



Council for Science and Technology

SCIENCE TEACHERS

**A report on
supporting and developing the profession of
science teaching in primary and secondary
schools**

February 2000

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I. EXECUTIVE SUMMARY

1. The report addresses the question of *what would make a material difference in helping science teachers in primary and secondary schools develop and improve their professional practice, individually and collectively ?*

2. The Government is already pursuing a progressive agenda to improve still further school standards and effectiveness. The growing number of Education Action Zones, Beacon Schools, Specialist Schools, and Advanced Skills Teachers are significant developments, as are the establishment of the National College for School Leadership and the National Grid for Learning. The Grid including the Virtual Teacher Centre represents a tremendous opportunity for developing the practice of science teachers.

3. The recent consultation paper on a new, high quality framework for teachers' continuous professional development (CPD), the new focus on the initial, key stage 3 of secondary school science including a new scheme of work, the new emphasis on the teaching of higher order thinking and problem solving skills and a new set of targets to monitor pupils' progress at the age of 14 are further significant steps in taking this agenda forward.

4. We welcome all these steps. Ensuring that young people have the best possible education in science during their compulsory schooling is essential to them as individuals, and as future adult members of our society in a time of considerable scientific and technological change and opportunity.

5. Young people gain their first substantive experience of science from their schools and science teachers. Both their schools and their teachers have profound effects on their attitudes and interests in science and technology generally, and on the level of attainment they reach in science by the end of their compulsory schooling, as well as on subjects they choose to study subsequently. In all these respects, the knowledge, confidence and competence of their science teachers are critically important factors.

6. We commissioned a survey last summer to obtain a robust, up to-date picture from the teachers' viewpoint. Over 900 head teachers and 1500 science teachers participated from 1300 primary and secondary schools in England. Many of the secondary head teachers reported that their science departments were not developing as quickly as those for other subjects. Among the teachers, levels of confidence varied widely across the national curriculum science topics and pupil year groups, showing a marked drop among those teaching science at key stage 4, leading up to GCSE examinations. Many were teaching science subjects in which they had no qualification at A-level or first degree level.

7. The teachers reported that they were not engaged in a subject related, class room based, systematic process of continuous professional development (CPD) matched to their individual needs and that they had little opportunity to learn from their peers. They were critical of the adequacy of the existing appraisal arrangements in their schools for assessing their performance and CPD needs. Those in the early years of their careers reported that their individual CPD tailed sharply away once their status as Qualified Teachers was confirmed at the end of their first induction year.

8. These teachers also highlighted difficulties in identifying and accessing suitable products and services for their individual CPD, as well as the constraints of time and money which militated against this essential activity. They did not rate particularly highly the advice and support available to them from within the school and external sources. Only rarely, did they make use of the extensive range of curricula material and other support made available by numerous organisations in the private, voluntary and public sectors.

9. On the basis of this survey and other evidence, we are convinced 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 and is assisted by modern, effective arrangements.

10. In taking forward its agenda, the Government should take full account of the particularly complex and demanding nature of science teaching in schools. It should ensure that the new CPD framework positively encourages, empowers and enables science teachers to develop and improve their professional practice.

11. **Leadership:** Strong, committed leadership and clear lines of responsibility and accountability must be established at all levels, along with transparent funding and monitoring arrangements. 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. The success of this new framework hinges upon strong, effective leadership from the governors and head teacher of each school.

12. **Capacity:** The capacity and capabilities of schools to manage and enable the professional development of their science teaching staff needs to be increased significantly, especially at the levels of Head Teacher, Head of Science Department, Science Co-ordinators (in Primary Schools) and senior teachers with staff management responsibilities. Their appraisal, mentoring and coaching skills need to be developed and continuously strengthened. Best practice guidelines and benchmarks should be promulgated to assist them.

13. **Products and Services:** A core set of quality assured products and services is needed for science teachers to use in their own learning and development. These must be “teacher designed” and be easy for the teachers to access, use and apply. All new entrants should be made aware of this, their essential professional tool kit.

14. **Supply Arrangements:** These products and services and those for otherwise supporting science teachers in their work must be supplied in a teacher friendly way through modern, effective arrangements. The Government should work in partnership with the key stake-holders to improve the operation of the market for such products and services, which is at present highly fragmented on the demand side (schools and teachers) and the supply side (numerous providers, products and services).

15. **Centre of Excellence:** To achieve all these outcomes for science teaching and science teachers, the new framework should include a body that acts as the national driver and catalyst for change and continuous improvement. This body, for which we have used the term “national centre of excellence”, should:

(a) encourage and enable science teachers to seek and adopt new teaching strategies and approaches in their work with pupils;

(b) provide support services to new and inexperienced science teachers, as well as weaker members of the science teaching profession; and

(c) add value at the national level in developing the professional practice of science teaching.

16. The added value, role and functions of the “centre” should be assessed fully, possibly under the auspices of the new General Teaching Council, in the light of the Government’s wider plans for teachers’ professional development and school science. These matters of purpose, together with the contingent ones concerning the centre’s organisation and structure, should be addressed in partnership with the key stakeholders. The “centre” would need to work through regional and local arrangements using a modern IT infrastructure.

17. For **informing** and **underpinning** the further development of its policies, the Government should ensure that research is conducted into how science teachers learn their professional practice through CPD, including the productivity of this process. In neither of these two respects is there much research evidence at present.

18. Science teaching is both an art and a craft, learned, developed and shared by individual teachers working with their pupils in the classroom. Within its new CPD framework, the Government must ensure that a **top class professional support**

system exists to service the present and future needs of these teachers for these purposes.

II. MAIN REPORT

Introduction

1. As part of our programme of work for 1998/99, we established a sub-group of members to consider what more science teachers needed to teach science to the highest possible professional standards to pupils during their compulsory schooling, and how these standards could be developed by the profession over time.

2. Through an initial study in the latter part of 1998,¹ we decided to concentrate our further work during 1999 upon identifying ways and means for:

- improving the continuous professional development (CPD) of qualified science teachers;
- facilitating the identification and spread of “good” or “best practice” in science teaching among these teachers;
- making the most of the resources and other support provided to them by third parties; and
- harnessing the potential of Information and Communication Technology for these purposes.

3. The work was led by Professor Julia Higgins. The other members of the group were Sir Aaron Klug, Dr Rob Margetts, Dame Bridget Ogilvie and Professor Sir Stewart Sutherland.

4. They were assisted by a number of co-optees comprising Dr David Moore (Association for Science Education), Dr Ray Peacock (Science, Engineering, Technology, Mathematics Network), Ms Juliet Strang (Head of Villiers High School, Ealing), Dr Kay Stephenson (Head of Science and Chemistry, Felsted School, Essex), Ms Becky Parker (Head of Science, Simon Langton Girls School, Canterbury), Mrs Jay Pye (Head, St Michael’s Church of England Junior School, Maidstone, Kent), Mr Roger Mitchell (Deputy Head, Warren Junior School, Romford, Essex) and Mr Justin Dillon (School of Education, King’s College, London).

5. The group took account of the many positive steps already being taken by the Government to raise school standards and effectiveness including the National Grid for Learning, the establishment of Beacon Schools and a cadre of Advanced Skills Teachers, as well as the 1998 Green Paper for modernising the teaching profession².

6. They drew upon a wide range of published research and other information, as well as the results of a survey which was commissioned specifically to obtain a robust and up-to-date picture of the views, needs and requirements of the teachers

¹ *School Science: Fit for the Future*, CST website at address www.cst.gov.uk

² *Teachers: meeting the challenge of change*, DfEE, London December 1998.

themselves. The survey was undertaken in July 1999 by the School of Education, King's College London under the leadership of Mr Justin Dillon and Dr Jonathan Osborne.

7. Over 150 primary and secondary teachers from 50 schools in five regions of England participated in focus groups and a survey was conducted with three questionnaires being sent to each of a randomly selected sample of 1973 primary and 735 secondary schools. A total of 2,355 questionnaires were returned (29% of the total distributed) from 1279 schools (47%):

	Primary	Secondary
Number of Schools	745 (38%)	505 (68%)
Number of Headteachers	565 (29%)	360 (49%)
Number of teachers	854 (22%)	576 (42%)
within first five yrs of career	289	223
over 5 yrs into career	565	353

8. We are indebted to these schools, headteachers and teachers for their invaluable contribution to our work. We are publishing the full results of this survey in a separate report by the King's College team but have included a summary in Annex A. The other evidence which has informed our views and conclusions is summarised in Annex B.

9. In the course of its work, the group benefited from the expert views of many other people who are also acknowledged in Annex C. We are most grateful to all of them for their invaluable assistance.

The Hallmarks of Top Quality Science Teaching

10. While many factors are associated with the level of attainment in school science which pupils reach, the research evidence confirms the common sense view that the personal attributes, knowledge, skills and competencies of their teachers are critically important and influential. Developing and improving the professional practice of science teachers therefore lies at the heart of raising the level of attainment which their pupils achieve during their compulsory schooling, and hence school standards and effectiveness in science education.

11. The effectiveness of science teachers stems mainly from their attitude, their confidence, their knowledge of the subject and how to teach it (pedagogy). Truly inspirational science teaching occurs when a teacher is not only enthusiastic about the science topic being taught but also understands that topic fully in order to present it in a comprehensible and meaningful way to each pupil.

12. Good subject knowledge (both substantive and syntactic) and understanding of the substance, content, structure and organisation of the science subject itself is essential for the teacher to explain not only the facts of science but, more importantly, the arguments for the scientific picture. When it is weak, many teachers find it difficult

to deal with pupils' questions and resort to teaching from a text book to avoid having their lack of knowledge exposed³.

13. Research indicates that science teachers need to possess good subject knowledge in order to develop the subject related pedagogical knowledge, skills and competence that is so necessary to present a science topic to pupils, in comprehensible and stimulating ways by drawing on the best possible analogies, examples, illustrations, explanations and demonstrations to build on each pupil's existing level of understanding⁴.

14. Effective pedagogy additionally requires science teachers to be able to set clear and explicit learning objectives and realistic high expectations. They must have a high level of involvement with their pupils and provide a very high level of personal support for each of them. They must be able to use of a variety of teaching and learning strategies and provide innovative learning activities in well ordered, stimulating lessons. They also need to be able to strike up positive relationships with each pupil and between all the pupils in their classes.

