Integrated Science in the UK, 1965-1996: its origins, characteristics, implementation and subsequent absorption into the National Curriculum in Science

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Thesis submitted for the degree of
Doctor of Philosophy of the University of London

Institute of Education
University of London

July 1999

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Abstract

Integrated science courses for secondary schools were developed in the late 1960s and early 1970s. The rationale for the courses was the need to bridge the interface between school science and the personal lives of the students, so that they gained an understanding of themselves, and of the science and technology related issues that they would meet in their environment. There was also a wish to help students develop an awareness of the nature of science and of its limitations, so that if all the detail of courses was forgotten they held on to some idea about what science was and what it could do.

The author argues that while the ideal of integrated science was moulded by events much of the dynamic remains and can be found in a different guise in the science curriculum of the mid 1990s. The socialisation of science teachers into particular science disciplines, concerns about teacher expertise to teach such courses and the organisational features such as the need for unusual timetable slots were all factors which militated against the implementation of this ideal.

The 'centre-piece' of the research is a case study of change to integrated science for all pupils up to 16 in one secondary comprehensive school, between 1977 and 1980. The interplay of organisational, personal and ideological factors in the science department was like a rehearsal for a play, which was to be acted out on a national scale in the 1980s when a common examining system was put into place and science became compulsory. In the school, as in the wider context, the courses were modified by events, and in later years were designated as 'science'. Nevertheless it was possible to identify significant links to ideas in the early integrated science courses.

Acknowledgements

I should like to acknowledge the help of colleagues at the Institute who have at various stages helped with the supervision of this research; Professor Helen Simons who taught me how to conduct a case study; Professor Peter Gordon who took over as my second supervisor; and Professor Denis Lawton for guidance during the final stages of the research and preparation of the thesis.

I am indebted to the teachers in the case study schools who gave generously of their time to answer my questions, who allowed me to report on their day to day lives and who kindly read and commented on my reports; in particular the heads of science. My special thanks go to the head of science at Duckworth comprehensive school who so willingly assented to my request to follow the change at the school between 1977 and 1980. As teachers appear by pseudonym in the text, I cannot name them personally here.

I should like to thank Professor Jon Ogborn, Ralph Levinson, Alastair Cuthbertson, Marilyn Leask, John Bausor and Mike Coles for discussions, at various stages, about the significance of the findings. The advice received from Brian Woolnough and Jonathan Osborne has also been invaluable.

Last, but most importantly, my gratitude goes to my family, particularly my late husband, Harry Frost, for continuous support and encouragement, and my daughter, Ruth Frost, for help with proof reading.

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Acronyms

ABET	Association of Biology Education Tutors
AEB	Associated Examining Board
ADEPT	Association of Department of Education Physics Tutors
APSSM	Association of Public School Science Masters
APSST	Association of Public School Science Teachers
APU	Assessment of Performance Unit
ASE	Association for Science Education
ASET	Association of Science Education Tutors
AST	Association of Science Teachers
AT	Attainment Target (National Curriculum)
AUCET	Association of University Chemistry Education Tutors
AWST	Association of Women Science Teachers
BAAS	British Association for the Advancement of Science
BBC	British Broadcasting Corporation
CAT	Computerised Achievement Tests
CEE	Certificate of Extended Education
CESIS	Curriculum and Examination System in Integrated Science
CSE	Certificate of Secondary Examination
DES	Department of Education and Science
DES/WO	Department of Education and Science and Welsh Office
GASP	Graded Assessments in Science Project
GCE	General Certificate of Education
GCSE	General Certificate of Secondary Education
GNVQ	General National Vocational Qualifications
HMI	Her Majesty's Inspectors
HMSO	Her Majesty's Stationery Office
HoD	Head of Department
ILEA	Inner London Education Authority
INSET	Inservice Education and Training
IS	Integrated Science
LAMP	(Science for) Less Academically Motivated Pupils
LEA	Local Education Authority
LEATGS	Local Education Authority Training Grants Scheme
MEG	Midland Examining Group
NC	National Curriculum
NCC	National Curriculum Council

NEAB	Northern Examination and Assessment Board
Nf	Nuffield Foundation
NQT	Newly Qualified Teacher
NSI	Non-Selective Intake
NSS	Nuffield Secondary Science
OFSTED	Office for Standards in Education
PE	Physical Education
PGCE	Post Graduate Certificate of Education
PoS	Programme of Study (National Curriculum)
QCA	Qualifications and Curriculum Authority
RE	Religious Education
ROSLA	Raising of the School Leaving Age (1973) 'ROSLA Pupils'
SAPA	Science A Process Approach
SATs	Standard Attainment Tasks (later Tests) (National Curriculum)
SATIS	Science and Technology in Society
SCAA	Schools Curriculum and Assessment Authority
SCDC	School Curriculum Development Council
SCISP	Schools Council Integrated Science Project
SEG	Southern Examining Group
SEN	Special Educational Needs
SEREB	South East Region Examining Board
SIMS	Schools Information Management System
SMA	Science Masters' Association
SMT	Senior Management Team
SoA	Statement of Attainment (National Curriculum)
SSCR	Secondary Science Curriculum Review
SCUE	Standing Committee on University Entrance
TGAT	Task Group on Assessment and Testing
UNESCO	United Nations Educational, Scientific and Cultural Organisation
VSO	Voluntary Service Overseas

CHAPTER 1

THE ORIGIN OF THE RESEARCH QUESTIONS

a. Research Questions

In 1965 I became a science teacher in one of the new comprehensive schools in South London. With the gusto and enthusiasm of many a young teacher I embraced new challenges and was soon a trials teacher for one of the 1960s curriculum development projects in science, *Nuffield Secondary Science*, an integrated science course intended initially for 'The Young School Leaver'. In 1970 I gained a lecturing post with responsibility for Integrated Science at the Institute of Education in London. In addition to my work there in initial teacher education, I provided support to the *Schools Council Integrated Science Project* from 1975 to 1988 and wrote and edited units for a project initially called *Curriculum and Examinations System in Integrated Science*. By the mid 1980s the term 'integrated science' was heard less and less. By 1995, it had virtually vanished.

This research is a retrospective look at integrated science of that period, with the hope of finding answers to:

- What was integrated science?
- Whatever integrated science was, what happened to it and why?

I have followed Goodson's advice that to ignore the history of curriculum subjects is to fail to understand curriculum (Goodson, 1985). I have also taken heed of the example of writers who have shown how the history of subjects within schools is inextricably linked to contemporary social and political ideas (Layton, 1984, 1973, Jenkins, 1979, Woolnough, 1988). The historical thread starts here with the history of my own involvement in science education, as a learner and as a teacher; within this lies the motivation for the research.

b. Motivation for the research

Primary School, South London suburbs, 1948-1954

I was born during the Second World War, just ahead of the post war 'baby boom'. I started primary school in 1948. I can recall only isolated events from the time at the school. I spent six years there, and learned to read, write and do arithmetic sufficiently well to pass the 11+ examination which gave me entry to a grammar school. Other subjects included history and geography, painting, needlework, physical education, rounders, races, how to do 'intelligence tests', perform in school plays, do the minuet and sing hymns in assembly. I am sure there was more to it than that but I cannot say with any certainty whether I studied nature study, some broader conception of science or no science at all. At age eleven those not going to the single sex grammar schools went to the single sex secondary modern schools. I really had little idea of the difference between the grammar and secondary modern schools despite the fact that both my parents taught in the latter, and they seemed keen for me to go to the former.

Secondary Grammar School, South London suburbs, 1954-1961

I moved to a girls grammar school in 1954 where my formal study of science began. The curriculum in the first two years included a general science course (taught by one teacher) along with a range of other subjects which I believe comprised English, mathematics, geography, history, Latin, French, art, needlework and games. Science in the third year was taught as three separate subjects (biology, chemistry and physics) by different 'specialist' teachers. I continued, in the fourth and fifth years, to study three separate sciences along with mathematics and five other subjects for GCE O level (taking the examinations in 1959). This choice in the fourth year enabled me to stop studying geography and history. I did not have to study all three sciences and there were others in the class who dropped one or more science to allow choice of other subjects. In the sixth form, which was divided into Arts and Science sections, I continued to study three sciences and mathematics at A level, (dropping biology at the end of the first year in order to take pure and applied mathematics separately) and physics and applied mathematics at S level. The S level was indicated only by whether a state scholarship had been won or not. Of the science teachers I had at school, (all women), the physics teacher had been called back out of retirement as there was no one to fill the post.

The classes at the school were streamed on the basis of results from the end of first year examinations. These streams remained substantially unchanged with only one or two transfers between them for the next four years. The top stream continued with Latin to O level, the second took a modern foreign language instead, and the third dropped a language other than French, doing more needlework and domestic science instead. Latin was still a requirement for university entrance when I started at the school, so I suppose its inclusion was seen as expedient if nothing else. It also indicated that those in the second stream of a grammar school were considered unlikely to go to University, an assumption which looks out of place today. In practice the Latin requirement had been dropped for most subjects (and certainly for science) by the time I went to university.

Higher Education, Manchester, 1961-1964

On applying for higher education in 1961, I faced considerable competition for a place on an honours physics course, ending up as one of six women out of a class of one hundred at the University of Manchester, where I graduated in 1964. The lecturers and professors on the course were all men.

Teaching in a mixed secondary school in Ghana, 1964-5

The year after graduation, 1964-5, was spent in a mixed secondary school in Ghana through VSO, Voluntary Service Overseas. My teaching was confined to physics and mathematics to both the 'science' and 'arts' sets in the fourth year (at the time the most senior year in the school) and mathematics lower down the school. The 'science set' was composed entirely of boys. Not all children went to secondary school in Ghana. Primary schooling was available for all, but fees had to be paid for secondary education, or at least for the boarding element. It was not unusual to have people in the classes who were older than the normal school age as they had had to take time out to work to pay for their education. Some people received a secondary education through the training colleges which trained teachers for the primary schools.

Acquaintance with Nuffield O Level Physics, 1964 onwards

While in Ghana I attended a course for physics teachers in the Easter vacation, and met Ted Wenham, from the Nuffield Physics Project. What he was advocating seemed to me, at the time, to be very different particularly from the 'guide' I had taken with me, a traditional O level Physics text book. This influenced me to seek a post in a 'Nuffield' school when I returned in 1965 and was subsequently offered a place at a girls comprehensive school where the head of the science department (and of physics) was Beta Schofield, herself a trials teacher for Nuffield Physics. .

Girls Comprehensive School, South London, 1965-1970

The pattern of science courses and examinations

I have retained the comprehensive school's original file of 'notes for science teachers' which summarised the organisation of science courses for the years 1965/6 and 1966/7 and these are given in figures 1.1 and 1.2. Physics, at the time, was being given equal status with biology and chemistry, and the choice of science subjects at CSE (Certificate of Secondary Education) level was removed by the implementation of a natural science course which covered a range of science. Science was a component of every pupils' education up to the age of 15 or 16 or 17, depending on leaving age.

Figure 1.1 Pattern of Science Courses - Girls' Comprehensive, 1965/6

1	C Air; CO_2; O_2	B Animals:- reproduction, movement,	P Materials, weigh/meas, density	C Sol'ns, tech. states of matter kinetic theory	B Animals:- Respiration Feeding	P Air pressure based on kinetic theory
2	P Conduction of electricity - solids & liqu.	C Hydrogen & water	B Patterns of life in animals: invertebrates	P Expansion: Thermometer Transfer of ht.	C Atoms and molecules; formulae, equ.	B Patterns of life- insects and birds
3	P Astronomy and light	C Hardness water; Purification of supply	B Food of animals and man	P Grav. & mag. EM effects EM induction	C Acids Alkalis salts equations	B Photosynthesis etc
4	4aAbB London O level in Bio, Chem, P/C, Nf Phys		$4S_{1-4}$ CSE in Biology or	$4C_1$ Chemistry	4RD2 N.F. Newsom non exam	$4C_2$ (TV) forms
5	5aAB London O lev Bio & P/C		$5S_{1-3}$ Oxford O lev H. Biology	$5C_1$ RSA Bio	$5S_4$ CSE Bio or Chem	$5C_2$, C_3, RD1 N.F. Newsom No exam
6	6A London A level Bio. Chem. Phys.		OL Repeats Lon. Bio and	 Oxford H.Bio	CSE Chem.	
			General Course (heredity)			
7	A Level Bio. Chem. Phys.					
			General Course			

Streaming practices are evident from the labels 'Relatively academic': 'Average ability': and 'Remedial' in figure 1.2. There was opportunity of movement between streams. A common general science syllabus ran for years 1 & 2, with one teacher per class. In the third year, most girls continued with a general science syllabus (taught by one teacher), but the Nuffield O level Science Courses were started with the top two streams and taught by specialist teachers. The girls themselves made this choice, and we tended to steer those who thought they might take three sciences in this direction. The 'academic stream' had the choice of one, two or three O level science courses, the 'social band' had no choice, they did a Natural Science CSE Mode 3 which the school had written. Courses in the sixth form included Advanced level courses in physics, chemistry and biology; science as part of general studies, and CSE in Biology and Chemistry for pre-nursing courses. The preference for biology and to some extent chemistry, and the lack of uptake of physics can be seen from the subjects available.

