed for science teachers to use in their own learning and development' (ibid.: 29). The report further recommended that:

> the Government should examine thoroughly the rationale, affordability and value of establishing a new body to act as the primary driver and agent for change and continuous improvement which we have simply termed as a 'national centre of excellence'. (CST, 2000a: 34)

The function of the centre broadened to include being a venue where teachers, scientists and industrialists would be able to meet although the rationale seemed to be that the last two groups could offer teachers 'innovative thinking' and 'advanced resources'—a clear deficit model of teachers and schools.

A 2001 Labour Party election manifesto commitment that the national centre would be 'based at a leading university' was honoured although the National Science Learning Centre (based in York) is actually managed by a consortium comprising the Universities of Leeds, Sheffield, York and Sheffield Hallam. The regional centres, which opened in 2004 and 2005, are mainly based in centres of science education.

In the three years to 2008, the National Science Learning Centre received a contribution from the Wellcome Trust of £11 m to building costs and £9 m to running costs with a further £0.6 m from government. From 2008 to 2013 the Wellcome Trust has agreed to contribute £10 m towards core running costs including delivering 'Project ENTHUSE'. The regional centres received £25.4 m from the government for the three years to March 2008 with a further £18 m for the three years to March 2011. Project ENTHUSE, which came into operation in July 2008, provided bursaries for which teachers from every maintained school in the UK could apply. The grants covered fees, travel and accommodation for individual teachers, as well as the cost to schools of providing teaching cover. Project ENTHUSE provided £17 m in bursaries from 2008 to 2013, including £10 m from central government and £7 m from industry.

In terms of impact, a survey of participants in Science Learning Centre courses during 2007–08 reported that 80% felt it had some positive impact on their motivation. Ninety per cent reported being satisfied with the quality of training received (DCSF, 2008). In a similar survey in 2008–09, 82 per cent of participants reported that 'pupils had access to new and better learning activities', 73 per cent said that 'pupil motivation had improved', and 56 per cent indicated 'an improvement to pupil learning' (NNSLC, 2009, p. 16).

A more rigorous evaluation of the impact of the network was carried out by the National Audit Office (NAO), a body wholly independent of government. They reported in 2010 that 'participation by teachers in Learning Centre programmes is associated with improved teaching and learning, and higher take-up and achievement in science at their schools' but noted that 'take-up by teachers varies between areas' (NAO, 2010, p. 6). The NAO looked at schools that had been involved in a number of STEM interventions including taking part in training at the National Science Learning Centre. Schools which had a specialism in science, technology, engineering or mathematics and computing showed an increase of 2.808 in the percentage of their students achieving GCSE science A*-C grades between 2004/5 and 2008/8 in comparison to other schools. In comparison, schools whose staff had taken part in a day's training at the NSLC showed an increase of 0.099 percent. This is not a significant impact and there is no evidence of causality—it may be that schools which are determined to improve are more likely to send their teachers for professional development.

VIII. Conclusions

The significant gap in the scores of the highest and the lowest students in international comparisons of science suggest that there is much potential for improvements in science education in England. The major changes that have been made recently include a revised national curriculum, an increase in the diversity of routes into teaching and a focus on recruiting increased numbers of physics specialists at the expense of biology specialists. It is too early to say what impact these changes will have to the long-term future of initial teacher education institutions particularly university departments of education which appear under threat.

The lack of adequate professional development opportunities for science teachers identified at the turn of the century has never been adequately addressed. Some clusters of schools are beginning to reward teachers for undertaking more professional development but it is, again, too early to see any measurable impact.

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イングランドにおける理科の教師教育に関する動向

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要　旨

各種国際学力調査の結果は，科学に関する子どもの到達度の最高値と最低値の間に相当な開きがあることを明らかにしている．このギャップは，教員養成教育と現職教育の両方を通して教育（とりわけ教師の教科知識等）の質的向上に真剣に取りかかる必要性を示唆している．科学教育の質的向上を目的とした近年の政府の変化は，教職への新しいルートを開拓し，物理を専門とする教師の数の増加に焦点化されていた．単に「科学」と認知される教科による教員養成教育よりも専門科目（物理，化学，生物など）に基づく教員養成教育が行われるようになったことは，生物科学と物理化学とのバランスに影響を及ぼしている．新しい奨学金制度は，学生にとってよい学位の取得に結びついている．教員養成教育における（学生数や教職へのルート等）増加などある程度の成功は認められるものの，他方現職教育に目を向けると，教師が必要とする，あるいは望んでいる現職教育の機会が得られているとはまだ思われない．

キーワード：理科の教師教育，教育，カリキュラム，評価，教師としての専門的成長，イングランド

（訳：磯﨑哲夫）