15. Many of these hallmarks apply to the teaching of other subjects on the school curriculum but they are particularly demanding ones in the case of science since science teachers are dealing with subjects, topics, issues and boundaries that are continually changing. Even though the substance of the national curriculum for school science is relatively static and unchanged, the rapid advances in science which are occurring provide a particularly tough and complex context for their work with pupils, as do the increasingly important and profound social, moral and other implications of so many of these advances. Compared with other school subjects:

- the science curriculum is very extensive;
- a significant number of pupils are negative about the intrinsic and extrinsic merits of science and/or the science curriculum⁵;
- science is conceptually complex and fast changing, raising many unprecedented, often profound ethical and other issues for pupils and teachers alike;
- it is multi-disciplinary in nature, but the majority of teachers teaching it are not;
- there is a far greater range and diversity of support material and other sources available for teachers to use, if they wish and are able to do so. In many cases, they need to be trained before they can use it in their work; and

³ *Are we producing teaching technicians or science educators ?* Finlayson H, Lock R and Tebutt B, Educational Review, Vol 50, No. 1, 1998

⁴ For instance in one study, "exemplary" science teachers, chosen for the high quality of their science classes, were found not to be picking up pupil misconceptions when teaching outside their specialist area. They tended to use inappropriate analogies which confused their pupils and sometimes used factually incorrect material. " *What does it mean to be an exemplary science teacher ?* " Timmins K and Fraser R, Journal of Research in Science Teaching, (1990) ,27, pp 3-25.

⁵ *Pupils' and Parents' Views of the Role and Value of the Science Curriculum*, Osborne J & Colins S, BERA Conference, September 1999.

- particularly at secondary level, it demands very high levels of knowledge and competence when teaching through demonstrations, experiments and investigations;

16. In our view, no other subject in the national curriculum involves such complexities or places such demands on its teachers, not only to keep abreast with contemporary developments but also on how best to deal with them in teaching. In our survey for instance, 47% of the primary teachers and 61% of their secondary colleagues wanted more material about the social and ethical issues of science to support their work with pupils.

17. The key requirement of every science teacher's professional practice and continuous professional development is to maintain and strengthen their subject knowledge and their ability to apply this knowledge to the specific circumstances of a pupil at that moment in time. As OFSTED states⁶:

When [..... science....] teachers are thoroughly in command of their subject, they are able to adapt their teaching to the response of pupils, to use alternative and more imaginative ways of explaining, and to make connections between aspects of their subject and with the pupils' wider experience, so capturing their attention and interest. The teacher's ability to answer pupils' spontaneous questions is an important factor in generating enthusiasm for the subject.

18. This applies particularly to science teachers in the early years of their careers and even more so to secondary school teachers who do not possess a GCSE or A level or equivalent level qualification in the science topic they are teaching.

19. A recent study by Leeds University⁷ shows that the deployment by secondary schools of science teaching expertise is now heavily influenced by resources and other contingencies including recruitment and retention difficulties. Generally, these schools are seeking to provide a broad and balanced science course for their pupils in the time and with the subject expertise available to them. While some secondary schools are undertaking non specialist science teaching at key stage 4 on principle, the majority are deploying staff to teach science within and outside their subjects in reflection of the limited or non availability of subject specialist teachers, especially in physics and chemistry.

20. In noting the substantial division among many of the science teachers over the principle of such specialist teaching, this study highlights the need to offer science teachers opportunities and resources to expand their substantive and subject related pedagogical knowledge across the three traditional disciplines of physics, chemistry and biology.

⁶ *Secondary Education 1993-1997: A review of secondary schools in England*, OFSTED, London, 1998

⁷ *The Expertise and Deployment of Science Teachers at Key Stage 4*, Donnelly JF and Jenkins EW, University of Leeds, 1999

Approach

21. We sought to obtain a robust, up to-date picture of the teachers' actual views and requirements concerning their continuous professional development (CPD) and the support currently available to them for this and for their teaching more generally.

22. We drew on a number of sources including the survey which was undertaken in July 1999. We concentrated as sharply as possible on those considerations that:

(a) are specific to the teaching of science, rather than those concerning teachers and teaching more generally, such as pay and promotion arrangements;

(b) affect the day to day professional practice of science teachers;

(c) concern the teaching of science to pupils between the ages of 9-13 years old since this is when young peoples' views and attitudes towards science generally and school science in particular change most significantly.

23. We took particular account of the views expressed by Her Majesty's Chief Inspector in a lecture in February 1999, entitled "The Rise and Fall of the Reflective Practitioner", and especially his concluding remarks that:

"... the way forward must be to continue to identify our most effective schools and to find ways to open up the practical knowledge and understanding that they possess to others so the gap between the good and the weak can be narrowed."

24. In designing the survey, we sought to overcome the lack of published information for assessing the impact and implications of:

(a) the serious and enduring shortage of well qualified science graduates into the teaching profession;

(b) the fact that subject qualifications of new graduate entrants into secondary schools lie principally but not exclusively, in one of the traditional scientific disciplines of physics, chemistry or biology; and

(c) their initial teacher training comprising little that enhances their substantive and syntactic knowledge of other science subjects forming the national curriculum, particularly those taught at key stage 4.

Science Teachers' Levels of Confidence

25. Our survey revealed remarkably wide variations in the science teachers' levels of confidence.

26. As might be expected, the teachers in the first five years of their careers generally had less confidence in teaching science than their more experienced colleagues.

27. But we were surprised by the significant drop in confidence levels from teaching key stage 3 science to secondary pupils between the ages of 11-13 years old to teaching key stage 4 science to pupils in the two years immediately before their GCSE examinations when many will be deciding on their post 16 courses of study.

28. The primary teachers were generally less confident about teaching science than about Mathematics or English at key stage 2. Only 57% reported having a lot of confidence in teaching science, appreciably lower than the figures for the other core subjects of English (66%) and Mathematics (63%).

29. As for key stage 2 science, their levels of confidence were notably low with only 44% having a lot of confidence in teaching the programme of study at key stage 2 for *Sc1 - Experimental and Investigative Science*, and 47% for *Sc4 - Physical Processes*.

Primary Confidence Levels at Key Stage 2												
Figures are % of the teachers covered in each row												
Years of Teaching	Sc1 Experimental			Sc2 Life & Living Processes			Sc3 Materials			Sc4 Physical Processes		
	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little
0-5 n=289	37	55	7	54	45	1	47	50	2	33	58	9
6-10 n=138	47	50	3	72	27	1	61	38	1	54	42	4
11-20 n=174	56	41	3	76	22	2	67	31	2	55	40	5
21-30 n=221	45	50	5	74	24	2	63	34	2	54	40	5
30+ n=31	32	68	0	77	23	0	61	34	3	39	55	6
All	44	51	5	67	31	1	58	40	2	47	47	6

30. Among the secondary teachers, confidence levels at key stage 3 were generally much higher, although 20% had less than a lot of confidence when teaching the programmes for *Sc2 Life & Living Processes* and *Sc4 Physical Processes*. Despite their generally high levels of confidence, 87% of these teachers wanted more ideas for science investigations.

31. At key stage 4, their levels of confidence generally fell markedly and varied much more widely across the four programmes of study and across the ranges of the teachers' experience.

32. Other than for *Sc1 Experimental & Investigative Science*, between 40% and 50% of the teachers had only some or a little confidence in teaching these programmes:

Secondary Confidence Levels at Key Stage 3												
Figures are % of the teachers covered in each row												
Years of Teaching	Sc1 Experimental			Sc2 Life & Living Processes			Sc3 Materials			Sc4 Physical Processes		
	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little
0-5 n=289	82	17	1	83	14	1	85	14	0	75	24	<1
6-10 n=138	94	6	0	88	12	0	90	10	0	82	18	0
11-20 n=174	93	7	0	83	15	1	88	12	1	80	18	<1
21-30 n=221	92	8	0	72	21	6	87	12	1	87	10	1
30+ n=31	96	5	0	73	27	0	86	14	0	91	5	5
All	89	11	<1	80	16	2	87	13	0	81	18	1

Secondary Confidence Levels at Key Stage 4												
Figures are % of the teachers covered in each row												
Years of Teaching	Sc1 Experimental			Sc2 Life & Living Processes			Sc3 Materials			Sc4 Physical Processes		
	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little
0-5 n=289	72	26	1	59	25	13	57	36	5	44	41	14
6-10 n=138	80	14	4	57	31	8	70	22	4	45	49	4
11-20 n=174	88	8	2	53	37	7	64	28	5	56	29	10
21-30 n=221	81	13	0	38	40	15	57	30	6	57	29	6
30+ n=31	77	14	0	46	23	23	50	36	5	50	32	9
All	79	17	1	52	32	12	60	31	5	50	35	10

Science Teachers' Subject Qualifications and the correlation with their Levels of Confidence.

33. Among the primary teachers the percentage of those without an A- level or higher level qualification in a science based subject were 69% for biology; 85% for chemistry; and 89% for physics. The percentages without a first or higher degree in a science based subject were 88% biology, 96% chemistry and 98% physics.

34. As for the secondary teachers:

<p>At key stage 3, the percentages of those teaching a science topic <i>without an A-level</i> in the subject were:</p> <p>37% of those teaching biology; 19% of those teaching chemistry; 37% of those teaching physics.</p> <p>and similarly the percentages of those <i>without a related degree</i> were:</p> <p>53% of those teaching biology 62% of those teaching chemistry 76% of those teaching physics</p>	<p>At key stage 4, the percentages of those teaching a science topic <i>without an A-level</i> in the subject were:</p> <p>26% of those teaching biology; 13% of those teaching chemistry; 29% of those teaching physics.</p> <p>and similarly the percentages of those <i>without a related degree</i> were:</p> <p>39% of those teaching biology; 51% of those teaching chemistry; 66% of those teaching physics</p>
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35. As covered more fully in Annex A, an analysis of the responses from all the teachers and from those within the first five years of their career revealed a correlation between these teachers' highest subject qualifications and their levels of confidence. For instance, a higher level of chemistry qualification was positively associated with confidence in teaching chemistry at both key stages 3 and 4.

Overall Assessment of Science Teachers Views and Requirements.

36. Despite these considerations however, the teachers were not engaged in systematic, subject related, class room based continuous professional development. Overall, the results convey a very strong sense indeed of the isolation felt by science teachers, mostly working alone in the classroom with little opportunity to either learn from or judge their practice against that of their peers in the same or other schools.

37. The teachers reported having little say in their individual CPD or the courses they do attend, and very real difficulties in identifying and accessing suitable products and services for their individual CPD, as well as constraints of time and money. What INSET they have received recently was mostly taken up by whole school issues, matters of administration rather than teaching science, and such national initiatives as those concerning literacy, numeracy and ICT. Only rarely did they have the opportunity to refresh their subject related substantive and pedagogical knowledge and skills.

38. Many recalled former times when they were able to attend courses lasting 10-20 days for these purposes. Both primary and secondary teachers reported that opportunities to build on their initial training were very limited and tailed away sharply after the first, induction year of their careers. In the questionnaire survey, less experienced teachers had attended notably fewer courses than their more experienced colleagues in the most recent (1998/99) school year.

39. The teachers were also critical of the adequacy of existing appraisal arrangements for identifying their individual strengths and needs. Nor did they rate particularly highly the INSET which they had received during the preceding school year.

Primary and secondary teachers' evaluations of the INSET that they received during 1998/99.