Figure 1.2 Pattern of Science Courses - Girls' Comprehensive, 1966/7

	Relatively Academic		Average Ability		Remedial
1	Common I_1 I_2 Parallel streams (3)	General Science I_3 I_4 Parallel streams (3)	Syllabus I F A Parallel	C E T streams (3)	I_5 I_6 (TV) (TV) Parallel (2)
2	(3)	(3)	(3)	(3)	Join common syllabus with modification (2)
3	(girls' choice) 3N1 3N2 Nuffield Sc (6)	3H1 3H2 (6)	3 F A Parallel	C E T streams (6)	3_5 3_6 (2) (2)

	Academic streams	Social Education	Commerce	RD
4	4AaBb NF Phys NF Chem NF Bio Girls may opt for 1, 2 or 3 science subjects (4 per subject)	4 S_1 S_2 S_3 S_4 Mode 3 Nat. Sci Syll. No choice (4)	4 C_1 C_2 Selected topics from Mode 3 CSE (2) (2)	RD Selected topics from Mode 3 CSE (TV) (2)
5	Mainly O level	Mainly CSE	CSE	

6	A level Bio 2 sets Chem Phys (7)	One year course for RN etc CSE Bio (6) CSE Chem (6)	Gen Studies Science for All (1 hr)	Retake O level Bio (6)	Retake CSE Bio (6)	Retake CSE Chem. (6)
7		May do one year course with 6th year				
8						

The charts indicated the number of periods per week spent on science out of a forty period week. The first two years had 3 periods or 7.5% of curriculum time, the third year had six periods (15%) and the fourth and fifth years had a minimum of four periods (10%) and a maximum of twelve periods (30%) of curriculum time. Seven periods (17.5%) were devoted to each A level science.

From the start of my teaching at the school, therefore, I was expected to teach all branches of science (chemistry, physics and biology) to classes in the first three years of the school and took this to be normal for a science teacher. We had teachers' guides for all courses except A level Physics, not just text books and syllabuses. Beta Schofield, in collaboration with other colleagues, had written teachers guides for the science courses for the first three years, so that all classes had the same programme and teachers had support outside their main specialism. Increasingly resources such as worksheets and other printed material were shared and filed centrally. The Nuffield O Level Physics teachers' guides were one of the most important resources to me at the time; long winded but with invaluable information about 'If I were teaching this, this is how I would explain it...' throughout the text.

Trials teacher for Nuffield Secondary Science, 1966/8

In 1966 the school became a trials school for Nuffield Secondary Science (NSS) and I, and one other teacher, became trials teachers. Draft material was trialled with a 'social education' group and a group leaving at age 15. As a trials teacher I attended regular conferences run by the project, allowing not only feedback from the teaching and discussion with other teachers, but opportunities to learn new science. I began to learn about such things as geology, animal husbandry, the science of musical instruments, and electronics. In teaching this course, I was expected to be teaching outside my specialism to the 14-16 age range - but not to the 'top sets' where I continued to teach just physics. The school leaving age was still only 15 but most pupils in these trial groups stayed until 16, and expected to take some examination. We wrote our own mode 3 CSE (Certificate of Secondary Education) science examinations to match the NSS course. The school, subsequently, became a member of a London consortium which wrote a mode 3 syllabus based on NSS. I believe it was in the context of Nuffield Secondary Science that I first became aware of the phrase 'integrated science'.

In the academic year 1969/70 I remember a meeting at the school where a speaker was advocating Integrated Humanities for the first year at the school. There was considerable interest, but a word of caution was provided by the head of modern languages, who commented that she was happy to teach other subjects providing someone would supply a teacher to teach French in her place. I had left the school before any decision was made.

Institute of Education, 1970 to present

Integrated science department established in teacher education

The NSS project involved people from university departments of education, one of whom was Dr Julia Clarke, from the Institute of Education in London. Part of her work at the Institute was to run general science course for science graduates training to be secondary specialist science teachers. In 1968/9 she had persuaded the management of the Institute of the need for a separate department for training of science graduates to teach the new emerging integrated science courses and such a department of integrated science started with its own group of students in 1969/70. Dr Clarke was a biologist and sought a physical science person to take a temporary post in the department. I filled that temporary post in January 1970, initially on a part time basis so that I could complete the courses for the 'examination classes' at the school. The department became its own empire, recruiting its own staff, having its own facilities, resources and technician, and competing with colleagues in the specialist physical sciences (physics and chemistry) and biological science departments for the recruitment of students. The three departments were located in different areas of the building representing the fact that science had been represented initially by just chemistry and physics, and that biology was added later and integrated science later still.

I therefore, after five years teaching science and physics in a comprehensive school, took on the job of initial teacher education, only too aware that my own professional training had come through school teaching experience and through the inservice education of 'shredding meetings' for Nuffield Physics Questions and involvement in Nuffield Secondary Science. As a graduate at the time, I was 'allowed' to enter the teaching profession without professional training. In 1972 I took the professional qualification (Post Graduate Certificate of Education, PGCE) as an external student.

Professional associations for tutors in science education

Three separate professional associations existed at the time for tutors in departments of education in universities, ADEPT, ABET and AUCET (Association of Department of Education Physics Tutors, Association of Biology Education Tutors, and, Association of University Chemistry Education Tutors, respectively). It did not occur to me that these had only been set up a for short time, and that their designation could be queried. I merely commented that I did not seem to fit in any of them, but as I had a physics degree I received the papers for ADEPT's annual meeting. Neither did I think to comment that membership was restricted to teacher training in the universities. By 1971 the three associations had agreed to meet at the same time and in the same place for their annual meetings and to have some sessions in common. They eventually became a single association, ASET, with membership open to all universities, polytechnics and colleges of education.

Justifying integrated science

Justification of integrated science as something sufficiently different and distinct in character to warrant a new department, was necessary. I usually gave a talk to all science students about the aims and structures of new courses in schools, and the ways in which they differed from what had gone before. I have not retained lecture notes from that time, but did retain one paper which I wrote for the students in 1973 titled the 'Philosophy of Integrated Science'. I have to admit that the task was not easy, and I enlisted the help of my husband who was involved in developing science courses in adult education and the liberal studies movement in polytechnics. Some of the arguments for a scientifically literate population and for liberally educated, rather than narrowly vocationally trained, engineers and technicians, were similar to those found in advocacy of integrated science. There was not a coherent single argument that could be drawn on: more a cluster of different considerations, philosophical, pragmatic and social, and I think it was here that my difficulties lay.

Integrated Science for the 11-14 age range

I did not at the time think of integrated science as a label I would automatically attach to the courses for 11-13 year olds published from the late 1960s onwards. One of the first, *Nuffield Combined Science*, (1970) was constructed as a series of topics constructed from material drawn from the separate O level science courses. It was planned as an adequate base for the later separate science courses and could be used over a wider ability range than the original O levels. The expectation was that one teacher would teach the course, just as one teacher had taught the general science course at my grammar school and science teachers had taught the whole of the science courses at the comprehensive school. The publication, *Scottish Integrated Science*, a course for 12-14 year olds, based on the Scottish Curriculum Paper 7 (Scottish Education Department, 1969), did carry the phrase 'integrated science' in the title, because the curriculum paper itself referred to it. The organisation of the material, however, was probably better described as a series of discrete topics.

I believe that one of the reasons why I did not automatically think of the courses for the 11-13 year olds as part of integrated science, was that I rarely had to argue about these. An increasing number of schools had combined science courses of one sort or another taught by one teacher and this pattern was accepted as normal. Arguments became more acrimonious in discussion of courses for third year onwards when certification at age 16 was approaching, particularly for GCE O level. I think this is why the development of the Schools Council Integrated Science Project, SCISP, which started in 1969 was so significant. Success in the course conferred *two* GCE certificates, not one as with General Science, and with the unfamiliar titles 'Integrated Science - Principles' and 'Integrated Science - Applications'.

Integrated Science - an International Phenomenon

Interest in integration in school science was international. UNESCO ran five annual conferences on integrated science from 1970 to 1978 in their series on New Trends in

Science Education (Richmond, 1971, 1973, 1974; Cohen, 1977, Reay, 1978). Integrated science courses emerged in other countries, but many of them focused on courses for the start of secondary school and for primary. Several had similarities with the Scottish Integrated Science Course, where members of the Scottish writing team had been involved as consultants. Discussions at the conferences focused on the meaning of 'integration' and principles which could guide the construction of integrated science courses. A sixth conference, in 1988, reviewed the previous decade of integrated science, and showed a marked increase in the articles about primary science (Chisman, 1990).

Involvement in the after-care system for the Schools Council Integrated Science Project (SCISP), 1975-1990

Closer involvement with developments in integrated science in schools occurred in 1975, when I took the opportunity to become an area co-ordinator for the support programme of SCISP for schools in south London (a small job, typical of outside work taken on by people in university faculties of education). I was keen to have a model of an 'academic' integrated science course to discuss with student teachers. My support role extended to the related examination process and to standardisation and moderation of the teacher assessed component. The support systems associated with SCISP originally included annual week-long inservice conferences, one of which I ran in 1976, but by 1978 these ceased for lack of recruitment. What I did retain for a few years were inservice courses on geology, organising weekend geology trips and lectures for science teachers for whom this subject was new. Project funding came to an end in 1984. Support was reduced to running the standardisation meetings, financed through the examination board. During the time I was involved with SCISP, there were two issues which dominated the biennial meetings of area co-ordinators: the acceptability of SCISP certification to Universities, post-16 Education establishments and Employment; and the need for related CSE courses many of which were being written by teachers in schools. The project devoted considerable time to both.

CESIS, Curriculum and Examination System in Integrated Science - more 16+ preparations

Another involvement with Integrated Science came through a project with the acronym CESIS (Curriculum and Examination System in Integrated Science). Beta Schofield, who had by this time moved to the Chelsea Centre for Science Education, was appointed, from 1974 - 1978, to design a common examining system for SCISP and NSS at 16+ in anticipation of changes in the examining system. She decided that she could not do this without designing a joint curriculum as well and this was the start of CESIS . She developed over the next few years a set of co-ordinated units that would allow for the whole ability range in the 14-16 age group to study integrated science. I wrote and edited several of the units (Frost, 1979).

Conference on Science in Schools - Which Way now?

In the summer of 1977 two colleagues ran a one-day conference for science teachers and science educators to discuss the recent HMI survey of secondary school science (HMI, 1977, January). The conference, which was part of the much wider debate (the so-called *Great Debate*) about what the curriculum in general education should be, addressed the future pattern and emphasis of science education given the diversity which existed, particularly in the fourth and fifth year. This diversity had been well documented in the report, the authors pointing out that science occurred almost entirely within the option systems and in some schools as many as 9 science courses were on offer (HMI, 1977, p4).

The conference initiated two things of significance for this brief history. The first was the publication of *Science in Schools - Which Way Now?* (Ingle and Jennings, 1981). Included in this was a suggested 'core' for science education for all. My colleagues had asked me to write the physics section of the core, which I found impossible, on the grounds that any particular facts did not seem to me to be essential without some context and overall pattern. In the end someone else wrote the physics part and I submitted a more general summary of what science courses should achieve, (Frost, 1981, pp 97-99).

Case Study of a school in transition

The second outcome of the conference was the identification of a school, Duckworth, which was about to rationalise its science courses over the following two years and which was prepared to allow me to monitor the changes. This is the school became the focus of the case study described in chapter 5. It was a SCISP schools within my area, so I was acquainted with some of the teachers. This is essentially where the research began. I was hunting for a definition of integrated science which I hoped would emerge from the pragmatic engagement of teachers with the curriculum, rather than from a pencil and paper design from curriculum planners outside schools.

Articulation of a 'consensus' model for science education in secondary schools

In their 1979 report on science education, HMI articulated a possible model for the way forward: the adoption of a 'balanced' course of science education (balanced between the separate disciplines of science; balanced between content and process; and containing a range of contexts reflecting the interactions of science, society and technology). They avoided 'taking sides' on the issue of integration of the sciences, first by using the somewhat neutral word 'balanced' and by maintaining that there was a number of ways to construct courses within their guidelines. They focused on the technical issue of the time needed for science, suggesting that science should occupy 20% of the timetable (and no more) in years 4 & 5, 10% in years 1 & 2 and 15% in year 3. No-one should be allowed to drop science until the school leaving age of 16. They were presumably aware of the potentially controversial nature of their proposal by the tentative language of 'seem to be a satisfactory...' in:

> ...schools more commonly expected intending scientists to devote 4 (sometimes 5) periods a week to each of the three separate sciences. Yet 8, rather than 12 or more out of 40 would seem to be a satisfactory proportion of the timetable for this area of the curriculum (DES, 1979, p40).

It would be wrong to regard this as a consensus across the science teaching community, but it provided a framework, which would eliminate some of the decisions schools had hitherto had to make. For many schools a change to 20% of timetable time to be spent on science for all pupils throughout the 11-16 age range meant an increase in the number of hours devoted to science teaching and hence an increase to staffing in science departments. Concern about an adequate supply of science teachers had already prompted DES to fund conversion courses for teachers of other subjects and we ran one from 1977-1979.