Topic	P n=	S n=	Generally useful %		Sometimes useful %		Rarely useful %	
			Primary	Secondary	Primary	Secondary	Primary	Secondary
Preparation for senior management	127	57	64	58	35	40	0	2
Preparation for middle management	72	104	54	57	43	39	0	4
ICT	507	308	54	41	38	50	6	8
Class management	201	171	44	37	45	58	5	5
Teaching skills	255	215	66	53	30	42	2	3
Subject knowledge	193	86	65	57	29	38	2	2
Assessment	454	251	50	45	43	49	3	2
Mentoring	150	111	55	50	39	42	5	7

Key Issues

40. Following extensive consultations involving the Association for Science Education and many other experienced parties about the results of our survey, we are satisfied that they are sufficiently accurate and representative of the present situation of the science teaching profession overall today, in schools in England at least.

41. Meta-analysis in the US⁸ shows that to make any lasting, and noticeable difference to teachers' performance, their individual CPD must be long term and classroom focused, involving both pupils and expert advice. It must meet their individual learning needs and preferences and it must provide an appropriate mixture of learning opportunities, within and outside the classroom. Other research⁹ indicates that that effective CPD must include personal, social and professional development rather than simply skills and knowledge training.

42. Against this established benchmark, there is clearly much scope for improvement. Within and across schools, a life time of professional learning and development by science teachers individually and collectively must become very much the norm. By the end of the first five years of their careers, all science teachers, and

⁸ *Student Achievement through Staff Development*, Joyce, B., & Showers, B. (1988). New York: Longman.

⁹ *Teacher Development; A model for Science Education*, London, Falmer,

especially those in secondary schools, should be well on the way to developing the necessary skills and knowledge to become not only life long learners themselves but also to be able to contribute to the development of the professional practice of science teaching itself.

43. *In broad strategic terms, we consider that in establishing its new CPD framework, the Government should aim to bring about a transformation in the collective culture and ethos of schools and science teachers from that which presently exists. It should seek to make it endemic and the “natural professional thing to do” for science teachers to be engaged in continuous, subject specific, classroom based professional development.*

44. *More specifically, to achieve this transformation, it should take full account of the distinctive features and circumstances of school science and ensure that:*

(a) as a general rule, the career progression of science teachers is dependent upon them engaging in systemic, continuous professional development that is appropriately recorded and accredited;

(b) secondary school science teachers have the opportunity to broaden and deepen their subject knowledge and their subject related pedagogical knowledge for teaching science at either key stage 3 or key stage 4;

(c) especially for secondary school science teachers, continuous professional development activities are sustained, class room based and supported appropriately by top class coaching and mentoring;

(d) by the end of the first five years of their careers, all science teachers, and especially those in secondary schools, are well on the way to developing the necessary skills and knowledge to become not only life long learners themselves but also to be able to contribute to the development of the professional practice of science teaching itself; and that

(e) a top class, professional support service exists for all new entrants into secondary school science teaching for the first full five years of their careers.

45. *The new framework should also:*

- encourage and enable science teachers to seek and adopt new teaching strategies and approaches in their work with pupils;*
- create a pro-learning, innovative culture in which teachers regard themselves as science educators.*

46. *The framework should further provide an individual CPD entitlement to subject based professional development for each science teachers, one that is on par with that in other areas of professional life.*

47. The remainder of this report presents our views on what we judge to be the key components of such a system.

Leadership and Accountability for the CPD of Science Teachers

48. During our work, we encountered widespread doubt and confusion about the respective roles and responsibilities of DfEE, the National Standards Task Force, the new General Teaching Council, the TTA, the QCA, Local Education Authorities, and individual schools regarding the CPD of science teachers.

49. Our survey revealed an extraordinarily wide variation in the per capita funds of the schools for all INSET/CPD purposes.

	Finance available per staff member (£k)				
Primary Schools n=565	£0-100	£101-300	£301-500	£501-1000	>£1000
% of schools	8	17	52	9	15
Secondary Schools n=360	£0-150	£151-300	£301-600	£601-1000	>£1000
% of schools	15	38	38	8	<2

50. Our survey did not investigate the reasons for these variations, but we consider that the future funding arrangements and allocations should differentiate clearly and strike the right balance between the professional development of individual teachers; the development of a school and complement of teachers as a whole; and national initiatives such as those concerning literacy, numeracy and the use of ICT by teachers.

51. *Accordingly, we believe that Government must ensure that:*

(i) there is clear responsibility and accountability for the monitoring, direction, control and co-ordination at the national, UK wide level that is necessary for the implementation of the new CPD framework;

(ii) schools and individual teachers fully understand their respective responsibilities and obligations;

(iii) there is clear and authoritative guidance on these matters; and that

(iv) appropriate, transparent funding arrangements are in place, with clear output or performance measures that reflect the full range of CPD activities and the appropriate balance of public expenditure on them.

52. For monitoring purposes at least, the Government could usefully track the number of state schools securing Investors in People (IiP) status, even if it decided against setting national targets for schools with IiP.

School Management's Role and Requirements

53. Significantly, some 20% of the secondary head teachers (43 out of 260, who responded to an open ended question about their concerns regarding science education in their schools) commented that their science departments had not developed as quickly as other subjects. Among the reasons they mentioned specifically was weak management at the head of department level.

54. Further, whereas the primary and secondary head teachers judged INSET delivered in school by staff to be more useful for their science staff than that delivered outside school, the science teachers held exactly the opposite view.

55. We believe that this divergence of view is symptomatic of the inevitable tensions involved in the allocation by school managers of the limited time and budgets available for CPD purposes, especially for dealing with whole school issues, national initiatives and generic matters such as new administrative routines on the one hand and providing for the subject related needs of individual science teachers on the other. Our survey indicates broadly how these matters are currently resolved:

Method of allocating INSET funds	Primary schools (n=565)	Secondary schools (n=360)
	%	%
Head decides	50	15
Colleague decides	25	61
Budget devolved to individuals	6	29
Bids from individuals	11	9
Other	32	29

56. We were also struck by much anecdotal evidence suggesting that in many schools, science teaching is equated with just the science part of the national curriculum, rather than requiring a team effort across all curriculum subjects. It seems to be a rare exception for teachers in the same school to meet regularly together to discuss their respective roles, plans and contributions to teaching science to pupils in a particular year group across all the national curriculum subjects.

57. The survey results also reveal, at least from the science teachers' viewpoint, that top quality professional, mentoring, assessment and guidance for their professional development and training is another rare exception.

Primary and secondary teachers' opinions about their science INSET in 1998/99.

Source	Primary (P) n=	Secondary (S) n=	Mostly useful %		Some use %		Little use %	
			P	S	P	S	P	S
			In school, from colleagues	724	493	61	37	35
In school from outsiders	568	385	54	29	43	57	3	15
Out of school	658	392	56	53	42	42	2	4

58. Building up science teachers' trust and confidence in these processes is of paramount importance, as is building up the capacity and capabilities of all those involved in these processes in their school. We doubt whether many, if any of the respondents to our survey would be so open about their levels of confidence in a performance review situation: the survey was designed specifically to safeguard their individual returns from their school colleagues and head teachers.

59. Creating a pro-CPD culture in a school and increasing its capacity and capabilities to sustain and nurture the subject related expertise of its teaching staff effectively are essentially school management issues. More money is undoubtedly needed: our survey indicates that the main constraints on science teachers' CPD are time, money, workload and fatigue, along with the lost opportunity costs involved in arranging supply cover to attend external courses.

60. Nevertheless, and given the constraints and pressures on public expenditure, schools and their staff managers will need to get much better at dealing with them effectively. The new National College for School Leadership undoubtedly has an important role to play in these regards, developing the abilities and competence of current and prospective head teachers and their deputies.

61. But we believe that their senior staff and those with line management responsibilities for less experienced staff have a very important, if not pivotal role to play, one which they can only discharge through distinct and specific CPD and support. This applies to both outstanding teachers in a school and to those in schools that work together on teaching science, including the growing number of Beacon Schools and Advanced Skills Teachers. Many if not most of these outstanding teachers will need specific CPD training and support in order to fulfil their intended mentoring, assessing and staff developmental roles.

62. We are aware that a number of sponsors of school science such as the Royal Society for Chemistry are already piloting approaches involving diagnostic tools, guidance and support for these particular purposes. These will need to be co-ordinated and brought together in suitable ways from the view point of these teachers as managers.

63. *The Government needs to build up the capacity and capabilities of schools to manage and enable the professional development of their science teaching staff by developing and continuously strengthening the appraisal, mentoring and coaching skills of all the staff concerned. Best practice guidelines and benchmarks should be promulgated to assist them.*

64. *Further, it is vital that these new processes and associated tools are introduced into schools in ways that support and enable:*

(i) the establishment of norms and good practice across schools;

(ii) the creation of trust and confidence of science teachers in these practices and processes; and

(iii) Beacon Schools and the cadre of advanced skills teachers to provide their fullest possible added value contribution. The effectiveness of their contribution to other schools needs to be monitored closely. So does the capacity of these other schools and their staff to absorb and learn from their contributions.

65. We further consider that the production and promulgation of benchmarks and best practice are necessary to enable school managers to deal effectively with this particular set of responsibilities. We are attracted by the option of producing a school version of the People Skills Scoreboard for the Engineering Industry¹⁰. Not only would this provide schools with useful comparative data for forming and executing their CPD plans, it might also form a valuable and much needed source of market information for all those INSET providers and others forming the supply chain, and especially so if it included expenditure figures.

Products and Services for Science Teachers' CPD

66. In our survey, the teachers attached primary importance to developing their professional practice by learning systematically from their professional peers, and other sources of knowledge, e.g. research into science, science teaching, and learning by science teachers.

67. In the focus groups, some teachers spoke highly of the videotaped lessons distributed as part of the national numeracy and literacy initiatives. They and others pointed to the dearth of useful videotaped lessons, showing and demonstrating good practice in science teaching.

68. Our survey highlighted three essential requirements in providing for the CPD of science teachers:

- it must be centred on the needs of individual teachers;
- these needs must be identified through an objective, professional assessment of their individual strengths and weaknesses; and
- their resulting CPD must be suitably structured around their subject related competencies with particular reference to:
 - raising their awareness;
 - updating their subject knowledge; and
 - enhancing their subject related pedagogy.

69. All science teachers need “quality” time to revisit and enhance both their subject knowledge and pedagogy repertoires, as well as their more general skills and competencies. Individually and at different stages of their careers, their CPD

¹⁰ The 1999 Scoreboard was published on 6 October 1999 by EEF/EMTA, ISBN 1464-9004

requirements vary. But particularly in their early years, top class mentoring and learning from their peers is the common and paramount requirement.

70. Further, as mentioned earlier, the research evidence shows that the CPD of individual science teachers needs to be planned, sustained and executed over a prolonged period, lasting some 12-24 months, if any real, lasting incremental difference to their performance and standards is to be achieved. Science teachers' CPD should be based firmly on research and other hard evidence about how to ensure that their CPD is effective. It should draw on international practice in terms of the standards aimed for and the delivery of CPD provision. In addition to catering for the needs of individual teachers, it should also focus on and create teams of science teachers learning and developing their practice together.

71. For this to happen, a clear, properly structured and organised framework needs to exist, preferably including an individual CPD entitlement of at least five days per annum to be spent on subject based professional development. Such human resource development practice is very much the minimum these days in many other areas of professional life.

72. The other main need highlighted by our survey was for science teachers to learn systematically from one another, both within and outside their classroom. Most of this individual learning and development needs to occur on the job, while teachers are working in the classroom with their pupils, with top class mentoring and guidance from experts, just as it occurs in other professions.

73. This learning and developing process depends crucially upon the quality and relevance of this process of interactive exchange, involving the transfer and development of professional tacit knowledge, e.g. in the form of ideas, hints and the like. Yet in our survey 24% of primary teachers and 31% of secondary teachers rated the help they had received from LEA advisers as poor, and 31% of primary teachers, and 42% of secondary teachers gave the same poor rating to teachers' centres when judging their external sources of professional advice, as distinct from their formal INSET.

74. The establishment of the National Grid for Learning (the Grid) and advances in ICT more generally clearly present a major opportunity for significant improvements. Though plainly associated, we believe that this opportunity for meeting science teachers' CPD must be treated quite distinctly and separately from the provision of ICT based learning of their pupils. Our work suggests that this fundamental distinction has yet to be drawn sufficiently clearly in the work by the Government and its partners on establishing the Grid by 2002.

75. In our firm view, three core components need to come into operation simultaneously if the Grid is to realise its full potential:

- schools must have sufficient funds, resources and skills for dealing with ICT based networks;

- the ICT infrastructure must have a cache of interactive applications and other relevant software which work and are recognised, valued and used by the science teachers for their CPD; and
- there must be sufficient volume of such material on the NGfL to service their needs and to encourage them to use it fully. Our survey indicates just how low is the current level of use with 9% of the secondary teachers reporting that they used ICT regularly.

76 The Government is already seeking to ensure that there is a sufficiently robust system in place for managing the architecture of the Grid and for ensuring that schools have sufficient resources, capacity and capabilities to exploit its potential fully. It is also developing the main pages (websites) and their links to others in order to ensure that there is a wide range of easily accessible content material for science teachers and their pupils to use. We understand that some 4000 such sources have been identified already in this developmental work.

77. Our survey revealed just how much remains to be achieved in that the Grid was used only ‘rarely’ by 71% of primary teachers and 72% of secondary teachers of science. Only 9% of the secondary teachers reported using computers ‘often’ in science lessons, 65% used computers ‘occasionally’ and 26% used them ‘rarely’.

	Primary (n=854)	Secondary (n=576)
Constraint on teachers’ use of ICT	%	%
Know how	56	37
School access	42	18
Equipment access	40	65
Time	88	86
Help	48	38
Cost	29	28

78. We believe that a suitable range of products and services must be created for science teachers to use for their individual CPD, both on and off line. For instance, our survey highlights a very real demand among these teachers for multimedia “master” classes from their peers about teaching the various programmes of study in the national curriculum. Yet, nothing like such a compendium of professional practice exists at present, one that is available to and widely used by all teachers, and especially those still learning their art and craft during the early years of their career.

79. *Accordingly, we urge the Government to address this paramount CPD need of science teachers with a view to establishing a core set of suitable, quality assured products and services, one that is made available and known to all new entrants, as their essential professional tool kit. The creation of this tool kit must be teacher led and its contents should be easy for the teachers to access, use and apply. Its contents should be supplied through teacher friendly arrangements that make the most of the potential of the National Grid for Learning.*

Supply Arrangements.

80. Our survey and other evidence shows that material to support, enhance and extend teaching of the curriculum is by no means extensively employed. A high proportion of teachers rarely use the vast amount of support material and resources that is produced and sponsored by very many companies, professional bodies, charities, education organisations and institutions.¹¹

Source	Frequently %		Occasionally %		Never %		Not aware %	
	<i>P</i>	<i>S</i>	<i>P</i>	<i>S</i>	<i>P</i>	<i>S</i>	<i>P</i>	<i>S</i>
Industry	2	4	32	50	45	37	20	9
Societies	1	8	11	50	55	38	32	4
Government agencies	<1	1	12	31	52	51	34	17
Charities	<1	1	19	27	41	40	39	31
Museums	8	2	63	41	23	49	5	7

81. We have been told by these providers that the science teachers who draw regularly on their products and services are a small minority, mainly the more outstanding members of their profession. Although use is growing¹², even the most popular are rarely used by more than 2% of the total population of teachers comprising the relevant client group. Despite much effort, the providers have yet to find ways of reaching and engaging the vast majority of science teachers.

82. Many teachers may be unaware of what is available, unable or unmotivated to access it, insufficiently acquainted with it to use it in their work, or unable to use it due to lack of knowledge, training, money or time.

83. The position is not helped by the very large volume of unsolicited paperwork concerning schemes, resources, activities, etc. which arrives in schools daily, coupled with the limited time available for teachers to consider its appropriateness and possible benefit to their teaching. The advent of the Grid and other ICT based systems in schools carries a very real danger of compounding this information over-load problem very significantly indeed.

84. At present, as seen by science teachers, the supply side with its vast volume of curricula support material created by numerous providers appears confusing. It is difficult to find out easily and quickly what is available and relevant. The products on offer are of variable quality and relevance, and too much time is needed either to make any reasonable assessment or to learn enough about them to use them. The means of access and supply of these products and services do not stand comparison with good supply chain practice in other sectors of our economy;

¹¹ The website of the Science, Engineering, Technology and Mathematics Network (SETNET) has information on over 1000 resources, schemes, activities in this field and details of more than 100 provider organisations.

¹² Information from the SETNET survey of July 1999 compared with that of one year earlier.

85. Conversely from the viewpoint of the providers, the decision making processes on the demand side comprising schools and teachers is complex and highly fragmented; this complexity, together with some unfamiliarity with the 'market' presents costs, uncertainties and other disincentives to invest in products and services for supporting science teachers. The unpredictability of the teachers' distrust or dislike of whatever they perceive to be the commercial interests of the providers is a particular risk and difficulty. Access routes and links into schools open to providers are complex, vary throughout the country and are frequently uncertain or unfamiliar..

86. Whatever else these considerations entail, the question clearly arises of how greater value could be secured from this considerable expenditure of time and of money, amounting to millions of pounds per annum by the extraordinarily large and extensive range of organisations in the public, private and voluntary sectors which support school science and science teachers.

87. *We believe that, in partnership with both sides, the Government should seek to improve the operation of this market which is highly fragmented on the demand and supply sides at present.*

88. We can see no good reason why it should not be possible to establish new arrangements for overcoming the significant inefficiencies and weaknesses that exist by the adoption and introduction of good supply chain practices the school science sector. Marketing, Branding and Quality Assurance of both product and the supply/distribution chain should be considered together with Partnership Sourcing, and the application of the 'Approved' producer and distributor concepts.

89. All these approaches would secure far greater leverage and value from the relatively small amounts of public funding that is currently provided.

A Centre of Excellence for Science Teachers

90. As our survey shows so clearly, the highly fragmented nature of the existing arrangements and means by which science teachers' CPD occurs and is supported through local management in schools, Local Education Authorities, Learned Societies, the Association for Science Education and numerous other bodies in the public, private and voluntary sectors raises many issues of drive, effectiveness, quality, relevance, standards, organisation and co-ordination.

91. The Grid along with the local and regional activities such as those involving Training Schools, Beacon Schools, Professional Learning teams could all too easily compound these issues if not appropriately co-ordinated and connected together in ways that produce a pool of professional knowledge and experience on which all science teachers are able to draw and use, and in particular those whose performance is judged weak and those in the early stages of their careers.

92. We do not believe that all the necessary developments to which we have already referred will come about, or come about quickly enough, unless the new CPD framework includes a body that acts as the national driver and catalyst for change, one

which operates pro-actively at the national level to add value to all these local and regional activities.

93. For convenience and without being in any way prescriptive about its constitution, organisation or structure, we simply refer to this body as a “national centre of excellence for science teachers”.

94. As we see them, the strategic purpose and aims of this “centre” should include:

(i) enabling and achieving the necessary cultural shift and other changes which we identified earlier;

(ii) ensuring that a sufficient and suitable range of core CPD products and services is available to all science teachers and that these are subject to appropriate quality assurance and marketing arrangements; and that they are provided in an appropriate user friendly way from the teachers’ viewpoint;

(iii) acting as a centre for piloting and developing innovative ways of teaching science under the national curriculum, taking account of national and international developments;

(iv) providing a proactive, professional support service to all new secondary school science teachers for the first five years of their careers; and

(v) providing a help line for all science teachers, for instance one that complements the Grid’s Virtual Teacher Centre, whatever mentoring and the like these teachers are getting in their schools, and the formation or execution of their CPD plans, in the light of their initial career entry profiles and subsequent annual performance assessments.

95. We see a strong case for the “centre “ to include a small but dedicated team of “expert”, quality assured account managers, each charged with nurturing a portfolio group of these newly qualified secondary school teachers, as clients.

96. Additionally, the “centre” could usefully:

(i) provide help in added value ways to those relatively few secondary schools which OFSTED judged to be teaching science at a less than satisfactory level;

(ii) enable innovation, experimentation, and the piloting and development of new ways and means of teaching science; and

(iii) encourage and enable all science teachers to seek and adopt new teaching strategies and approaches in their work with pupils.

97. *We believe that these proposals merit further substantive consideration, possibly under the auspices of the General Teaching Council, to assess its viability, affordability and value.* In our judgement, they are comparatively low cost, consistent with the rationale and principles of public, private partnerships and offer such advantages as economies of scale, efficiency savings and additionality. Although matters concerning its organisation and structure fall outside our advisory role, we believe that the “centre” would need to work through regional and local arrangements using a modern IT infrastructure.

Conclusions and Recommendations

98. There are a number of widely held, very substantive concerns about primary and secondary school science today:

- evidence that many pupils are dissatisfied with, if not turned off by, the quality of the experience that they are receiving in their school science education¹³;
- the number and quality of those pupils choosing to continue their study of science based subjects, not least in comparison to those choosing to study other subjects at more advanced levels¹⁴;
- the average A-level point score for entry into higher education science and engineering courses is falling while the average for humanities courses is rising. This suggests that able pupils are choosing not to study science at University;
- past and continuing shortfalls in the recruitment and retention of suitably qualified teachers of science at primary and secondary levels; and
- the level of scientific literacy attained by all pupils by the end of their compulsory schooling¹⁵

99. Since the introduction of broad and balanced science in the National Curriculum eleven years ago, schools and their teachers have raised significantly the participation and level of attainment of each successive cohort of pupils. Generally UK school science stands very favourable comparison internationally¹⁶.