Pressure for science in primary schools - development of inservice courses for primary teachers - 4/84 funding

The 1970s also saw a rise in the development of science in primary schools. When the PGCE primary course started at the Institute in 1983, science was an optional subject and for several years I ran the science component. HMI reported in their 1978 survey on primary education the generally better performance in schools which included science in the curriculum. Pressure for science in primary schools increased (DES, 1978). We developed an inservice diploma in Primary Science which began in 1983. To a large extent the development of primary science is only marginally part of the Integrated Science Story, but its increase over the next decade, its inclusion in the National Curriculum as a 'core' subject alongside English and Mathematics, meant that it had implications for the secondary curriculum.

When government designated money for specific inservice needs under, first, The In-Service Teacher Training Grants Scheme (DES circulars 4/84, 3/85) and second, the Local Education Authority Training Grants Scheme (DES circular, 1/86), it targeted primary science as an area of priority and sought help from institutions (including the

Institute) to run 35 day courses for primary teachers and I took a major responsibility for this from 1984 onwards. After a few years these were reduced to 20 day courses. The 1990s showed a waning in inservice primary science work not only in the Institute, but in the country as a whole, as funds and time were devoted to inservice for literacy and numeracy. We ceased to run the primary science inservice courses in 1998/9.

Courses for head of science - management of science departments- 4/84 funding
Another area designated for GEST funding was management of science departments, in recognition that changes in the science curriculum would not be easy to manage. Providers were sought for such courses and one of my colleagues ran a 35 day course for heads, or potential heads of science departments from 1984 - 8.

Climate of collaboration - and consensus building - SSCR and 4/84 course providers
I experienced the early 1980s as a period in which collaboration, involvement and discussion were key elements. Vic Green as chief inspector for science played an important role in organising annual conferences for providers of 4/84 courses. We were able to discuss issues and progress with other providers across the country.

The Secondary Science Curriculum Review (SSCR) with its regional committees sought to involve as many teachers as possible in the implementation of the ASE's policy for science education (ASE, 1981). It adopted a 'periphery to centre' model as opposed to the centre to periphery model of the 1960s curriculum development. This added to the sense of a joint enterprise and the 'right' of science teachers to be involved in the shaping of national policy. The reports from the regions, the regular newsletters of SSCR, and the final set of publications *Better Science* (1987) provide a useful insight into the implications of a 20% timetable of science for all up to 16.

Policy document science 5-16
The first policy document from DES on science education was published in 1985 (DES/WO, 1985). The 20% timetable time for science and the requirement for balanced science courses for all began increasingly to look like a directive rather than an option. There was still an element of leaving 'options open' for schools to decide how they organised their science courses but implications for those who still retained marked independence of the three separate sciences were expressed as follows:

> 81. But the aims of this paper imply more radical changes for pupils of all abilities than simply pruning the content of existing physics, chemistry and biology courses to provide more room for investigative, applied and problem solving aspects and then continuing to teach those subjects in

> isolation from each other. Those schools which do continue to teach separate subjects will need to arrange much closer collaboration between the teachers of these subjects than is commonly found at present, to secure more orderly progression in the acquisition of knowledge and skills across the spectrum of science and to avoid unnecessary repetition or gaps. The reforms now needed require science departments to be united in philosophy and method. (DES/WO, 1985, p22).

Undoubtedly this document, along with previous HMI documents were highly supportive of SCISP as they advocated an organisation into which it readily fitted. Probably only too aware of the possibility of renewing old arguments about the virtues or otherwise of integrated science, Paul Black chose the occasion of his presidential lecture to the ASE annual conference in 1986 to address the issue of 'Integrated or Co-ordinated?' (Black, 1986) in considering the implications of the 1985 policy document. He highlighted the epistemological problems with many of the claims of integration and indicated the virtues of a co-ordinated course under the umbrella title of 'science'.

GCSE introduction

GCSE was finally introduced in 1986, first to be examined in 1988. A survey of GCSE provision by the ASE published under the simple title of *Three into Two*, (ASE, 1987), showed that all boards had some form of double science courses available, alongside the separate sciences. Many were based on co-ordinated science programmes, with the board which had originally examined SCISP (The Associated Examining Board, AEB) providing an integrated science course. The divergence between different syllabuses began to diminish with the development of national criteria for first, the separate sciences (DES, 1985 b) and then, for science (DES, 1985c).

The Introduction of the National Curriculum

The following ten years (1986-1996) saw the introduction and implementation of the National Curriculum in Science. This part of the history is left to Chapter 6. The term 'integrated science' slowly disappeared. It was retained as the title of examination papers until 1994 for the Southern Examining Group (the examining group which subsumed AEB in the reorganisation of examining boards in 1986 with the introduction of GCSE). The National Curriculum left individual schools to decide how to organise schemes of work, as they thought fit, providing they included all elements of the National Curriculum.

How had these changes been reflected in the organisation and work of the science departments at the Institute?

The separateness of the departments (Integrated, Biological and Physical sciences) at the Institute of Education was slowly eroded and all were subsumed under one heading of 'Science'. This was facilitated by a move to a new building in 1976 where laboratory facilities and tutors' rooms were together, whereas in the old building they had been scattered at different places, and this had inhibited collaboration. There was successive and increased co-ordination of the initial teacher education programme for different science students and while we still, in 1998, recruit potential teachers under the headings of chemistry, physics, biology and 'science', the initial teacher education course is under one organisation and has been since the mid 1980s. As early as 1978 we had established a significant component of the courses which was taught in common and which addressed the need for teachers to be able to teach across the sciences at KS3. At the present time (1999), the retirement or resignation of other physics tutors, has left me, by default, as the only physics specialist and responsible for the physics component.

Summary

'Integrated Science' emerged in the 1960s in relation to specific curriculum projects and as the title of a post to which I was appointed. It was regarded as an entity in its own right, about which people argued, seeing it as the solution (or not) to questions about what science education should be. It could be found in the titles of a few GCSE syllabuses as late as the early 1990s but did not appear in National Curriculum documentation, and had faded almost entirely from science education by 1996.

When I started teaching, there was considerable euphoria about the transformations that integrated science courses would occasion. This was probably part of the wider sense of renewal which the large scale, well funded, curriculum developments of the 1960s promised. In this research, however, I have tried to single out the integrated science story, to understand its emergence, its implementation and its apparent disappearance.

The ways in which I undertook the research form an eclectic mixture. I have drawn on case studies of three different schools which were implementing integrated science courses in the late 1970s, the main one being Duckworth School. I returned to conduct further case studies on two of the schools in 1996. The experience of implementation of SCISP in the aftercare system has also contributed to the research. Finally I have gone to literature concerning: the history of the education system and science education; studies in changes in science education; commentaries on integration in education; research on implementation of integrated science; and documents related to the development of a national curriculum with science as one of the core subjects. How the research was undertaken is the subject of chapter 2.

CHAPTER 2

THE STUDY AND RESEARCH METHODS

a. The Approach to the Research

The research questions:

- What was integrated science?
- Whatever integrated science was, what happened to it and why?

were formulated late in the research.

The research began late in 1977 with the opportunity to follow the development of integrated science courses at Duckworth school (see Chapter 1). The staff of the science department had already made the decision to implement science for all students up to the age of 16 by providing appropriate integrated science courses and abandoning all other science courses. Planning the new courses which were to start in September 1978 and be examined for GCE and CSE for the first time in 1980, had already begun. I requested permission to follow the development; this was granted and hence the research began. It focused almost entirely on the 14-16 age range as this was where the changes were being made. At the time I paid little attention to the 11-13 and the 13-14 science courses, even though these were, broadly speaking, 'integrated science'.

My initial interest was in the nature of the science curriculum which would emerge during this development. I hoped to find answers to questions such as: "How would the teachers interpret 'integrated science?'" and "Was their interpretation one which could be used by others?". Early observations, however, drew attention to the processes the staff went through in the transition to the new courses and I began to collect information on the ramifications of the curriculum change for other aspects of the life in the science department. What started, therefore, with a question about the nature of integrated science, provided information about the way the change to integrated science interacted with the context in which it operated and how it affected that context. The process of curriculum change remained the focus of the research for some time and hence drove the collection of data.

In order to validate the findings at Duckworth, I studied two other schools, Timburn and Sixford in 1979/80. These two schools had already implemented integrated science courses for all students up to the age of 16. I studied the nature of the courses, the way in which the teaching was organised, and how the departmental structure was designed to support the course arrangements.

There were other sources of information about change to integrated science courses in the 14-16 age range and its interrelationship with context, which linked with the research in the three schools. The 'aftercare' programme of the Schools Council Integrated Science Project was one such source. My work in the programme gave me intermittent contact with, and information about, twenty schools in the south London area using SCISP. The twice yearly meetings with other area co-ordinators gave access to information from similar schools across the country. Another source was the Secondary Science Curriculum Review, set up to support the implementation of 'science for all' up to the end of compulsory schooling, based on the ASE (1981) policy document. While the brief of the SSCR was not directly to implement 'integrated science' there was sufficient overlap in the issues that schools were facing with those tackled by Duckworth that its work was relevant.

The research, however, laid fallow for several years and when I returned to it in 1995, there was a need to bring it up to date. I returned to Duckworth to find out what changes had taken place and also to Timburn. By this time GCSE had been introduced as a common examination system for all at 16 and the national curriculum was in place. There was much more central control of education than there had been in the 1970s. The heads of science of the two schools provided considerable information about changes, many of which concerned the need to respond to directives from outside. I began therefore to develop a new theme for the research which focused on the changing autonomy of science teachers in matters of curriculum design and examination, between the two sets of case studies. This focus for a while made a lot of sense, especially as the early case studies were done when school based curriculum development was becoming a dominant mechanism of curriculum change, and there was a lot of interest in how it operated. It proved however too far from the original foci to draw the work together.

Eventually a retrospective view of the 'integrated science' movement was taken as the focus research. This required a slightly different approach. The case studies had to be put into a wider perspective. This was done in several ways. First the time span considered was increased, so that the case studies became part of a longer story. Second, the contexts of the contemporary school and examination systems were taken into account, because these and the changes in them, may have had a considerable effect on the shape and form that integrated science courses took. Third, Bernstein's commentary on the implications of integration in the curriculum generally was used to interpret events in the integrated science story. Fourth, other evaluations of integrated science curricula and their implementation were used to extend the findings of the case studies. Fifth, the original case studies focused on the 14-16 age range; the final thesis addresses the whole of the 11-16 age range and gives some attention to the developments in science education in primary schools.

I therefore answered 'What was integrated science?' by considering a range of related questions about the contexts in which it emerged, what it was supposed to replace, how it was conceptualised at first, how people talked about it, how it manifested itself in courses in schools, what it was expected to achieve that existing science courses could not.

I answered: 'Whatever integrated science was, what happened to it and why?' through such questions as: What happened to curriculum materials when they went into schools? How was the teaching organised and who taught the courses? Where and to whom was it taught? What were the constraints on implementing integrated science? What were teachers' attitudes to it? To what extent had the 'predictions' of Bernstein about integrated curricula, manifested themselves in the case of integrated science; how had these impacted on its success of otherwise? Was it only the name that had vanished? Had some of the ideas associated with it in the 1960s survived? If so, which ones and where?

b. Research Methods for the case studies of schools

The initial study of Duckworth school took place over two to three years. I set out just to observe and interpret events in the science department at the school, with the hope of having little effect on what happened. My role was close to that of a non-participant observer although my position within the aftercare system of SCISP encouraged participants to use me as an adviser or at minimum as a sounding board for ideas. My main method of working was to record observations, to write fuller accounts from these records and then to use these accounts to identify significant issues which I then explored in more detail.

This approach was described by Cohen and Manion as follows:-

> The purpose of such observations is to probe and to analyse intensively the multifarious phenomena that constitute the life cycle of the unit with a view to establishing generalisations about the wider population to which the unit belongs.
>
> (Cohen and Manion 1985, p 131).

My attempt to generalise the findings from Duckworth School was done by studying two other schools which were not dissimilar. The three schools were mixed comprehensive schools; they all had some form of core curriculum for 4th and 5th year pupils in which science was a component; the three science departments were committed to providing only integrated science courses for 4th and 5th year pupils; they used SCISP as the basis of the O level course entering candidates for the Associated Examining Board (AEB) examination; they wrote mode 3 CSE courses to run parallel with the O level SCISP course. They had all had links with trials of SCISP: Duckworth School had been a phase 1 trial school in 1972; subsequently two members of the science staff moved to Sixford School when it opened and a third to Timburn School, eventually to become head of the science department.

There were, however, differences in events which had led to development of integrated science courses in each school. Duckworth school had responded to, amongst other things, the effect of falling rolls; Timburn had experienced a 'crisis' in the whole curriculum not only in science; and Sixford, being a new school had developed integrated science courses from the start, as part of a coherent curriculum plan for the whole school.

The study at Duckworth school was the most extensive and was conducted *during* the development of new integrated science courses for the 4th and 5th year students. The case studies at Timburn and Duckworth, on the other hand, were conducted over a sixth month period, *after* integrated science courses for 4th and 5th year students had been implemented. The study at Duckworth was almost complete before the other two studies started.

Negotiating access to schools for 1977/80 case studies and dates of visits

Negotiations were relatively informal. I consulted the heads of the science departments in the three schools, and sought permission to be in the schools for the purpose of research from the respective head teachers; this was granted. Nothing was put in writing and none of the head teachers asked to discuss the purpose and methods of the research nor the implications for the school before I started. I did subsequently meet head teachers as part of my work.