100. There is no room for complacency however, given the growing importance and impact of science, now and in the years ahead from all viewpoints. We were therefore

¹³ *Pupils' and Parents' Views of the Role and Value of the Science Curriculum*, Osborne J & Collins S, BERA Conference, September 1999.

¹⁴ Since 1990 in stark contrast with the trends at GCSE level, the proportion of the age group studying A-level physics has been static at around 6%. There has been a slight increase in A-level chemistry from 6 to 7% and a larger one in biology from 6 to 9%.

¹⁵ See for instance *Beyond 2000: Science Education for the Future*, published on the 17 November at the Royal Society, London. By “scientific literacy” is meant a basic understanding of how the natural world works, and the scientific ways and means of knowing and thinking critically and creatively about how and why it works as it does, along with the inherent uncertainties and limitations of new scientific knowledge from leading edge research.

¹⁶ The Third International Mathematics and Science study (TIMSS), 1995.

pleased to note during our work a number of further steps taken by the Government to build on these firm foundations. They included the production of a revised version of the national curriculum, a new scheme of work covering key stage 2 science, the preparation of a new scheme of work for key stage 3 science and a new structure for post 16 qualifications.

101. As we completed this report, the Government announced a number of new steps to improve science teaching through a new focus on the initial, key stage 3 of secondary school science including a new emphasis on the teaching of higher order thinking and problem solving skills and a new set of targets to monitor pupils' progress at the age of 14.¹⁷

102. More recently, the Government published a consultation paper about the professional development of teachers.¹⁸ Among the many proposals in this paper, we were especially pleased to see those concerning a core set of basic principles, performance management arrangements, recognition and commitment, career planning, improved CPD opportunities through bursaries, mentoring, peer networks and professional learning teams, and teacher relevant research.

103. We trust that this report proves a useful and distinctive, evidence based contribution to the development and successful implementation of these proposals. We are convinced that the subject of our report will become even more important in the foreseeable future than it is today:

- Over 60% of our most experienced science teachers will reach retirement age during the next 20 years and some 25% over the next ten. There are insufficient teachers in the earlier years of their professional lives to step into their shoes, especially at secondary level.
- The nature and character of the pool of new teachers into the profession is likely to continue to change profoundly for demographic and labour market reasons and because they have graduated in degrees which differ substantively from the mostly single science subject degrees of previous generations of science teachers.
- Proportionately more new teachers will probably follow the modular or school employment based route for their initial training and proportionately more might enter at an older age upon making a career move into teaching;
- Information and Communication Technology (ICT) is likely to transform the means and ways of supporting and enabling the practice of science teaching in schools including the continuous professional development of the science teachers.

104. As in all other areas of life which are being affected by advances in ICT, the business of school science education will probably go through a process of re-modelling and re-engineering, in as yet unclear and unpredictable ways. Only the Government can pro-actively manage this profound process of change nationally.

¹⁷ *Raising Aspiration in the 21st Century*, the Rt Hon David Blunkett MP. Wigan, 6 January 2000

¹⁸ *Professional Development: Support for teaching and learning*, DfEE, February 2000

105. We fully recognise that in a number of respects our report deals with matters that apply generally to the professional development and support of all teachers, no matter which subject they teach, particularly those which we have presented under the headings of Leadership, Accountability and School Management. We have therefore sought to draw out those considerations that relate specifically and distinctly to science teaching and science teachers.

106. Our recommendations are listed in the attached appendix. They are all directed at improving the standards and effectiveness of science teaching.

107. In taking forward its proposals for the professional development of teachers, we would caution the Government against being over prescriptive as to what should comprise a science teacher's continuous professional development (CPD); and a framework for a science teacher's career-long CPD. Nor do we believe that it should or needs to specify what constitutes "best science teaching practice" or the criteria for judging this. What works for one class of pupils for one science teacher does not always work for another class with the same or another teacher.

108. Rather we consider that in establishing the new framework for teachers CPD, it should focus on creating a top quality system comprising effective means, ways and processes for helping and supporting science teachers in their complex, demanding and vitally important work, one that positively encourages, empowers and enables science teachers to develop and improve their professional practice. In brief, we believe that the Government should concentrate upon:

109. **Leadership:** Strong, committed leadership and clear lines of responsibility and accountability must be established at all levels, along with and transparent funding and monitoring arrangements. 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. The success of this new framework hinges upon strong, effective leadership from the governors and head teacher of each school.

110. **Capacity:** The capacity and capabilities of schools to manage and enable the professional development of their science teaching staff needs to be increased significantly, especially at the levels of Head Teacher, Head of Science Department, Science Co-ordinators (in Primary Schools) and senior teachers with staff management responsibilities. Their appraisal, mentoring and coaching skills need to be developed and continuously strengthened. Best practice guidelines and benchmarks should be promulgated to assist them.

111. **Products and Services:** A core set of quality assured products and services is needed for science teachers to use in their own learning and development. These must be "teacher designed" and be easy for the teachers to access, use and apply. All new entrants should be made aware of this, their essential professional tool kit.

112. **Supply Arrangements:** These products and services and those for otherwise supporting science teachers in their work must be supplied in a teacher friendly way

through modern, effective arrangements. The Government should work in partnership with the key stake-holders to improve the operation of the market for such products and services, which is at present highly fragmented on both the demand side (schools and teachers) and the supply side (numerous providers).

113. **Centre of Excellence:** To achieve all these outcomes for science teaching and science teachers, the new framework should include a body that acts as the national driver and catalyst for change and continuous improvement. This body, for which we have used the term “national centre of excellence, should:

(a) encourage and enable science teachers to seek and adopt new teaching strategies and approaches in their work with pupils;

(b) provide support services to new and inexperienced science teachers, as well as weaker members of the science teaching profession; and

(c) add value at the national level in developing the professional practice of science teaching.

114. The added value, role and functions of the “centre” should be assessed fully, possibly under the auspices of the new General Teaching Council, in the light of the Government’s wider plans for teachers’ professional development and school science. These matters of purpose, together with the contingent ones concerning its organisation and structure, should be addressed in partnership with the key stake-holders. The “centre” would need to work through regional and local arrangements using a modern IT infrastructure.

115. For **informing** and **underpinning** the further development of its policies, the Government should ensure that research is conducted into how science teachers learn their professional practice through CPD, including the productivity of this process. In neither of these two respects is there much research evidence at present.

116. Science teaching is an art and a craft, one learned and developed by individual teachers through experience in the classroom once initially qualified. Within its new CPD framework, the Government must ensure that a top class support system exists to service the present and future needs of science teachers for these purposes..

117. Although beyond the scope of this report, we welcome the Government’s intention to review about the national curriculum for science with the objective of making it relevant and appropriate to this coming century.

119. We do not favour whole scale reform of the national curriculum which has undoubtedly had beneficial effects¹⁹. In our view, the key question is how to educate the minority of pupils who choose to follow science based courses of study and careers

¹⁹ eg “Science Teaching in Secondary Schools under the National Curriculum” JF Donnelly and EW Jenkins, Leeds, 1999

subsequently while also educating the majority in science who do not during their years of compulsory schooling.²⁰

²⁰ *ibid* 5

LIST OF RECOMMENDATIONS

General - Paragraphs 40 to 47

1. *In broad strategic terms, we consider that in establishing its new CPD framework, the Government should aim to bring about a transformation in the collective culture and ethos of schools and science teachers from that which presently exists. It should seek to make it endemic and the “natural professional thing to do” for science teachers to be engaged in continuous, subject specific, classroom based professional development.*
2. *More specifically, to achieve this transformation, the Government should take full account of the distinctive features and circumstances of school science and ensure that:*
 - (a) *as a general rule, the career progression of science teachers is dependent upon them engaging in systemic, continuous professional development that is appropriately recorded and accredited;*
 - (b) *secondary school science teachers have the opportunity to broaden and deepen their subject knowledge and their subject related pedagogical knowledge for teaching science at either key stage 3 or key stage 4;*
 - (c) *especially for secondary school science teachers, continuous professional development activities are sustained, class room based and supported appropriately by top class coaching and mentoring;*
 - (d) *by the end of the first five years of their careers, all science teachers, and especially those in secondary schools, are well on the way to developing the necessary skills and knowledge to become not only life long learners themselves but also to be able to contribute to the development of the professional practice of science teaching itself; and that*
 - (e) *a top class, professional support service exists for all new entrants into secondary school science teaching for the first full five years of their careers.*
3. *The new framework should also:*
 - *encourage and enable science teachers to seek and adopt new teaching strategies and approaches in their work with pupils;*
 - *create a pro-learning, innovative culture in which teachers regard themselves as science educators.*

4. *The framework should further provide an individual CPD entitlement to subject based professional development for each science teacher, one that is on par with that in other areas of professional life.*

Leadership and Accountability for the CPD of Science Teachers - Paragraphs 48 to 52

5. *The Government must ensure that:*

(i) there is clear responsibility and accountability for the monitoring, direction, control and co-ordination at the national, UK wide level that is necessary for the implementation of the new CPD framework;

(ii) schools and individual teachers fully understand their respective responsibilities and obligations;

(iii) there are clear and authoritative guidance on these matters; and

(iv) appropriate,, transparent funding arrangements are in place, with clear output or performance measures that reflect the full range of CPD activities and the appropriate balance of public expenditure on them.

6. *For monitoring purposes the Government could usefully track the number of state schools securing Investors in People (IiP) status.*

School Management's CPD Role and Requirements - Paragraphs 53 to 65

7. *The Government must build up the capacity and capabilities of schools to manage and enable the professional development of their science teaching staff. especially at the levels of Head Teacher, Head of Science Department, Science Co-ordinators (in Primary Schools) and senior teachers with staff management responsibilities. Their appraisal, mentoring and coaching skills need to be developed and continuously strengthened. Best practice guidelines and benchmarks should be promulgated to assist*

8. *It should introduce these new processes and tools into schools in ways that support and enable:*

(i) the establishment of suitable norms and practices across schools;

(ii) the creation of trust and confidence of science teachers in these practices and processes; and

(iii) Beacon Schools and the cadre of advanced skills teachers to provide their fullest possible added value contribution. The effectiveness of their contribution to other schools needs to be monitored closely. So does the capacity of these other schools and their staff to absorb and learn from their contributions.

9. *To enable school managers to deal effectively with this vital set of responsibilities, suitable benchmarks and best practice guidance should be*

promulgated, possibly using “ the People Skills Scoreboard for the Engineering Industry” as a model.

Products and Services for Science Teachers’ CPD - Paragraphs 66 to 79

10. In managing the roll out and developing architecture of the National Grid for Learning, the Government should ensure that schools have sufficient resources, capacity and capabilities to exploit its potential fully.