In addition at a science department meeting in December 1977 at Duckworth School I explained that I wanted to follow changes as new courses were developed; that I would write interim reports for staff to comment on; that individuals would be consulted before anything which might be confidential was included and that staff could veto any sections. I assured the department that articles about the school would not appear in publications such as the Times Educational Supplement without consultation. These oral assurances were the basis of the relationship between myself, as a researcher, and the staff. Similar assurances were given to heads of department at the other two schools but not to the whole department.

During the study at Ducworth I established patterns of working which were later used at the other schools, so the Duckworth study is reported separately first below. The dates of visits made to each school are given in figure 2.1.

The type of setting: Duckworth School, 1977-80

I was allowed to wander around the science department; to sit in preparation rooms and observe the general life of people as they came in and out; to waylay staff in corridors and laboratories, providing that I did not prevent them from being in lessons on time and that I did not interrupt other work. I always asked whether staff had time before engaging in a conversation or an interview. When staff were busy they often indicated times later in the day when they would be available.

One preparation room served as a tea and coffee room at morning break and at the end of the school day so it was relatively easy to find everyone there. Science staff used the main staff room before morning registration and at lunch time, in order to reduce isolation from the rest of the school. I talked with them there and occasionally met teachers of other subjects. Nevertheless many teachers were unaware that research was being done in the school.

Figure 2.1 Dates of visits for 1977/80 case studies

DUCKWORTH			
28	9	1977	half day meeting with head of science
14	12	1977	sc. dept. meeting 16.00 -18.00
18	1	1978	sc. dept. meeting 16.00 - 17.05
6	2	1978	all day visit + after school meeting of course planning group
18	4	1978	sc. dept. meeting 16.00 - 17.30 - first short account given
9	5	1978	day visit with PGCE students
11	12	1978	all day
25	6	1979	all day
21	11	1979	all day
17	12	1979	all day
10	3	1980	half day
21	4	1980	1st day of term; all day + after school meeting on assessment
22	4	1980	all day; two lessons observed
24	4	1980	most of day; assessments and lessons observed
25	4	1980	all day - long account (40 pages) given to staff
1	5	1980	3 hours in the morning
6	5	1980	2 hours in morning
14	5	1980	mid morning to the end of school
9	6	1980	1 hour visit
19	6	1980	all day
25	7	1980	afternoon
TIMBURN			
13	6	1980	all day
18	6	1980	report delivered to school
29	10	1980	all day; school's half term (annotated reports returned)
May 1981 and May 1982			all day visits with PGCE students
SIXFORD			
4	9	1980	meeting with head of science
26	9	1980	all day;
October 1980/2/3;			visits with PGCE students
early 1983;			supervision of PGCE student

I never presumed to visit lessons without prior invitation and only did so on a few occasions at the end of the study. On several occasions staff invited me to teach classes 'to find out how it is going for yourself'. I did not accept. I never arrived unannounced. Permission to visit on a particular day was sought either in writing or by telephone from the head of the science department, or was agreed on the previous visit. This setting determined to a large extent the way observations were made and the types of interview undertaken.

Talking with the staff: conversations and interviews: Duckworth School, 1977-80

Exchanges with teachers and technicians were often informal and unstructured, but as they contributed, or had the potential to contribute to research data they are better classified as interviews. Throughout exchanges I had a research focus and hence my questions probed aspects which were relevant to the research.

In some interviews questions were open and designed to encourage respondents to talk about what had been happening in the school. Examples of such questions were: 'How are things going?' 'Has anything new happened since I was last in the school?'. In these interviews questions were deepened as particular events were reported in order to elicit further details of the events, to find out how the events affected the respondent or to find out the respondent's attitude to them.

Other interviews were semi-structured. In these, questions were more specific and had been prepared prior to the visit. Some of these questions followed up particular issues, e.g. 'Have you resolved the problem that arose when some pupils chose an inappropriate course?', 'How are funds for the greenhouse coming along?'. Other questions were suggested by analysis of data, e.g. 'Everyone except you and two other members of staff have talked of the problem of their new role in the department; had you noticed this; can you think why it is?'. Later in the research, as staff could put events into some sort of perspective, the science teachers and technicians were questioned more systematically:- 'Now that the dust has settled, how has the curriculum change affected you and your job?'.

There was a third type of exchange which occurred. I found that before long some members of staff seemed to seek me out deliberately to make sure that I heard their side of the story. Others rarely spoke unless I asked to talk with them. There were probably a range of reasons for these behaviours, such as people believing they had nothing of value to add. But whatever the reasons I soon realised the necessity of finding questions for all members of staff, and systematically talking to everyone.

'In-house' written material: Duckworth School, 1977-80

Staff made available relevant documents produced within the department. These included short discussion papers written for staff meetings, reports of meetings, summaries of decisions taken, and papers relating to teaching and assessment of the new courses. Some of these were in the form of charts and instructions pinned on a central notice board. Analysis of these provided more information on the effects of the change. They are listed in the references.

Using a questionnaire: Duckworth School, 1977-80

On one occasion a questionnaire, figure 2.2, was used to collect information about the effects of change on teaching staff. This proved particularly useful especially as completed papers were collected personally rather than received by post, when staff added information orally. One teacher who had not previously completed it, did so while I was present. He gave much more information orally than he wrote on paper.

The findings were summarised in an interim report and circulated to staff in April 1978. Nothing had seemed particularly contentious but one person reminded me of my agreement to check before statements were made public. The person concerned reported that he would have 'worded it differently', in the circumstances.

Making notes: Duckworth School, 1977-80

Staff became accustomed to my taking notes. Sometimes brief notes were made during conversations but more often immediately afterwards. For instance notes of discussions with a teacher during break were often made shortly afterwards when the teacher went to take a class. Opportunities to write in isolation were important. They enabled me to digest information and generate more questions while on site thus saving time and reducing the need to return to the same point at a later visit. I did not use tape recorders for interviews, but did use one to record impressions of the day during the journey home. Within a week, preferably the same night, I typed up notes as fully as possible.

These three activities, writing notes immediately in odd quiet times, recording impressions on the way home and writing a fuller account within a few days helped to bring to conscious level events observed but not seen to be significant at the time. Odd comments and occurrences sometimes took on a possible new meaning to be checked during a following meeting. The writing became the main source of questions for the next phase.

Figure 2.2 Questionnaire to all science teachers at Duckworth School, 1979

Questionnaire about involvement in teaching and writing, Duckworth

A. What courses have you taught (other than new I.S. courses in yr. 4&5)?

Level	Subject	no of years
A-level	______________	______
6th form gen. studies	______________	______
O level	______________	______
CSE	______________	______
5th yr. gen. course	______________	______
3rd yr. IS	______________	______
2nd yr. GS	______________	______
1st yr. GS	______________	______
other	______________	______

B. What teaching have you done in the new 4th and 5th yr. courses?

	Double science		Single science	
	4th yr. 78/9, 79/80	5th yr. 78/9, 79/80	4th yr. 78/9, 79/80	5th yr. 78/9, 79/80
Top stream				
Middle stream				
Bottom stream				

C. Before you became involved in writing units for either the single or the double science course, what experience had you of curriculum innovation? (e.g.. had you written other courses? written examinations or tests for colleagues? written worksheets for others etc.?)

D.(i) Did you find parts of the processes of developing a new course particularly difficult? (e.g.. writing lessons for others, finding suitable resources, writing tests that matched objectives). Please specify.

(ii) Did you find that you were particularly good at some of the processes involved in creating the new course? Please specify.

(iii) What skills did you develop during the development of the new courses?

(iv) If you feel you learnt new skills have you any idea how you learnt them? Are you conscious of having learnt them from anyone in particular. Please be as specific as possible.

E. What interests or skills do you have which have been useful in the science department but which are slightly outside academic science. (e.g. hobby activities, photography, gardening, car maintenance, philosophy of science, first aid etc.)

F. What responsibilities and tasks do you have in other parts of the school?

G How do other members of staff know you?! (e.g. just another member of the science department, or also as a form teacher, drama enthusiast, exams expert, games enthusiast, the man who keeps the chickens, youth wing leader etc.)

H. If you left the school what activities might stop altogether - or which of your skills is not shared by anyone else?

After a while notes began to read like an on-going account, or a serial, where I attempted to pick up the story where it had been left on the previous occasion. At times the case study had similarities with dreaming. In dreams events appear plausible but coherence vanishes if they are related to others. Dreams do not form a smooth narrative. Neither does life; but in life people usually have reasons for their behaviours. When I found the 'story' revealed unexplained actions and decisions I could return and enquire, often finding some antecedent that nobody had thought necessary to mention.

> At the end of the day he comes home with a wealth of information on a variety of points, but nothing conclusive on any one point. Over the weeks and months his evidence on a given point gradually accumulates and the various points start to fit together into a tentative pattern.
>
> (Deising, quoted in Cohen and Manion, 1985, p 131)

Seeking significant issues in the account: Duckworth 1977-80

The accounts were searched for significant features related to the curriculum change. These were things that the staff had talked about and seemed concerned about on several occasions, or things which I thought were important. These are discussed fully in chapter 5 but the following are examples:-

- Staff members attached importance to their roles, such as 'heads of chemistry, physics and biology' both within the department and school. Areas of authority and responsibility were discussed frequently and passionately as the separate science courses were removed from the 14-16 curriculum, revealing close links between departmental structure and courses taught.

- The curriculum change involved collaboration and negotiation. Many staff meetings were held but formal meetings soon gave way to informal channels of communication. This saved time, but some people were be left out of discussions.

- Planning, managing and implementing the changes involved hard work. As one member of staff said 'It is one thing to have ideas, it is another to have them down on paper in a form that everyone can understand.' The health, stamina and patience of staff were at a premium. Tensions arose amongst staff who had previously get on well together.

- The 'hardware' of the department was organised to match the previous science courses. When the courses changed, resources had to be rearranged.

- Costly resources developed for previous courses were under-used in new courses. Discussions about scrapping them were particularly distressing to those who had created them in the first place.

- Initially when staff decided to make changes there was sufficient expertise amongst them. Worries appeared however when key people left, especially if there had not been a way of passing on expertise to another member of the team.

- A new structure of the science department emerged with hierarchies less tied to separate subjects and more to roles concerned with co-ordination.

Writing accounts for the staff: Duckworth School 1977-80

In order to inform all concerned and to check the internal validity of observations 'accounts of accounts' were compiled. Reports of field notes were written into an account of events against a developing analytical background. For example the status and position of staff within the science department seemed to be significant and hence observations of events were interpreted in terms of this issue. Inevitably once these issues had been formulated they affected later observations.

The first short account was given to teaching staff in April 1978. The second long (40 page) report of findings was given to teachers and technicians for critical comment two years later in April 1980. Although an attempt had been made in interviews to use open-ended questions, the selection, collection and interpretation of data had been comparatively subjective and I had hoped that when people had the report they would correct misinformation or make alternative interpretations.

The short document produced considerable feedback, mainly factual, such as corrections about:- courses, numbers in the school, finances, teaching arrangements. The longer account produced less. Many people wrote nothing, merely commenting: 'I found it very interesting'. They did not feel in a position to add to what had been written. Many were intrigued to read an account of their daily lives but treated the document as 'for information only'. Only one member of staff looked at it through the eyes of a researcher and added to the list of significant issues. This is consistent with what others have found; teachers do not spontaneously adopt a research role. (Rudduck, 1982)

Generality: external validity: Case studies at Timburn and Sixford schools: 1980

To check whether the findings were specific to Duckworth school, I set out to find whether the 'significant features' occurred in two other schools, Timburn and Sixford. The types of settings in which I worked were similar. I was allowed to wander around the science departments and talk with staff as appropriate. I wrote accounts for the staff and again found that most people did not add much except correction of detail.

There were, however, two important differences between the first study and these two. The first difference was that the focus of the research had already been determined at Duckworth school. Hence I started with a long list of questions I wished to ask and information I wanted to collect. I therefore quickly collected information on such things as departmental structure, organisation of courses, distribution of teaching, constraints of the building, storage of written material, and use of technicians. The second difference was that the implementation of integrated science courses had taken place prior to the research and I had to rely on people's memories to collect relevant information about the development phase.

Studies at Duckworth and Timburn Schools in 1996

In 1996, I returned to two of the three schools, for relatively short periods of time to talk with the heads of the science departments about changes since my visit. There had, of course, been a large turn-over of staff since 1980 and only one or two of the original teachers and technicians were still there.

I approached all three schools more formally than before by letter to the head of science with a copy to the headteacher (see appendix 1, A1.1). I had a positive response fairly quickly from Timburn, and made the first appointment by telephone. In the cases of Duckworth and Sixford, after a suitable delay and no reply, I rang the respective heads of department. In both cases they had cleared the research with their colleagues but had not yet contacted me. I made appointments to go to both schools. A few days before the meeting at Sixford, the head of science had to cancel the appointment because of other priorities which were more pressing. We agreed to leave it to the start of the new term to make contact again, by which time, I was convinced that a further specific case study would not reveal significant new information, so I did not pursue the Sixford data. (I subsequently therefore summarised the 1980 account of Sixford, which had originally been written in the same detail as Timburn, in order to bring out essential similarities and differences between it and the other two schools.)

I sent, in advance of my meetings, the accounts relating to the schools in 1980 which appear in chapter 5 for Duckworth, and in chapter 6 for Timburn. I started with Timburn (see list of summer 1996 visit dates in figure 2.3) and the interview involved the head of department systematically going through the 1980 study and explaining differences. On a second occasion I spoke with both him and the second in the department, and was also lent the departmental handbook which was an invaluable source of information.

From this first set of interviews I realised the list of essential base line information which I needed from the other schools and produced the questionnaire (appendix 1, A1.2) to be used in subsequent interviews at the other schools. I sent this questionnaire in advance to the heads of science at Duckworth and Sixford, but it was only used, of course, at Duckworth.

Figure 2.3 Dates and times of visits to schools in 1996

School visits 1996

Timburn		
18 June 1996	11.45 - 12.45	meeting with Dai Cotton, HoD
24 June 1996	9.00 - 9.45	meeting with Dai Cotton , HoD
	14.00 - 15.30	meeting with Janice Osborn, second in dept.
15 July 1996	9.00 - 10.45	meeting with Dai Cotton, HoD
5 Sept. 1996	16.00- 19.00	meeting with Janice Osborn to discuss draft of study
Duckworth,		
9 July 1996	11.00 - 14.30	meeting with Iola Mason, HoD
3 Sept. 1996	16.30 -	meeting to discuss first draft of case study
11 Sept. 1996	08.00 - 12.15	meeting with Iola Mason, and others
Sixford		
12 July 1996	13.45	meeting with HoD (cancelled)

Over the same period of collecting information for the later case studies, I wrote most of chapter 6 which documents the changes in science education nationally in legislation and policy which had occurred between 1980 and 1996. It was a reminder to me of the dates at which things had happened. The retrospective documentation of the changes made it much easier to ask questions to extract more precise details when I returned to talk with the heads of science, and to 'explain' what I found in the schools.

Using the information Timburn and Duckworth I wrote drafts of the case studies during the summer 1996. These were sent to the respective heads of department for comment and correction. In the case of Timburn, a copy was also sent to the 'second in department'. People wrote on the text of the drafts but I was also able to discuss their comments and corrections with them, at subsequent meetings (see dates above). A summary of the main points from the reports forms chapter 7 of the thesis.

c. Literature reviewed

As the research focus widened the literature base for the research shifted away from texts about curriculum change and school based development. Explanation of the emergence and disappearance of integrated science was sought in the historical and social contexts in which it occurred, as well as in the internal life of schools and science departments. This required a review of: histories of the schooling and examination systems in England contemporary with the introduction of integrated science and accounts of changes in them in the period studied; histories of science education in both primary and secondary schools; contemporary commentaries on events in science education, including surveys of the numbers studying different science courses; government reports on the state of science in the country; accounts of debates on Integrated science; accounts of how curriculum projects were constructed, when they were published and for which age group; evaluations of curriculum projects, the extent of take up, teachers' attitudes towards them, their acceptability by different stakeholders; and commentaries on integration in general. The background to the emergence of integrated science is included in chapter 3. This chapter also contains a brief outline of the general science movement in the first half of the century as general science came across many of the same constraints as integrated science. It ends with an account of predicted implications of curriculum integration (Bernstein, 1971). How integrated science manifested itself in curriculum projects in UK and some evaluation of the implementation of integrated science is given in chapter 4.

d. Interpretation of the data

The interpretation of the data overall was, of course, problematic. I had information about integrated science education spanning almost thirty years from both the national scene and the very local scene of two or three schools. I had to be careful not to allow the intensity of the early case study at Duckworth, and especially the issue of staffing structures which I have drawn out in the second part of chapter 5, to feature too prominently at the expense of other important points.

The interpretation was also problematic because a single concept of integrated science did not emerge. The difficulty was increased by integrated science being seen as the opposite of separate sciences, which I believe was a false dichotomy. In order to find answers to the question 'What was integrated science?' I constructed a list of features which were associated with integrated science. Curriculum projects and critiques of integrated science were the main source of evidence.

'What happened to integrated science?' was answered from a range of evidence: statistics on implementation of projects; implementation reports and evaluations; research from integrated science in use; the school case studies that I undertook and others reported in the literature.

Somewhere towards the end of the 1970s and the mid 1980s, the story of integrated science blurred into the story of 'broad, balanced science', and then into the story of compulsory balanced science for all. I have not taken integrated science and balanced science as synonymous. I have, however, continued to track the features associated with integrated science into the balanced science era and into the national curriculum in science era to identify which features survived and which ones were lost.

The last part was to try to find out reasons for what had happened. I had to explain why the features which emerged did so at that point in time, and why some have survived and why others have disappeared. I made the assumption that there would be many 'causes' and that the level of certainty which I could achieve about the contribution of each one would be strictly limited.

Summary

The final research questions were:

> What was integrated science?
> Whatever it was, what happened to it in the UK and why?

A semi-historical approach has been adopted in answering the questions. Four phases have been identified: namely, the emergence of Integrated Science as an apparent entity and the realisation of this in curriculum projects in the 1960s and early 1970s; the implementation of integrated science courses in secondary schools from the 1960s to early 1990s; the confusion between balanced science and integrated science from the early 1980s, the replacement of both 'balanced' and 'integrated science' by 'double science' from about 1986 and certainly from 1994 and hence the disappearance of the term 'integrated science' by the mid 1990s.

Information was gained from a range of literature as well as from case studies of schools which were implementing integrated science courses throughout the 11-16 age range. The case studies of the schools provided the bulk of the first hand data used in the research and were conducted using illuminative evaluation techniques.

Reasons for the changes were sought in: the ambiguities of the concept of integrated science; the contexts in which it operated; and the curriculum histories which preceded it. Understanding of the effects of, and the constraints on, a change to integrated science were sought in Bernstein's thesis on the classification and framing of educational knowledge (Bernstein, 1971).

CHAPTER 3

CONTEXT OF THE EMERGENCE OF INTEGRATED SCIENCE

This chapter covers three contexts in which integrated science emerged: the changing system of secondary education; the background to the patterns of science education which existed in the 1950s; and the proposals in the early 1960s for renewal of the science curriculum and the expansion of science education to a wider section of the population. Interest in integration and interdisciplinary studies in general increased, with, for example, the integrated day in primary schools, integrated studies courses, integrated humanities and integrated science in parts of secondary schools.

The chapter ends with a summary of Bernstein's thesis on 'integrated' and 'collected' educational codes. Bernstein (1971) argued that the way knowledge is organised, assessed and transmitted in the process of education reflects the distribution of power between different stakeholders and that a change in the organisation of the curriculum, such as in some form of integration, will have an effect on the distribution of power. His thesis will be discussed in the specific context of integrated science.

a. Changing System of Secondary Education

The emergence of integrated science coincided with the transition from a selective system of secondary education to a comprehensive system, intended to broaden the educational opportunities of all pupils. Teachers in comprehensive schools were faced with designing a curriculum which would provide a marriage of the curriculum patterns which had grown up in the separate branches of the selective system i.e. in the grammar, secondary modern and technical high schools, or of devising a new one.

The post war pattern of secondary education and the difference in status between the schools

Grammar Schools

The selective grammar schools admitted about one fifth of the secondary school population, by the 1950s. The minimum school leaving age had been raised in 1947 to 15, but the majority of pupils in grammar schools stayed until 16, taking the School Certificate examinations, and, after 1953, the single subject General Certificate of Education Ordinary level examinations. Prior to 1944 a place at a grammar school could be gained by success in the entrance examination, or by parents paying fees. After 1944 places could be gained only by success in the 11+ examinations.

The grammar school curriculum was based on a series of discrete subjects taught by subject specialists. By the 1950s, up to twelve different subjects were typically taught in the schools. At some point, usually at the age of 14 or 15, choice was necessary; while school certificate remained as a 'group examination' the choice was constrained by examination boards and by university matriculation requirements. Once the group examination was replaced by a single subject examination, choice was constrained, for those aspiring to higher education, by requirements of universities. In practice only one in eight pupils from grammar schools went to university.

Secondary Modern Schools

While the grammar schools of the 1950s had a history which dated back essentially to the mid to late nineteenth century, the post second world war secondary modern schools had a shorter history. Before the war, schooling for the majority of pupils comprised attendance at elementary schools. The minimum leaving age was raised from to 12 to 14 in 1918 and remained at that age until 1947. It was not raised to 16 until 1973. The elementary schools were originally set up as mixed infant schools for children of age 5-7, with separate boys and girls departments for ages 7-14; from 1902, they effectively ran as a *parallel* system of education to the secondary (grammar) schools. The Hadow report of 1926 is taken as the point when secondary schooling was seen as *consecutive* to elementary education. Elementary schools were subsequently reorganised into infant departments (age 5-6) and junior departments for ages 7-11, which together formed 'primary education' and beyond that was 'secondary'. The higher forms of the elementary schools therefore became the secondary schools for about 80 percent of the population. In practice the situation was more complex than this, with a number of local authorities having set up 'central', senior high and senior elementary schools for older pupils not at grammar schools from the turn of the century. The central schools in London took pupils from 11-16. These schools were later referred to as 'modern' schools as they did not teach classics, and they became the forerunners of the secondary modern schools which were created following the 1944 Education Act. Pupils in secondary modern schools could not take school certificate examinations.

Technical high schools

The technical high schools, of which very few were set up, had their origins in a range of pre-war trade schools for 13-15 year olds which had developed for vocational training of pupils when they left elementary school. While the curriculum in some of these trade schools was tightly linked to the skills needed for a particular trade, many gave a more general education with a technical or commercial slant. Nevertheless the technical high schools failed to develop a coherent and consistent image of an appropriate curriculum, which was a genuine 'alternative road' to the grammar schools (McCulloch, Jenkins and Layton, 1985, ch. 4). The curriculum was often close to the curriculum of the grammar schools, with a large number of discrete academic subjects, but with an increase in attention to scientific and technical studies. The number of these schools was small: only about 4% of the school population attended technical high schools in the late 1950s.

The purposes of the different schools

The 1944 Act which had established secondary education for all up to the age of 15 gave no particular recipe for the sorts of schools which would be appropriate; it left local authorities to prepare plans which fitted the area. The earlier Spens report on Secondary Education (Spens, 1938), however, had based many of its arguments on the idea of different types of children with different types of *ingenium*. Its suggestions that different types of schools should be set up for children with 'academic', 'technical' and 'practical' attributes became strongly embedded in educational thinking. It had been reiterated in the 1943 Norwood Report on Secondary Curriculum and Examinations, despite vehement criticism of its having no educational or psychological basis (Rubinstein and Simon, 1973, p28/9).

The Spens report acknowledged the difference in esteem of the schools which existed:

> Unfortunately, in present circumstances other things are not equal. Grammar Schools and Modern schools are administered under different Codes and often different authorities. They have different salary scales, and the required conditions of building and equipment and sizes of classes show differences which are not merely such as are involved in differences of curriculum. These differences, taken as a whole, are such

> as to give the impression that the Grammar School is necessarily better than the Modern School.
>
> (Spens Report, 1938, pxxxv)

While the esteem of the secondary modern schools increased in the period 1950-1960, the majority of parents preferred their children to go to grammar schools, or the technical high schools where they existed.

The emergence of comprehensive schools

The idea of a single secondary school went back to the 1930s and a few LEAs drew up post-1944 plans for developing a system of secondary education based on these lines. London, for instance, prepared its plans for reorganisation with a unified system of a single school, two weeks prior to the publication of the Act.

There was a small number of all ability secondary schools in the 1940s, mainly in rural areas where population densities were low. However, with the development of bilateral and tripartite systems in many local authorities, coupled with the desire not to lose the status of the grammar schools, the trend away from multilateral schools began to gain ground from 1945 to 1952. Only large multilateral schools were allowed, on the grounds that small ones would not have the resources to maintain the different curricula needed by different types of children. Southend, Bolton, Reading and Oldham were the first authorities to begin reorganisation along comprehensive lines. London was the first to open a large purpose built comprehensive school, Kidbrooke, in South East London in 1954. By 1957 it had opened three more schools, merging selective central and modern schools. One of these was the one in which I started teaching in UK in 1965.

By 1962 there were about 200,000 pupils in comprehensive schools in the country, about 6% of the school population. Other changes were affecting attitudes and patterns of schooling. Real incomes were increasing and there was a demand for more education. One manifestation of this was that between 1953 and 1962 the number in 6th forms in grammar schools had doubled. New ideas about how children learned had shifted away from the fatalistic ideas of a set intelligence. Technological developments put a premium on specialisation and skills, and on adaptability in employment. The number of unskilled jobs was diminishing requiring 'a reassessment of what must be attempted by people of only average intelligence' (Crowther, 1959, quoted in Rubinstein and Simon, 1973 p 54). So despite a slowing in the pace of change the move to comprehensive schools made increasing inroads into the selective system and a shift in beliefs about the possibility of educating a wider range of people for a longer time.