11. In partnership with science teachers and the community of provider organisations in the public, private and voluntary sectors, the Government should establish a core set of suitable, quality assured products and services that is made available and known to all new entrants, as their essential professional tool kit. The creation of this tool kit must be teacher led and its contents should be easy for the teachers to access, use and apply. Its contents should be supplied through teacher friendly arrangements that make the most of the potential of the National Grid for Learning.

Supply Arrangements - Paragraphs 80 to 89

12. In partnership with both sides, the Government should seek to improve the operation of this market which is highly fragmented on the demand and supply sides at present.

Centre of Excellence - Paragraphs 90 to 97, 109 and 110

13. 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 ”:

(i) enabling and achieving the necessary cultural shift and other changes which we identified earlier;

(ii) ensuring that a sufficient and suitable range of core CPD products and services is available to all science teachers and that these are subject to appropriate quality assurance and marketing arrangements; and that they are provided in an appropriate user friendly way from the teachers’ viewpoint;

(iii) acting as a centre for piloting and developing innovative ways of teaching science under the national curriculum, taking account of national and international developments;

(iv) providing a proactive, professional support service to all new secondary school science teachers for the first five years of their careers; and

(v) providing a help line for all science teachers, for instance one that complements the Grid’s Virtual Teacher Centre, whatever mentoring and the like these teachers are getting in their schools, and the formation or execution of their CPD plans, in the

light of their initial career entry profiles and subsequent annual performance assessments.

14. For informing and underpinning the further development of its policies, the Government should ensure that research is conducted into how science teachers learn their professional practice through CPD, including the productivity of this process.

ANNEX A

SUMMARY OF SURVEY RESULTS

Introduction

A1. This annex presents the main findings of our survey into the views and needs of teachers of science in primary and secondary state schools concerning:

- their career-long continuous professional development (CPD);
- the identification, collection and spread of good practice in science teaching;
- the support for school science provided by the many private and public sector organisations and institutions; and
- the use of Information and Communication Technology (ICT) for these purposes.

A2. The survey was undertaken by the School of Education, King's College London during June and July 1999 through:

- 20 focus groups involving more than 150 teachers from 50 schools in five regions of England; and
- a questionnaire survey of a randomly selected sample of 1973 primary and 735 secondary state schools in England.

A3. Three questionnaires were sent to each school – one for the headteacher, one for a teacher of science with less than five years experience, and one for a more experienced teacher of science.

A4. A total of 2,355 questionnaires (29% of the total of 8124 distributed) were returned from 1279 schools (47% of the total sample) as follows (:Table 1):

Table 1: Response rates to the questionnaire survey.

	Primary	Secondary
Number of Schools	745 (38%)	505 (68%)
Number of Headteachers	565 (29%)	360 (49%)
Number of teachers	854 (22%)	576 (42%)
within first five yrs of career	289	223
over 5 yrs into career	565	353

Teachers' qualifications

A5. Among the primary teachers, the percentage of those without an A-level or higher qualification in a science based subject was 69% for biology, 85% for chemistry and 89% for physics. The percentages without a first or higher degree in a science based subject were 88% for biology, 96% for chemistry and 98% for physics (:Table 2).

Table 2: Qualifications of primary teachers by science subject (n=854)

Subject of qualification	Qualification obtained					
	<O/GCSE	O/GCSE	A-level	BSc	MA	PhD
Biology	19	50	19	11	<1	<1
Chemistry	42	42	12	3	0	<1
Physics	47	42	9	1	<1	0
All subjects	108	134	40	15	<1	<1

A6. The results for secondary teachers are shown in Table 3 below:

Table 3: Qualifications of secondary science teachers at Key Stages 3 and 4 (n=576)

<p>At key stage 3, the percentages of those teaching a science topic <i>without an A-level</i> in the subject were:</p> <p>37% of those teaching biology;</p> <p>19% of those teaching chemistry;</p> <p>37% of those teaching physics.</p> <p>and similarly the percentages of those <i>without a related degree</i> were:</p> <p>53% of those teaching biology</p> <p>62% of those teaching chemistry</p> <p>76% of those teaching physics</p>	<p>At key stage 4, the percentages of those teaching a science topic <i>without an A-level</i> in the subject were:</p> <p>26% of those teaching biology;</p> <p>13% of those teaching chemistry;</p> <p>29% of those teaching physics.</p> <p>and similarly the percentages of those <i>without a related degree</i> were:</p> <p>39% of those teaching biology;</p> <p>51% of those teaching chemistry;</p> <p>66% of those teaching physics</p>
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Teachers' levels of confidence

A7. The teacher's self professed levels of confidence varied considerably depending, *inter alia*, on the area of the curriculum being taught, the length of experience of the teacher and whether the teacher is primary or secondary.

A.8. As might be expected, the teachers in the first five years of their careers generally had less confidence in teaching science than their more experienced colleagues. But even among the more experienced there were significant variations, especially between the science topics taught and between key stages 3 and 4 (:Tables 5a-5c):

A9. All the primary teachers taught across the curriculum: 15% reported teaching science for 1 hour each week or less, 55% taught science for 2 hours, 19% taught 3 hours per week and 11% taught science for more than 3 hours per week (:Table 4).

Table 4: The number of hours per week of science taught by the primary teachers (n=854)

Number of hours	Teachers	
	Number	%
<1 hour/week	17	2
1 hour/week	114	13
2 hours/week	466	55
3 hours/week	165	19
4 hours/week	47	6
5 hours/week	18	2
> 5 hours/week	26	3

A10. Altogether the primary teachers were less confident about teaching science than about mathematics or english at key stage 2. Only 57% reported having a lot of confidence in teaching science, appreciably lower than the figures for the other core subjects of english (66%) and mathematics (63%). As for key stage 2, their levels of confidence were notably low with only 44% having a lot of confidence in teaching the programme of study at key stage 2 for *Sc1 - Experimental and Investigative Science*, and 47% for *Sc4 - Physical Processes*.

Table 5a

Years of Teaching	Primary Confidence Levels at Key Stage 2											
	Figures are % of the teachers covered in each row											
	Sc1 Experimental			Sc2 Life & Living Processes			Sc3 Materials			Sc4 Physical Processes		
	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little
0-5 n=289	37	55	7	54	45	1	47	50	2	33	58	9
6-10 n=138	47	50	3	72	27	1	61	38	1	54	42	4

11-20 n=174	56	41	3	76	22	2	67	31	2	55	40	5
21-30 n=221	45	50	5	74	24	2	63	34	2	54	40	5
30+ n=31	32	68	0	77	23	0	61	34	3	39	55	6
All	44	51	5	67	31	1	58	40	2	47	47	6

A11. Within their generally high levels of confidence in teaching at key stage 3, 1 in 4 secondary teachers only had some confidence when teaching the programmes for *Sc2 Life & Living Processes* and *Sc4 Physical Processes*. Moreover, 87% of all these teachers wanted more ideas for science investigations despite their high level (a lot) of confidence.

Table 5b

Secondary Confidence Levels at Key Stage 3												
Figures are % of the teachers covered in each row												
Years of Teaching	Sc1 Experimental			Sc2 Life & Living Processes			Sc3 Materials			Sc4 Physical Processes		
	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little
0-5 n=289	82	17	1	83	14	1	85	14	0	75	24	<1
6-10 n=138	94	6	0	88	12	0	90	10	0	82	18	0
11-20 n=174	93	7	0	83	15	1	88	12	1	80	18	<1
21-30 n=221	92	8	0	72	21	6	87	12	1	87	10	1
30+ n=31	96	5	0	73	27	0	86	14	0	91	5	5
All	89	11	<1	80	16	2	87	13	0	81	18	1

A12. Significantly, secondary teachers' levels of confidence drop markedly with far greater variation across the 4 programmes and bands of experience when they teach pupils at key stage 4, the final stage leading up to the GCSE examinations, which are now used as a one of the most important measures of a school's performance.

Table 5c

Secondary Confidence Levels at Key Stage 4												
Figures are % of the teachers covered in each row												
Years of Teaching	Sc1 Experimental			Sc2 Life & Living Processes			Sc3 Materials			Sc4 Physical Processes		
	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little	A Lot	Some	Little
0-5 n=289	72	26	1	59	25	13	57	36	5	44	41	14
6-10 n=138	80	14	4	57	31	8	70	22	4	45	49	4
11-20 n=174	88	8	2	53	37	7	64	28	5	56	29	10
21-30 n=221	81	13	0	38	40	15	57	30	6	57	29	6
30+ n=31	77	14	0	46	23	23	50	36	5	50	32	9
All	79	17	1	52	32	12	60	31	5	50	35	10

A13. At key stage 4, only a half of the respondents had some confidence in teaching the programmes *Sc2 Life & living Processes* and *Sc4 Physical Processes*. The figures for Life & Living Process are perhaps surprising in the light of the growing proportion of graduates with biology or another life science based degree who are entering the profession.

A.14. Other than for *Sc1 Experimental & Investigative Science*, between 40% and 50% of the teachers regardless of years of experience felt themselves as having only some or a little confidence in teaching these programmes.

Correlation between qualifications and levels of confidence

A15. An analysis of the responses from all the teachers and from those within the first five years of their career revealed a correlation between these teachers' highest subject qualifications and their levels of confidence:

(a) Higher level biology qualifications were not associated with confidence in teaching biology at KS3 ($r = 0.01$) for inexperienced teachers but were positively associated for all teachers ($r = 0.14$). Higher level biology qualifications were positively associated with confidence in teaching the subject at KS4 for both groups ($r = 0.23$ (inexperienced)/ 0.24 (all)). They were negatively associated with confidence in teaching physics at KS4 ($r = -0.21/-0.10$).

(b) A higher level of chemistry qualification was positively associated with confidence in teaching chemistry at KS3 (0.21 (inexperienced)/ 0.24 (all)) and at KS4 ($r=0.20/0.24$).

(c) A higher level qualification in teaching physics was correlated with a lack of confidence in teaching biology both at KS3 ($r = -0.24$ (inexperienced)/ -0.19 (all)) and KS4 ($r = -0.33/-0.17$); had little correlation with the teaching of chemistry (KS3: $r = 0.0/-0.03$, KS4: $r = -0.10/0.02$); and had a positive correlation with confidence in teaching physics at KS3 ($r = 0.22/0.18$) and at KS4 ($r = 0.27/0.24$).

Funding of INSET

A16. The amount of money available for INSET varied widely among the schools which responded to the survey. The mean total amounts available were £4,140 in the primary schools and £14,730 in the secondary schools. The money available for INSET per member of staff varied from £20 to £3000 in the primary schools and £50 to £1500 in the secondary schools (: Tables 6). The average amount per teacher was £445 in primary schools and £304 in secondary schools. (The mean size of schools was: primary 9.3 FTE, secondary 48.5 FTE).