The government's circular 10/65 (DES, 1965) required local authorities to prepare proposals to move to a completely comprehensive system. A range of patterns were accepted: the single tier 11-18 school, an 11-13/14 school, followed by an upper school; 11-16 school followed by 6th form colleges or colleges of further education; 8-12 (or 9-13) school followed by an upper school. From 1964 the age of transfer no longer needed to be 11. Money was only available for new schools if they were to be comprehensive and limited money meant that amalgamations had to be undertaken under existing budgets. Despite considerable retrenchment and a fight to retain grammar schools, the comprehensive schools increased steadily in number. In 1965 there were 262 comprehensive schools with 8.5% of the school population in them, by 1969, 960 schools serving 26% of the school population, and by 1973, 1825 schools with 48%. Selection mechanisms began to be phased out (Bradford was the first to cease the use of the 11+ in 1964), leaving only three local authorities with them in the 1990s. About 90% of the school population were in comprehensive schools by 1994 (Benn and Chitty, 1996).

The curriculum of comprehensive schools was based essentially on the many subject curriculum of the grammar school, modified after the age of 14 by the inclusion of vocational subjects which had been taught in secondary modern schools. The organisation of classes within comprehensives involved streaming of children, continuing a pattern which existed in grammar and secondary modern schools and which had even infiltrated junior schools. The rigid streaming however began to give way to 'progressive differentiation during the first four years' (Rubinstein and Simon, 1973). The second wave of comprehensive schools in London set out to develop a general common course for years 1-3. (Rubinstein and Simon, 1973 p77); the pattern in the school where I taught (chapter 1) illustrates this type of organisation. With most of the schools having populations of over 1000, staff could comprise 80 or above teachers. Individual departments were large and often formed powerful units within the schools. The number of pupils who remained at comprehensive schools after 16 increased and began to form the 'new sixth form' i.e. students in full time education in schools post-16 who were not studying for A levels.

The schools were part of a more general acknowledgement of the potential for greater achievements of a wider proportion of the population and a recognition of many of the inequalities which had existed in the selective system. They were also seen as one mechanism for cutting across the differences of social class, which had been perpetuated in the pattern of education.

Independent schools

The public and 'private' schools were to a large extent outside government intervention, although the majority were subject to inspection by HMI. Boys public schools in particular were heavily criticised post war for being inflexible and for producing people who were too conformist. Their existence was seen as socially unjust as only people with money attended. There were people, including those within the private sector, who thought that these schools would not survive the reorganisation of state education along comprehensive lines nor the threat of the labour party in the 1960s to nationalise the schools. In practice the majority did survive, under the preferred name of 'independent schools', and emerged from what has been termed a revolution (Rae, 1981) with increased vigour and strength. They still serve a relatively small proportion of the school population.

The independent schools, however, provided a significant proportion of the 6th form education in the country in the 1950s: in 1956, for instance, 25% of the 6th formers were in independent schools and 50% of these were studying science and mathematics. They, like many of the grammar schools, had responded to the post war pressures for an increase in science and technology training (Barlow, 1946) by encouraging a higher proportion of students to take the sciences and by making more opportunities for science available. The old image of the public schools as ones where science and mathematics were taught only to the less able boys was no longer supported by the facts and they continue to have a strong science side today.

b. Science Education in the 1950s and early 1960s in Secondary Schools

The emergence of integrated science has to be seen within the context of the development of secondary education for all, and the development of equal opportunities for all irrespective of wealth, class or gender. The separate schools for people deemed to have different aptitudes were beginning to be replaced by schools which catered for everyone. A large untapped pool of potential talent was being acknowledged and an increase number of students were staying on at school beyond the compulsory leaving age.

The science education which existed in the different schools in the 1950s was very varied. Independent and grammar schools prepared pupils for external examinations; secondary modern schools did not; the curriculum in the former was therefore controlled loosely by examination boards; in the latter teachers had greater autonomy. All schools, however, were able to decide how important science was, how much time should be devoted to it and whether everyone was obliged to study it. Schools could also decide which subjects to offer. For examination purposes at O level, there were essentially physics, chemistry, biology, physics with chemistry and general science.

General science was a single subject O level course; it combined elements of physics, chemistry, biology and was taught by one teacher. It had developed the reputation of being an unco-ordinated collection of topics, although this was not what had originally been intended. It began to disappear just as integrated science emerged. Because of apparent similarity to integrated science, a brief outline of general science is given below.

General Science

'General Science' stemmed from an initiative in 1901 of science masters from four of the top public schools to address criticism concerning the neglect of science. Boys entered public schools at age 13 via success in an entrance examination, for which most were prepared in respective preparatory schools. The entrance examinations did not have a science component and the preparatory schools taught no science other than, perhaps, a little nature study. In contrast science was becoming increasingly popular in the later years of elementary schools and in the municipal secondary schools, especially helped by the introduction of grants to schools which elected to become a 'science school'. The meeting of the masters in 1901 became the start of the APSSM (Association of Public School Science Masters) (Layton, 1984).

Apart from supplying a general education 'for gentlemen' which was dominated by the high status subjects of classics and mathematics, the public schools prepared boys for entrance examinations for university (mostly Oxford and Cambridge), for officer training in the army and navy, for the medical profession, and for the various branches of the civil service.

Science, if it was included at all, enjoyed a lower status than other subjects and its form was increasingly influenced by requirements of external examinations. Requirements for botany and zoology qualifications for those going to medical school, requirements of army examinations for a science component, forced the teaching of these subjects in the later years of school and in the 'army' classes. Some public schools did have vigorous science courses (often for the non-classics classes) and prepared candidates for the specialist science examinations for university entrance at Oxford and Cambridge.

Early discussions of the APSSM revealed considerable difference of opinion amongst its members as to what an appropriate general education in science should be, and while negotiations with universities and other external bodies were underway, no general proposals were published, until *Science for all* proposals appeared in print in 1917 (APSSM, 1917). These proposals had originally formed the evidence to the Thomson Committee on Natural Science which was set up in 1917 to advise on the position of natural science in the educational system of Great Britain (Thomson, 1918). *Science for all* contained general principles which should guide the development of science education and these were exemplified by outlines of seven schemes of work, submitted by teachers from different schools. The report was at pains to point out that schools needed to prepare courses which were appropriate to their locations, pupils and teachers. Vassall (Harrow), author of one of the schemes, shared his set of 'golden rules' which he applied when trying to select content for his courses of general science. These included not starting on a 'niggling bit of formal science' but making sure that the 'landscape is mapped'; excluding any work which is 'not worth doing for itself'; including work which is educationally valuable e.g. scientific investigations; including also 'matters which occur in the average life of an educated citizen who is not actively concerned with a scientific career'; 'cutting out any work applicable only to those who will study science further'; 'be suspicious of anything which occurs in existing examinations'; 'consider the conditions of the school and the personal equations of the teachers rather than examinations in drawing up a syllabus for the average boy'. (reprinted as part of BAAS, 1928, p.480).

Schemes were diverse but interesting in their attempts to give a cultural, general interest in science, that would spark the imagination. A strong element of practical science was evident and there were many references to the importance of experience; ideas on how to engender the romance of science were given along with suggestions to include the history of science.

Two developments contributed to a wider community of science teachers being drawn into considerations of general science and it becoming less the exclusive preserve of the male public schools: the expansion of the APSSM and its collaboration with the women science teachers organisation and the introduction of the school certificate examinations. In 1919 APSSM opened its doors to male graduate science teachers in maintained and grant aided grammar schools, to be renamed the Science Masters' Association (SMA). Women science teachers had formed their own association in 1912 (Association of Science Teachers, AST), renamed the Association of Women Science Teachers (AWST) in 1919. The SMA and the AWST did not amalgamate into the Association for Science Education until 1961 but there was increasing collaboration leading up to the amalgamation. The journal of the SMA, *School Science Review*, was published by the SMA, but women published in it.

The school certificate examination system, a more centralised and rationalised system of examinations for schools than had existed, was at last established with the first entries in 1919. The *Science for All* Proposals became translated into a syllabus to be examined by the Oxford and Cambridge Joint Boards and by 1930 five of the remaining seven boards offered General Science courses. Hence it was put onto the agenda of possible courses for secondary schools entering candidates for examinations. The first General Science syllabus covered elements of astronomy; geology; biology, including agriculture, physiology and hygiene; physical properties of materials; chemistry, including the chemistry of a number of everyday materials and industrial processes; physics, including heat, light and vision, sound, magnetism, and electricity. The headings *physics*, *chemistry*, *biology*, *astronomy* and *geology* were not used, but the syllabus was divided into these sections. The course was illustrated by a great number of examples of how it might be taught but it was seen as 'non-prescriptive' (Jenkins, 1979, p 72)

Layton (1984) reviewed the production of *Science for All* and the subsequent inclusion in the examination system as a solution to the particular contexts and problems which affected the public schools at the time.

> Now, however, General science as an examination subject based on *Science for All* proposals, appeared to be a possible solution to many of the problems of incorporating science in the curriculum of the public schools and in the education of military and civil leaders. It consolidated the previously separate branches of science which had bedevilled curriculum planning in the middle years of public schools, offering a broad foundation for future specialists studies and a general education for all. It provided a remedy for over-specialisation in the upper school and in university entrance examinations....

> Unable to assume anything in the way of prior knowledge of science from boys entering public schools, their masters required a self-contained, two-year course which would not only interest boys but which could be adorned with an appropriate rhetoric of educational justification.
>
> (Layton, 1984, p 198)

The relative numbers of candidates for the different subjects in the years following the introduction of the school certificate examinations can be seen from table 2.1, published in the BAAS report of 1928. The report commented on the proliferation of different subjects, the almost total neglect of areas of biology other than botany, the fragmentation of physics and the lack of take-up of general science.

> In the science group of subjects, however, little serious attempt has been made to devise a course of instruction suitable for all pupils. There are syllabuses of mechanics and hydrostatics, light and heat, electricity and magnetism, chemistry, botany, natural history, and many other separate divisions of science, any one of which may be included in the curriculum for the purposes of the First Examination, but it can scarcely be suggested that a single subject of this kind represents what should be science for all in a general education...
>
> The statistics...represent the relative attention given to various scientific subjects in secondary schools, and it will be seen that these are almost entirely certain branches of physics, chemistry and botany. General science occupies a low place in comparison, and biological subjects other than botany are deplorably neglected.
>
> (BAAS, 1928, p 444)

Table 3.1 Numbers of candidates entering school certificate examinations in different science subjects (with English and Mathematics for comparison) (BAAS, 1928, p 525)

Subject	**1919**	**1922**	**1924**	**1926**
English	28479	42969	50176	54360
Mathematics	26438	39,180	46604	50956
Botany	8017	11841	18524	13627
Chemistry	9110	15939	19962	21527
Physics	5089	8443	11064	13255
Elementary or Experimental Science	1055	2392	3200	3042
General science	**513**	**1133**	**1266**	**1340**
Applied Science	281	339	219	238
Mechanics	1132	1985	2165	2138
Heat Light and Sound	1218	2351	2687	2980
Electricity and magnetism	924	1148	1744	1729
Biology			32	86
Agricultural Science	15		29	120

The limited take-up of General Science concerned the BAAS. Its recommendations entitled 'Reform in the Teaching of Science' (pp 456-458) for the first stage of secondary education (11-16), owed much to ideas developed through the earlier general science movement. The first stage of secondary school should have a course which 'should be broad rather than deep, and should include those subjects that will enable the pupil to enter into a real understanding of his, or her, physical environment' (p 457). They argued that the method of teaching was as important as the content and exhorted teachers to use the freedom from examinations in the 11-14 age range to develop appropriate ways of working and positive attitudes to science.

In fact the take up of General Science was more widespread than examination results indicated. Layton reports, for instance, that 'The adoption of General Science in girls' secondary schools was gradual, unheralded by policy pronouncements and provoking little comment. Quietly, and without controversy, it became the accepted curriculum alternative in the early years of secondary education for girls. By the time of the British Association survey in 1931, '69 per cent of the girls' schools responding ...took "General Science", though not necessarily in the School Certificate.' (Layton, 1984, p.215).

Following the next BAAS survey (BAAS, 1931) the SMA prepared publications on the Teaching of General Science (SMA, 1936 and 1938) containing a syllabus and a *minimum* syllabus with a specified time. Content was sectioned into physics, chemistry and biology; authors had not found it possible to integrate material and had an objection to preparing a syllabus around topics, mainly because it was haphazard and always left important items out. The syllabus had been constructed, evidently, by trying to find congruence between topics of natural interests to boys and the main principles of the sciences.

In 1937 the SMA reported that 'there was a widespread desire to broaden the basis of science teaching in the Secondary Schools' but went on to write 'How is it then, it may be asked, that General Science is not yet taught in our schools as a matter of course?' (SMA, 1938, p 4). The 'adverse factors' limiting the introduction of general science into schools were identified as 'the matriculation cult', the 'influence of the University scholarship', the fact that 'specialisation of function is a characteristic of the modern world', and that school teachers themselves had had a specialised education.

There was criticism of the quantity of science in the syllabus, some thinking it too little but the majority that it was too copious. Some critics failed to realise that many schools had only a quarter of the specified time. However, 'The most general objection to the teaching material which we provided is that it is too copious...In reply to this, we would state that there is no lesson in our schedule which has not been tried in practice by one or other of us within the allotted time.... *We would reiterate that the syllabus which we compiled was designed as a guide for teachers, and not as a prescription for examiners....* Some of our critics seem to think that no knowledge is of use unless it is readily available, in essay form, under examination conditions: a view from which we dissent most strongly' (SMA, 1938, p 13). The position of chemistry had caused concern, chemists arguing that their subject had been neglected in the general science syllabuses.