Table 6: Distribution of INSET funding per teacher

Amount	Primary Teachers % n = 565	Amount	Secondary Teachers n = 360
£0-100	8	£0-150	15
£101-300	17	£151-300	38
£301-500	52	£301-600	38
£501-1000	9	£601-1000	8
£1000+	15	£1000+	< 2

Allocation of INSET funds

A17. 50% of the primary headteachers reported that they themselves decided the allocation of INSET funds, whereas this figure was 15% for secondary headteachers (: Table 7). However, the combined figure for allocating funding by the headteacher or a colleague was similar in primary schools (75%) and secondary schools (76%).

Table 7: Allocation of INSET funds in the primary and secondary schools

	Primary schools (n=565)	Secondary schools (n=360)
Method of allocation	%	%
Head decides	50	15
Colleague decides	25	61
Budget devolved to individuals	6	29
Bids from individuals	11	9
Other	32	29

A18. When determining the allocation in INSET funding, 88% of the primary headteachers and 84% of the secondary headteachers ‘often’ (rather than ‘occasionally’ or ‘rarely’) determined INSET needs in line with School Development Plans (: Tables 8a and 8b). The second most important consideration was individual requests (41% ‘often’ in primary schools and 51% ‘often’ in secondary schools).

Table 8a: Basis for determining INSET funding allocations in the primary schools (n=565)

Basis	Often %	Occasionally %	Rarely %	Never/Omitted %
<i>Individual Requests</i>	41	56	2	2
<i>Informed by the School Development Plan</i>	88	11	0	1
<i>Senior Colleagues</i>	22	50	14	14
<i>Examination Results</i>	20	50	22	8
<i>LEA Inspector</i>	7	50	32	11
<i>Ofsted</i>	31	58	7	4
<i>Other</i>	9	2	1	87

Table 8b: Basis for determining INSET funding allocations in the secondary schools (n=360)

Basis	Often %	Occasionally %	Rarely %	Never/Omitted %
<i>Individual Requests</i>	51	47	1	2
<i>Informed by the School Development Plan</i>	84	15	0	1
<i>Senior Colleagues</i>	33	62	2	3
<i>Examination Results</i>	12	58	23	7
<i>LEA Inspector</i>	5	37	52	7
<i>Ofsted</i>	18	60	15	7
<i>Other</i>	11	7	1	81

The Teachers' INSET

A19. Most of the teachers who responded to the survey had received some formal INSET during the year, with over half having undertaken ICT INSET (: Table 9).

Table 9: The INSET that the primary and secondary teachers of science received in 1998/99

Topic	Sector	
	Primary (n=854)	Secondary (n=576)
	%	%
<i>Preparation for senior management</i>	15	10
<i>Preparation for middle management</i>	8	18
<i>ICT</i>	59	53
<i>Class management</i>	24	30
<i>Teaching skills</i>	30	37
<i>Subject knowledge</i>	23	15
<i>Assessment</i>	53	44
<i>Mentoring</i>	18	19

Table 10: Primary and secondary teachers' evaluations of the INSET that they received during 1998/99.

Topic	P n=	S n=	Generally useful %		Sometimes useful %		Rarely useful %	
			Primar y	Secon dary	Primar y	Secon dary	Primar y	Secon dary
Preparation for senior management	127	57	64	58	35	40	0	2
Preparation for middle management	72	104	54	57	43	39	0	4
ICT	507	308	54	41	38	50	6	8
Class management	201	171	44	37	45	58	5	5
Teaching skills	255	215	66	53	30	42	2	3
Subject knowledge	193	86	65	57	29	38	2	2
Assessment	454	251	50	45	43	49	3	2

Mentoring	15 0	11 1	55	50	39	42	5	7
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A20. Less experienced teachers attended fewer courses than their more experienced colleagues.

A21. Although few teachers regarded their INSET as ‘rarely useful’, their levels of satisfaction varied considerably for different topics (: Table 10). Courses that addressed improving teaching skills and subject knowledge were generally rated more highly than other topics. Teacher evaluations were lowest for courses on Information and Communication Technology (ICT), class management and assessment.

A22. Primary teachers rated the INSET given by colleagues in their own school as more useful than INSET received away from school. Secondary teachers rated the INSET they received away from school as more useful than INSET given by colleagues in their own school (: Table 11).

Table 11: Primary and secondary teachers’ opinions about their science INSET in 1998/99.

Source	P n=	S n=	Mostly useful %		Some use %		Little use %	
			Primar y	Second ary	Primar y	Second ary	Primar y	Second ary
In school, from colleagues	72 4	49 3	61	37	35	56	2	7
In school from outsiders	56 8	38 5	54	29	43	57	3	15
Out of school	65 8	39 2	56	53	42	42	2	4

A23. Headteachers in both primary and secondary schools viewed INSET delivered in school by colleagues as being more useful for their science staff (: Table 12) and also rated demands on teachers’ time and finance as being the most significant constraints on INSET provision.

Table 12: Primary (n=565) and secondary (n=360) headteachers’ opinions on the INSET provided to their staff.

Source	Mostly useful %		Some use %		Little use %	
	Primary	Secondar	Primary	Secondar	Primary	Secondar

		y		y		y
In school, from colleagues	54	70	38	27	3	1
In school from outsiders	38	42	47	50	4	2
Out of school	38	26	52	67	6	4

The Teachers' Views on Support from Third Parties

A24. 24% of primary teachers and 31% of secondary teachers rated the help that they received from LEA advisors as 'poor' (: Table 13). Teachers in urban schools were more critical of the advice than teachers in suburban or rural schools. 31% of primary teachers and 42% of secondary teachers rated the help that they received from teachers' centres as 'poor'.

A.25. Among those teachers who had heard of the main professional organisation, the Association for Science Education (ASE), the levels of satisfaction varied from 82% 'satisfactory' or better (primary teachers) to 90% (secondary teachers). Some 26% of the primary teachers had not heard of the ASE.

Table 13: Primary and secondary teachers' opinions about the quality of science advice received from various sources.

Source	P n=	S n=	Good %		Satisfactory %		Poor %	
			Primary	Secondary	Primary	Secondary	Primary	Secondary
Other teacher	675	529	59	70	37	27	4	3
LEA advisors	421	292	33	26	43	43	24	31
Teachers' Centres	338	146	21	7	48	51	31	42
ASE	335	324	32	36	50	54	18	10

A26. Teachers reported using a range of different sources of information in their lessons (: Table 14).

Table 14: The sources of information used by primary (n=854) and secondary (n=576) teachers of science

Source	Often %		Occasionally %		Rarely %	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Textbooks	43	89	36	10	21	1
Other books	61	46	35	46	4	7
Videos	26	51	54	45	19	4
CD ROMs	14	15	52	51	34	34
Periodicals	16	11	46	36	37	53
Courses	16	7	51	52	32	41
Colleagues	25	39	54	51	21	10

A27. Teachers reported using third party resources only infrequently (: Table 15).

A28. Criticisms of third party support included its lack of relevance to new versions of the National Curriculum, a lack of time to differentiate what was useful and poor independent advice on the value of third party materials.

Table 15: Sources of 3rd party materials used by primary (n=854) and secondary (n=576) teachers and their frequency of use.

Source	Frequently %		Occasionally %		Never %		Not aware of resources %	
	Prim	Second	Prim	Second	Prim	Second	Prim	Second
Industry	2	4	32	50	45	37	20	9
Societies	1	8	11	50	55	38	32	4
Government agencies	<1	1	12	31	52	51	34	17
Charities	<1	1	19	27	41	40	39	31
Museums	8	2	63	41	23	49	5	7
SETNET	<1	1	4	11	22	32	73	56
ASE	7	10	28	45	39	39	26	6

A29. The teachers also reported that they would like to have more resources provided to them on ideas for conducting scientific investigations (89% of primary teachers and 87% of secondary teachers) and also more courses for teachers themselves (81% primary and 78% secondary) (: Table 16).

Table 16: Resources that primary and secondary teachers of science would like more of.

Source	Yes %		Possibly %		No %	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Tours of scientific establishments	16	44	47	45	38	11
Ideas for science investigations	89	87	9	12	2	1
Teaching material about social and ethical issues of science	47	61	42	33	10	6
Other material	88	83	11	16	1	1
Courses for pupils	47	58	39	36	15	6
Courses for teachers	81	78	17	21	2	1

Use of Information and Communication Technology

A30. The National Grid for Learning was used only 'rarely' by 71% of primary teachers and 72% of secondary teachers of science (: Table 17). Only 9% of secondary teachers reported using computers 'often' in science lessons, 65% used computers 'occasionally' and 26% used them 'rarely'. The figures for primary teachers were more encouraging, with 42% of teachers reporting using computers 'often' in their teaching.

A31. 65% of secondary science teachers reported using computers 'often' for preparing materials and 62% used them 'often' for administration. The figures for primary teachers (43% using computers 'often' for preparing materials and 35% 'often' for administration) were lower due to limited resources and less non-contact time in primary schools (: Table 17).

Table 17: Primary (n=854) and secondary (n=576) teachers' use of computers for science teaching

Use	Often %		Occasionally %		Rarely %	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Preparing materials	43	65	41	27	16	8
Administration	35	62	33	26	32	12
Teaching	42	9	50	65	8	26
National Grid for Learning	6	3	23	25	71	72
Internet	11	21	33	43	56	36
Email	16	29	24	26	60	45

A32. The major constraint on teachers' use of ICT for teaching purposes was reported as a lack of time (88% of primary teachers and 86% of secondary teachers) (: Table 18). The next most important was reported as being 'know-how' for primary teachers (56%) and access to equipment for secondary teachers (65%).

Table 18: Constraints on teachers' use of ICT

	Primary (n=854)	Secondary (n=576)
Constraint	%	%
Know how	56	37
School access	42	18
Equipment access	40	65
Time	88	86
Help	48	38
Cost	29	28

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ANNEX B

OTHER SUPPORTING EVIDENCE.

B1. Deployment of Science Teachers by subject specialism

- A 1999 study on the deployment of science teachers at Key Stage 4²¹ suggests that:
 - specialist physics teachers are substantially under-represented in schools.
 - a substantial majority of schools (60%) have persisted with specialist teaching at KS4, compared to 30% at KS3.
 - while in some schools non specialist science teaching at KS4 is undertaken on principle, in a much larger number it appears to be a reflection in part of the limited availability of specialists in physics and chemistry.
 - in the experience of respondents, the emphasis on teaching across the sciences is greater in teacher training institutions than in schools.
 - science teachers are polarised in their views about the advantages and disadvantages of a reduction in specialist teaching of the sciences.
- The report's recommendations included the following:
 - a policy of seeking to train teachers to teach across all three science specialisms should be regarded as a longer-term strategy for professional development, requiring substantial resources and available to experienced science teachers who are willing and able to develop in this way.