Concern about competence to teach the course was expressed in a letter from a teacher quoted in the report:

> "I feel" he writes "that a certain amount of the opposition to General Science may be due not to the principle nor to any particular syllabus, but to the fact that specialists in one subject feel a lack of confidence in dealing with other subjects. Few of us like to admit this, however, and it is a tempting alternative to attack the whole idea."
>
> (SMA, 1938, p 9-10)

In November 1938, a syllabus drawn up jointly by the SMA and AWST was printed and sent to all the examining boards and teachers associations. The content was less than the original 1936 syllabus, because the majority of girls schools did not have anything like the time recommended. Apart from addition of the study of sexual reproduction and inheritance, there were no new topics. Text books produced to support teaching were similarly divided into different sections along the lines of the separate sciences, so that it became less easy to see the distinction between the separate science courses and a section of the general science course.

The entries to school certificate examinations in general science did increase steadily over the next six years, as shown by the figures in table 2.4. These figures show other interesting features. A response to the demand for a broader science curriculum was the introduction of physics with chemistry, so that along with biology this gave students a broad background. The numbers of candidates studying botany was reducing as biology was emerging as a integrated course of botany and zoology. Physics was no longer broken down into a series of separate compartments.

Table 3.2 Entries to Science Subjects in school certificate 1936 - 1942

Year	Physics	Chemistry	Physics with Chemistry	Biology	Botany	General Science
1936	21,676	29.975	5,128	14,003	10,307	4,847
1939	21, 493	29,475	7,373	18,071	6,240	12,497
1942	23,686	23,067	7,115	19,004	3,383	17,817

A somewhat weakened statement about general science emerged in 1943:

> There has been some misunderstanding and ambiguity in the use of the term 'General science'. Some people have thought that we advocated only a unified course of science, taught by one person General science teacher and that we wish the separate science subjects of the pre-school Certificate course to be replaced by 'General science'. We would maintain, however, that a school is, in fact, teaching 'general science' if its pupils study physics, chemistry and biology separately under different teachers, and do some geology and astronomy as part of their geography. It is an increased breadth of the science course that we advocate under the name of 'General science' and we are content to leave the details of the teaching of such a course to individual schools.
>
> (SMA, 1943, p346-7)

Post war Britain was committed to an expansion of science and technical education. In such a climate the drive for earlier specialisation began to dominate. A survey of 359 grammar schools in 1949 'showed that the emerging and dominant post-war pattern in the grammar schools was one in which General Science provided an introduction, of one to three year's duration, to the study of the separate science subjects.'(Jenkins, 1979, p 91). Waring, in her book on social pressure and curriculum change, reports the effective 'end' of the General Science in 1959 and reflects on its significance as one step in the long battle to have science accepted as a curriculum subject in general education in schools:

> In January 1959 a resolution expressing 'disapproval of the teaching of General science as a 'substitute for the separate sciences' was put before the members at the Annual Business meeting. The debate is recorded in the School Science Review, and makes very interesting reading. An amendment was finally passed which stated that 'the meeting disapproves of the continued teaching of General science in an inadequate time allowance.' The change reflects the contemporary current of opinion, and it supports the contention that the General science movement was in fact a means to more science, taught for more periods a week, to more children.
>
> (Waring, 1979, p 35)

A review of science teaching in grammar schools was taking place with sub-committees from the SMA and AWST. The report contained no reference to General Science. The syllabus in the first three years of secondary education was to include 'the main science subjects' (physics, chemistry and biology) but its detailed organisation was left to individual schools to decide in the light of their circumstances. In the fourth and fifth years flexibility was essential; the curriculum for future specialists needed to be more extensive than that for others, but all was expressed in terms of the separate sciences. The change in mode and practice became clearly evident in the examination entries. In the first year of the introduction of the General Certificate of Education, the number of O level entries for General Science were similar to those for Chemistry, Physics and Biology (GS 21,672; C 20,677; P 21,548; B 29,014 respectively) but by 1961 it was a much lower proportion of the total entry (G S27,891; C 67,371; P 79,691; B 99,531 respectively). (Jenkins, 1979, p 94).

General Science was in retrospect one 'face' of a much wider set of debates: the concern to include science in general education of all pupils; the wish to reduce the over specialisation which had become a characteristic of science courses; the need to find a form of science education which served both as 'general education' and as the basis of later professional training; the need to update syllabuses; the concern to prevent the training of specialists (the 'formalism' of courses in physics and chemistry) from shaping the science curriculum for everybody; the need to rationalise the diversity of examinations, so that teachers did not have to make choices between a plethora of different subjects; the problems of finding a means of assessment which influenced the science curriculum in a positive way; recurring concern about time to be spent on science for a realistic course to be taught and for adequate balance with other areas of the curriculum.

From its inception as a self contained science course which could be taught to the middle years (age 13-16) of boys public schools, General Science became the accepted course for the first two or three years of most secondary schools. It is interesting to note that science in preparatory schools was still a late starter. When the Nuffield O level Projects were developed in the 1960s, John Lewis put together a course for the preparatory schools, which was a combination of the science of the first two years of the course, and it was not until 1975 that a science became a compulsory qualifying subject in common entrance examination for public schools.

Science in Grammar and Independent Schools

The previous account of emergence of general science contains the story of the grammar schools and the independent schools. In the 1950s the pattern of the science curriculum in grammar schools was not dissimilar from that at my own school. Some form of general science in the lower years with the possibility of specialist courses later. There was considerable variation as to when the specialist courses began, with some schools starting them from the beginning of secondary schooling, others delaying them until 14, or even 16, where general science was taken. The pressure to increase the scientific and technical manpower in the country in the 1950s and 1960s was responded to by starting specialist courses earlier. There was also variation in the extent to which pupils were encouraged to take all three sciences at O level. In girls schools biology and chemistry were favoured compared with physics, and in boys schools physics and chemistry were favoured. Some schools attempted to offer a balanced curriculum by offering 'physics with chemistry' as one subject alongside biology. The education of a particular individual depended on the choices made and students could have one two or three, or perhaps zero, subjects in their science studies. Science education in the 16 - 18 range comprised a choice from three or four A level sciences (four where botany and zoology were still split). Schools were often divided into the arts and science 'sixth' forms, with the assumption that students would choose their studies wholly from one side or the other.

Science courses in grammar schools contained a mixture of pure science and applications. Ability to use scientific principles, do calculations, reproduce established scientific knowledge, explain the working of gadgets such as telephone receivers and the scientific basis of industrial processes such as the Harbor process were indicators of successful achievement. Practical work (which was not usually examined at 16) comprised demonstrations by the teacher and a limited number of 'cook-book' activities (Woolnough and Allsop, 1985), both reported in the pseudo-scientific mode of 'Aim, Method, Result and Conclusion'. The practical activities for physics were those which required measurement of some property or phenomenon; chemistry involved collection of gases and testing of their properties, and analytical exercises to find the composition of an unknown chemical. Biology practical work involved a lot of observation of specimens, tests on food substances to find ingredients and a study of models. Contentious issues were not included, nor any attempt to explain the nature of science, although the work of a few scientists was included. This does not mean that individual teachers and schools did not include issues and the nature of science as part of the curriculum but they were not examined.

While the earlier part of the century had shown a continuing battle to have science accepted as a legitimate part of the curriculum in grammar and independent schools and to some extent in post elementary education, the changed climate of the 1950s provided a better climate for the development of school science.

> In the changed climate of the 1950s with science in the ascendant politically, economically and academically, it seemed that extended pressure for more school science might at last be likely to succeed.
>
> (Waring, 1979, p 34)

The reports from the SMA/AWST (1961) became the starting point for the renewal of the grammar school curriculum funded in 1962 by the Nuffield Foundation.

Science in Secondary Modern Schools

The situation in secondary modern schools was different. The Newsom report, *Half Our Future* (HMSO, 1961) gave an indication of the progress and the problems faced by the schools in general:

> The 1944 Education Act changed the name and status of the old Senior Elementary Schools to Secondary Modern Schools, but at first changed little else. When the school leaving age was raised to fifteen in 1947, the country was faced with the enormous task of discovering how to provide an effective secondary education for a large part of the population which had never remained so long at school before. The teachers had to gain their experience on the job, often in old and unsuitable buildings, and even the younger ones that have started up since, have had to plan their development ahead through a period which has seen in every field of education chronic shortages of teachers and overcrowding of classes.
>
> (Newsom Report, 1961, p 12)

Many pupils in secondary modern schools did not complete the fourth year as they were allowed to leave school at the end of the term in which they reached the age of 15; consequently pupils left in December and April as well as in July. Courses devised for the schools often reflected this, by having three year courses followed by an additional course which could be stopped at various times. The typical fourth year curriculum (for 14-15 year olds) in secondary modern school showed about 24% of time spent on science and mathematics, 39% on humanities and 37% on practical subjects. The figures were similar in girls schools except that science and mathematics had only 22% and practical subjects had 39%. The percentage for science alone was 6% and 5% for boys and girls respectively (Newsom, 1961, p237). The practical subjects for girls included housecraft and needlework, in place of technical drawing and woodwork and metalwork for boys. Common additional subjects included rural science for boys and shorthand and typing for girls. Averages disguise variations: there were a few schools spending 5 hours a week on science in the fourth year; but the majority spent between one and a half and three hours. Some form of general science was the commonest course, but separate sciences of biology and physics were taught with only a few schools teaching chemistry (Newsom, p. 240). Some schools taught no science, more frequently girls schools than boys. The Newsom report also pointed out the difference in time allocation between the 'A' forms and the 'C' forms, the latter studying far less science. This discrepancy did not occur in mathematics.

The schools were set up with the explicit aim that they should not be subject to external examinations, so that teachers were free to develop whatever curriculum they saw fit. This did not survive and as the demand for widely recognised qualifications increased generally in society, the secondary modern schools began to use examinations such as those set by the Royal Society of Arts in commercial subjects. School Certificate was restricted to the Grammar Schools, but with the introduction of GCE in 1953, pupils from some secondary modern schools were entered for a number of subjects. The increase in the following ten years was impressive. Taylor reported:

> The increase in the number of candidates coming forward from Modern Schools during the past decade has been very considerable. In 1953 there were 4,068 candidates, 2,253 boys and 1,815 girls. By 1960 there were nearly 22,000 candidates - 11,830 boys and 9,850 girls.
>
> (Taylor, 1963, p118)

Jenkins (1979) gives figures relating to the science entries for 1961 from secondary modern schools, showing the predominance of physics for boys, biology for girls and very low entry for chemistry for both sexes. Candidates for the examinations came almost entirely from the 'A' streams. (Table 3.3).

Table 3.3 The number of candidates entering for GCE O and A level examinations from modern schools in 1961

		O Level		A Level*	
Subject	Boys	Girls	Girl:Boy Ratio	Boys	Girls
Physics	2,345	53	0.02	9	0
Chemistry	277	46	0.16	2	0
Mathematics	7,479	1,806	0.24	22	3
Biology	418	2716	6.50	3	5
General science	2508	420	0.17	-	-
All subjects	48,385	34,409	0.71	212	252

*The data include candidates from the very small number of 'all-age' schools in 1961.

(Jenkins, 1979, p197)

Some indication of the science taught in secondary modern schools in the 11-14 age range can be gleaned from the SMA subcommittee's report (SMA, 1953). The committee had been charged with the responsibility to do all that was possible to support the teaching of science in secondary modern schools, and in carrying out their brief produced a sample syllabus with associated practical activities.

The introduction to the report, written by H.F. Boulind, the chair of the subcommittee, gives an insight into the deliberations and assumptions which underpinned the construction of the syllabus. As the schools were new there was concern that their purpose was as yet ill-defined:

> The *raison d'être* of the Grammar school is fairly well defined, the Grammar School master knows where he is going, and follows the signposts provided by the examination system. The objective of the Modern School is much less obvious-in fact, such schools commonly seem to lack any objective at all, except the general one of "Education".
>
> (SMA, 1953, p. x)

Of the four arguments which people used to justify the position of any subject in the curriculum, they dismissed the vocational (it helps to fit pupils for their future occupations) as inappropriate as the pupils in secondary modern schools were not going to go to University and become scientists; they regarded the disciplinarian (it teaches them to think and sharpens their minds) as 'overplayed' and based on the outdated theory of faculty psychology. They therefore adopted the other two 'utilitarian: the subject helps pupils in everyday lives' and 'cultural: it forms "an essential part of our social heritage"' as guide for selection and emphasis in the course. But over-riding this was a priority to the child and to '*educating the child through science*' rather than '*teaching science as a subject.*'.

Individual or group practical work was deemed essential, with an insistence that science should not be reduced to a set of demonstrations and note-taking:

> It is not enough for the teacher to perform experiments in front of the class, explaining that such and such constitutes the scientific method; the pupils must experience it for themselves; be helped to devise experiments to test their ideas and to form their own conclusions.
>
> (SMA, 1953, p. 5)

Practical work was deemed so important that it could be used as the basis of the selection of topics to be included or excluded from a syllabus which could be overcrowded:

> There is so much material to be taught that any part of the syllabus that does not lend itself to individual work might well be omitted.
> (SMA, 1953, p.5)

There were four principles that the sub-committee used in deciding content and methods of teaching. The first was that educating through science required '*the scientific method of study*' to be as important as the acquisition of facts. 'The teaching of science is, therefore, more than a skilled exposition of facts and theories and inventions; the method of acquiring such knowledge is of paramount importance'. The second was that the scientific knowledge to be included must be selected both on grounds of the interest of pupils (and the assumption was that pupils were 'most interested in the things around them and the happenings they experience'), and on grounds that it should be scientific knowledge that an educated citizen should possess. The third principle was that pupils must be involved in the experimental work; 'actors first and spectators second' and the fourth was that science should have social relevance.