B2. Views of Teachers about the effects of the National Curriculum (NC) on Science Teaching

- Another 1999 study by Leeds University²² suggests that:
 - the teachers are spending more time on detailed lesson planning, clarifying their lesson objectives, making more use of textbooks, worksheets and “bought-in courses” and putting increased emphasis on schemes of work.
 - the NC has also led to greater collaboration among science teachers, increased demands on technical staff, closer monitoring of pupil progression,

²¹ *The Expertise and Deployment of Science Teachers at Key Stage 4*, Donnelly JF and Jenkins EW, University of Leeds, 1999

²² *Science Teaching in Secondary Schools under the National Curriculum*, Donnelly JF and Jenkins EW, University of Leeds, 1999

more homework for pupils, enhanced feedback to pupils about their work and improvement in the coherence of the science curriculum.

- As seen by the teachers, the NC has adversely affected their freedom of professional choice of teaching activities, the amount and range of laboratory activities undertaken and the pupils' enjoyment of science.

B3. Pupils' Views of School Science

- In an ongoing study by King's College London²³, pupils draw a clear, unfavourable distinction between school science on the one hand and the value and relevance of science and technology to their lives on the other.
- Pupils judge school science as authoritarian and dogmatic - a factual subject to learn rather than to engage with, one which does not compare favourably with other NC subjects.
- More especially:
 - the pupils were predominantly critical or negative about school science and especially the rushed nature of their lessons, the qualities of the subject, the difficulty of science and the disparate nature of the National Curriculum.
 - 50% of them felt that they had been frog marched across the scientific landscape with no time to absorb what they had just learnt, no opportunity to pursue topics of a particular interest and most importantly no time for discussion.
 - in contrast to other subjects such as English and History, school science did not allow them anywhere near as much opportunity for reflective and discursive activity. They judged it to be overloaded with context, with particular emphasis on learning facts and "right" answers and lacking sufficient relevance to their daily lives or concerns and sufficient examples of contemporary science.

B4. OFSTED Assessment of Science Teaching Standards

- OFSTED's 1997/98 annual report acknowledges weaknesses but refers to the improved motivation and achievement of pupils in many schools.
- The report refers to science teaching at KS4 as being good or very good in 40% of schools, satisfactory in another 48% and unsatisfactory or poor in only 12%. The position is much the same at KS3 but with slightly fewer schools (10%) in the unsatisfactory or poor category.

²³ *Pupils' and Parents' Views of the Role and Value of the Science Curriculum*, Osborne J and Collins S, BERA Conference, September 1999.

- In a recent report on Secondary Education in England²⁴ OFSTED refers to a steady improvement of standards in science teaching between 1993 and 1997, to 9 out of 10 KS3 and KS4 science teachers having a good command of their subject.
- In line and on a par with other subjects, OFSTED reports a continuing rise in teaching standards for science at KS1 and KS2.

B5. Key Stage Tests and Examination Results

- The test results at Key Stage 1 have shown a steady improvement in all three subjects of english, mathematics and science, with the results in science being consistently higher. At Key Stage 2, the test results for all three subjects are lower than for Key Stage 1 but have still shown improvement, with the science results again being highest.
- At Key Stage 3, the results for science have shown little improvement since 1995 and are lower than the results for english and mathematics (: Table 1). In a recent speech²⁵, the Secretary of State for Education and Employment, the Rt Hon David Blunkett MP highlighted concerns over these science results at Key Stage 3, stating that “there is evidence to suggest that pupils make 6 terms progress in science at Key Stage 3 instead of 9”.

Table 1: Trends in the percentage of pupils achieving target attainment levels in Key Stages 1, 2 and 3.

Year (1990s)	Key Stage 1 - Level 2 and above					Key Stage 2- Level 4 and above					Key Stage 3- Level 5 and above				
	95	96	97	98	99	95	96	97	98	99	95	96	97	98	99
English	80	79	80	81	82	49	57	63	65	70	55	57	57	65	63
Maths	79	82	84	85	86	45	54	62	59	69	57	57	60	59	62
Science	84	84	85	86	87	70	62	69	69	78	56	57	60	56	55

- At GCSE, approximately 70% of pupils are now sitting double award science and just under half are achieving A-C grades.
- Since 1992/93, there has been an increase in the numbers of pupils passing either single or double award science at GCSE (from 446,000 to 509,000) as well as an increase in the percentage of pupils passing these examinations (from 71% to 82%) (: Table 2).

²⁴ Secondary Education: A review of secondary schools in England, 1993-97, OFSTED 1997.

²⁵ *Raising Aspirations in the 21st Century*, booklet accompanying a speech by the Rt Hon David Blunkett MP, Secretary of State for Education and Employment at the North of England Education Conference in Wigan on 6 January 2000, DfEE, 2000.

Table 2: Proportions of 15 year olds passing GCSE science in either combined science or individual sciences: 1992/93 - 1997/98

Percentages

	Combined science			Individual science subjects				
	Single	Double	Total	Total	1	2	3	Mean
1992/3	13.9	57.1	70.9	12.6	2.9	4.2	5.5	2.23
1993/4	10.0	68.7	78.7	7.8	0.9	1.3	5.6	2.59
1994/5	9.2	70.9	80.0	6.5	0.6	0.9	5.0	2.68
1995/6	9.5	70.6	80.1	6.7	0.5	0.8	5.4	2.72
1996/7	8.3	72.2	80.5	6.6	0.5	0.8	5.3	2.72
1997/8	8.4	73.2	81.6	6.9	0.5	0.7	5.7	2.76

Numbers (thousands)

1992/3	74	305	379	67	15	22	29	
1993/4	53	366	419	42	5	7	30	
1994/5	53	410	463	37	3	5	29	
1995/6	56	419	476	40	3	5	32	
1996/7	49	423	472	39	3	5	31	
1997/8	48	421	469	40	3	4	33	

- The proportion of pupils gaining A*-C grades in single and double award science has increased by 5% between 1994/95 and 1997/98
- At A level, approximately 6% of the age cohort are sitting Physics, 7% are sitting Chemistry and 9% are sitting Biology. These percentages have oscillated a little during the 1990s with only Biology showing any real increase.
- The percentage of A-level pupils passing one, two or three science A-levels or one or two sciences plus mathematics has varied little since 1993/94 (: Table 3).

Table 3. Trends in the proportion of all 17 year olds passing at least one science A-level in England

Per cent

	Arts/social science only*	Number of science passes with or without other subjects			Sum	At least one science and maths	At least two sciences and one maths
		1	2	3 +			
1993/94	62	21	15	2	100	16	9
1994/95	61	22	15	2	100	17	10

1995/96	61	22	15	2	100	17	10
1996/97	60	23	15	2	100	17	10
1997/98	59	23	16	2	100	17	10

* includes Maths and computer studies

- The proportion of A-level candidates getting both one and two science passes has risen faster than the proportion getting one or more, two or more and three or more passes in any subject (: Table 4).
- The number of pupils gaining A levels in maths and science subjects increased between 1994/95 and 1997/98 as follows

Mathematics and Mathematical Sciences: by 17% to 49,528 from 42,497.

Computing/IT: by 29% to 6,631 from 5153.

Biology/Biological Sciences: by 30% to 37,846 from 29,142.

Physical and Chemical Sciences/Other Sciences: by 13% to 57,973 from 51,220.

Table 4: Trends in the proportion of all 17 year olds passing A-levels in science, compared to passes in all A-levels

Per cent

	Number of A-level passes			Number of science A-level passes			Number of science passes with maths		
	1 or more	2 or more	3 or more	1 or more	2 or more	3 or more	1 or more	2 or more	3 or more
1992	90	74	53	29	13	2	14	8	0.3
1993	91	76	56	34	15	2	15	9	0.3
1994	92	78	58	35	16	2	15	9	0.3
1995	93	79	61	36	16	2	16	9	0.4
1996	93	80	63	37	16	2	16	9	0.4
1997	93	82	65	38	16	2	16	9	0.5
1998	94	82	66	39	17	2	16	9	0.5

- This pattern would appear to indicate that science has increased its penetration of the A-level flow. However, the proportion of candidates passing science with maths has risen more slowly over the same period.
- There is also evidence of a skew in the percentages of comprehensive schools which have the highest proportion of candidates passing at least two sciences at A-level, and this skew has increased over time (: Tables 5a and 5b).

Table 5a: Candidates who passed at least two science A-levels in 1994/95

% of all A-level candidates in school who passed at least two sciences	No. of schools	% of schools	No. of pupils with two or more science passes	% of all pupils with two or more science passes
0-9	560	37	1,248	11
10-19	611	41	5,324	48
20-29	265	18	3,639	33
30+	68	5	941	8
Total	1,504	100	11,152	100

Table 5b: Candidates who passed at least two science A-levels in 1997/98

% of all A-level candidates in school who passed at least two sciences	No. of schools	% of schools	No. of pupils with two or more science passes	% of all pupils with two or more science passes
0-9	506	33	1,322	9
10-19	661	43	6,389	46
20-29	322	21	5,151	37
30+	63	4	1,074	8
Total	1,552	100	13,936	100

- 30% or more pupils are passing two or more science A-levels in just 4% of comprehensive schools and these schools account for 8% of the total number of pupils with two or more science passes. These pupils are more likely to be aiming to pursue a science or science-related subject at higher education level than those with just one A-level science pass.

B6. Looking ahead

- Table 6 shows the projected numbers of 11-15 year olds in secondary schools between 1999 and 2011.

Table 6: Projected numbers of secondary school pupils (11-15 year olds)

(000's)

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
11	631	650	642	652	659	654	630	633	614	604	614	600	602
12	617	631	651	643	652	659	654	630	633	614	605	614	600
13	614	617	632	651	643	652	659	655	631	633	615	605	615
14	591	613	616	631	650	642	652	658	654	630	632	614	604
15	581	580	602	606	621	640	633	642	649	644	621	623	605

- Over the next 10 years, some 25% of our most experienced science teachers will reach retirement age and during this time the numbers of secondary school pupils will rise and then fall again, leading to a reduced potential for intake into higher education and teacher training.

CST

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ANNEX D: Glossary of abbreviations and acronyms

ASE	Association for Science Education
CPD	Continuous Professional Development
DfEE	Department for Education and Employment
FTE	Full Time Equivalent (staff)
GCSE	General Certificate of Secondary Education
INSET	Inservice Education and Training
ICT	Information and Communication Technology
KS2	Key Stage 2 (Years 4-6) of the National Curriculum
KS3	Key Stage 3 (Years 7-9) of the National Curriculum
KS4	Key Stage 4 (Years 10-11) of the National Curriculum
LEA	Local Education Authority
NC	National Curriculum
NGfL	National Grid for Learning
OFSTED	Office for Standards in Education
PGCE	Postgraduate Certificate in Education
QCA	Qualifications and Curriculum Authority
QTS	Qualified Teacher Status
S&T	Science and Technology
SETNET	Science, Engineering, Technology, Mathematics Network
TTA	Teacher Training Agency