Interest could be generated by including examples of gadgets and services which occurred within the pupils' immediate environment, and by consideration of such personal matters as health and hygiene. Pupils were to be involved in their own investigations, the answers to which the teacher did not know, on the grounds that this would provide insight into the nature of science. They anticipated the criticism that there would not be time for pupils undertaking investigations by pointing out that the secondary modern schools had the luxury of not being driven by the examination system

The construction of the syllabus for the first three years comprised a series of topics illustrated by practical activities. Physics were most numerous followed by biology. The chemistry topic on 'combustion and oxidation' was large, containing 25 practical activities and covering also acids and alkalis and the reaction of metals with oxygen and water, but chemistry occurred only once in the syllabus. Much of the later part of the course is devoted to mathematical physics (topics 16, 17, 18, 19, 22), with just two biological topics included. One mathematical topic occurs earlier, work on density and Archimedes' principle. The order of the topics was considered important as later ones depended on work done in the earlier ones. (Table 3.4)

The fourth year course of nine topics had a slightly different emphasis, with strong local and social emphasis enhancing pupils' understanding of food production, disease and agriculture, and the science of services such as gas, electricity, sewage, telephones and transport. The emphasis continued in biology and physics. There was no detailed set of practical exercises although the 'Micro-organisms and Human Affairs' unit was expanded to give details of practical work which could be done. Many of the topics required visits to places in the locality such as the gas works and the sewage works.

Table 3.4 Suggestions for Science Course in Secondary Modern Schools (SMA, 1953)

	Topics for the First Three Years (in Teaching Order)	**No. of Suggested Practical Activities**	
1	The Air we Breathe	22	B,P
2	The Water we Drink	17	B,P
3	Heat and Temperature	20	P
4	Simple Studies of Plants and Animals	19	B
5	Magnetism	9	P
6	pressure of Air and Water, Density, Archimedes' Principle	20	P
7	Combustion and Oxidation	25	C
8	How Heat Travels	15	P
9	The Surface Skin of Water	15	P
10	Water as a Solvent	9	P
11	Electromagnetism	15	P
12Part A	The Plant and its Environment	22	B
12Part B	Life Histories of a few Common Insects	8	B
13	The Sun, Planets, Moon and Stars	8	A
14	The Earth's Crust	8	G
15	The Weather	5	M
16	Heat as a Measurable Quantity	12	P
17	Light and Its Applications	24	P
18	Work, Energy and Machines	11	P
19	Electricity	13	P
20	The Food Cycle	12	B
21	Human (and Animal) Physiology	14	B
22	The Ear and Sound Waves	24	P,B
	Nine Topics for the Fourth Year		
	Micro-organisms and Human Affairs		B
	Social Biology		B
	Biological Control		B
	Vitamins		B
	Gas		C,P
	Electricity		P
	Telephones		P
	Health		B
	Transport		P

The report carries a note of dissent from Rowse (Rowse, 1953). He argued that the topic approach would not lead to a coherent picture of science and that it would be better to stick to one area of science over a longer period. He challenged the role that practical activities were expected to play arguing that theoretical models are a necessary component of making sense of practical experience and that they should be taught in conjunction with practical work.

The SMA report gives an indication of the sort of course which occurred in the 11-14 age range schools, as it was culled from the experience of many teachers. As an increased number of pupils stayed on to 16, the A streams in secondary modern schools took O level examinations, and it was only the B and C streams where much experimentation could occur:

> By 1947, with the Grammar Schools and the School Certificate intact, it was to be the Modern Schools that were to be 'free'. By 1959, it is in the middle streams of these schools that the opportunities exist for experiment and informal methods. But examinations, albeit of a local, regional or single school type are spreading into even these levels of the Modern School; the incentive aspect of examinations is coming to be regarded as a valuable thing in itself, irrespective of any occupational or social advantages that they may confer.
>
> (Taylor, 1963, p128)

It is not surprising that the Newsom report, intended initially to cover all children in secondary modern schools, i.e. about 75% of the population, focused attention on the fifty per cent whose achievement was weakest. A reflection on the influence of the examinations on the curriculum was given by Bollen, reflecting in 1967 on his teaching in a secondary modern school in the years immediately after the war:

> To illustrate the effect of examination syllabuses on the actual topics taught, my personal experience may not be atypical. Fifteen years ago I included introductions to radio, astronomy, aeronautics and space flight in my course, but now these have been replaced by such topics as ray diagrams in optics, the parallelogram of forces, the preparation of salts etc. - these in an age when man's exploits in space command the attention of even our youngest children!...
>
> Where progress in science teaching has been made, it has often been with those pupils whose lack of ability eliminates them from the examination 'paper chase'. This point also lends itself to personal illustration. I have developed a series of twenty job cards to teach scientific principles through cars and motor cycles. Using several engines and spare parts, a complete electrical layout, a library of reference books and many relevant experiments, much useful scientific activity can be geared to the older boys' natural interest in this topic. Yet this work is for the lower streams only, except when the brighter pupils' external examinations are over and they are waiting to leave school.
>
> (Bollen, 1967, p 350)

The comprehensive schools were integrating these separate traditions. The same teachers were teaching a much wider range of pupils. Ideas from one course were necessarily 'leaking' into other courses. Pupils were being socialised into one community, and they were seen as having greater flair than perhaps they had been given credit for hitherto. Interest in integration of subjects was not confined to science. Integration of previously distinct subjects was on the educational agenda.

c. Implications of Curriculum Integration

Bernstein in his article on classification and framing of educational knowledge (Bernstein, 1971) identified four reasons for interest in integration. The first was the changing structure of knowledge, with both increased differentiation at higher levels and the integration of previously discrete areas, such as say the field of biochemistry. People entering this field would require background knowledge in both biology and chemistry. The second reason came from change in the labour market such that the ability to apply your mind to a range of contexts was at a premium.

> '...it could be said that the nineteenth century required submissive and inflexible man, whereas the twenty first century requires conforming but flexible man.' (Bernstein, 1971, p67).

The third reason was that an integrated code may lead to a less rigid social structure, because of less rigid schemes of socialisation, and this may be appropriate for an egalitarian education. The fourth reason was that advanced industrial societies allow a range of different beliefs and ideologies, which creates a problem of control of such a society because of no agreed underlying belief system. Individuals therefore have the problem of making sense of all these different positions, and of developing their own sets of beliefs. Integrated codes may be seen to provide some guidance in the 'making sense' in allowing the learner to connect diverse aspects of his experience.

In his article 'Classification and Framing' Bernstein (1971) proposed a way of using his concepts of *classification* and *framing* with reference to 'integrated' and 'collection' educational codes to analyse the organisation, transmission and evaluation of educational knowledge to highlight aspects of social control and power relationships. He argued that:

> How a society selects, classifies, distributes, transmits and evaluates the educational knowledge it considers to be public, reflects both the distribution of power and the principles of social control.
> (Bernstein, 1971, p 47)

Classification referred to the mechanism of boundary maintenance between different 'contents' of a curriculum. *Framing* referred to the degree of choice which teachers and pupils had over what was taught, in what order it was taught and how quickly it was taught.

He described contemporary educational systems (English, Scottish, French, German, American) as working under a *collection code*, whereby education involved the collection of a number of different subjects. The boundary between one subject and the next was relatively sharp, showing strong classification. He contrasted this with systems operating under an *integrated code* whereby previously separate subjects were subordinated under some overarching idea. In these boundaries between subjects were weaker and hence showed weaker classification.

Classification and framing in collection codes

Bernstein argued that several mechanisms acted as strong boundary maintainers within the specialised collection code characteristic of the English educational system. Long socialisation into the culture of a particular subject resulted in the steps in the educational road to say a degree, being like a rite of passage into a rather exclusive club. Personal identity therefore became linked strongly to educational identity as witnessed in phrases such as 'I am a physicist', 'I am a historian', rather than 'I know quite a lot of physics or history'. Screening procedures, tests and examinations, determined those who were included and those excluded. *Difference from* was emphasised rather than *communality with* people from different specialisations. These were the mechanisms which retained the boundaries between subjects, and hence strengthened the classification.

In *framing* of knowledge Bernstein considered the extent of the choice over what was selected, how it was ordered and how quickly it was taught. A hierarchical organisation of knowledge was inherent in all forms of collection code, especially the specialised collection code, such that the 'higher mysteries' of the subject were revealed at the end of a long apprenticeship. Only those who stayed the course, passing through the necessary hurdles gained insight into the 'true' nature of the subject. Bernstein here made a more general point:

> As this mystery, under collection codes, is revealed very late in educational life, - and then only to a select few who have shown the signs of successful socialisation -then only the few experience in their bones the notion that knowledge is permeable, that its orderings are provisional, that the dialectic of knowledge is closure and openness. For the many, the socialisation into knowledge is socialization into order, the existing order, into the experience that the world's educational knowledge is impermeable.
>
> (Bernstein, 1971, p57)

Such a hierarchy gives an order in which things are taught, such that there are particular ages at which it is deemed appropriate to teach particular topics. Questions outside these might be dealt with by "You need to leave that till next year when we 'do' that". Bernstein argued that the European system with a centralised curriculum was more tightly framed than the English curriculum at the time.

He drew attention to one important aspect of framing - the inclusion or otherwise of common sense knowledge. He argued that educational knowledge was not common sense, because it is 'freed from the particular, the local, through the various languages of the sciences or forms of reflexiveness of the arts.' (p58). He observed that when this frame is relaxed to include everyday knowledge (as is often the case with the 'less able') then this is done for purposes of social control. He argued that by doing this the less able are excluded from the more esoteric club of those that have access to the abstract, non-common sense knowledge (p58).

Bernstein argued that both the European and English systems of the collection code could be difficult to change; the European because it was highly framed through central control, and the English because individual heads and principals had comparative autonomy over what went on in their schools .

Bernstein feared that for those who did not go beyond the early stages of education in a system organised under the collection code, the education 'can sometimes be wounding and seen as meaningless' (p59).

Classification and framing in integrated codes.

Bernstein was writing at a time when there was emerging interest in integration of previously distinct subjects at both school and university level. His examples drew not from whole educational systems but from sections or courses within particular age groups - (infant schools, the first year course in a few comprehensive schools, A level physical science). He acknowledged that 'the code at the moment exists at the level of ideology and theory, with only a relatively small number of schools and educational agencies attempting to institutionalise it with any seriousness'. (p59).

The shift from 'content closure to content openness' reduced classification as the boundary between subjects will be weakened and this would cause 'disturbance of existing authority structures, existing specific educational identities and concepts of property.' (p59). The authority of the separate subjects becomes subsumed under the authority of the relational idea. But he argued that if a group of teachers is working to the same 'umbrella idea' then they are likely to be more constrained in what they can select and the order in which it is taught than when they operated within their separate subjects. The chances are that an integrated code might lead to stronger framing.

On the other hand he argued that the increase in the framing for the teachers may decrease the framing for the pupils. The relational idea could give access to the 'deeper structures' of the subject (the ones often not revealed until the learner has gone through all the rites of passage to the end). Learners would not have to wait until the end to discover the problematic nature of the subject. They were therefore more likely to have access to how knowledge was built up, not just to the knowledge once it has built up (p61).

Organisational consequences of collection and integrated codes

Schools, especially selective secondary schools at the time, had an organisation based on the collection code. Separate subject departments had a hierarchical structure (head of department, second in department, various posts of lesser responsibility, and 'junior members of staff'). There was no need for staff to collaborate across departments on matters of teaching and learning as individual departments were responsible for socialising pupils into their respective separate subjects. Heads of department would collaborate (or compete) over such matters as time allocation on the timetable, resources, staffing and general management issues. The work relationships of the more junior members of staff would be within the departmental hierarchy with little need to discuss other matters with colleagues from other departments other than maybe 'how do you cope with 3C, I find them hard'. The work relationships of senior members of staff could be both horizontal and vertical, while those of the junior members of staff were likely to be only vertical. As a result both the acts of administration and of teaching are relatively invisible to most members of staff.

Once teachers have to work together under some integrating idea, they are forced to talk with teachers from outside their subject areas, on work matters. The content, order and pace of teaching become matters for more open discussion and more importantly, for agreement. The allocation of resources will also be more visible and accountable. Allegiances to subjects are weakened by the development of allegiances to a larger purpose; so the control of the head of department over 'her staff' will also weaken. It is possible that whoever is set to co-ordinate the collaboration which is necessary will have increased power across the pre-existing vertical hierarchies. Bernstein also argued that the relationships between pupils and between pupils and staff might alter as a result of working under integrated codes .

Bernstein predicted that a shift from a collected to an integrated code would have several consequences (p63):

- 'change in what counts as valid knowledge'
- 'change in what counts as valid realization of knowledge'
- 'change in what counts as valid transmission of knowledge'
- 'change in organisational context'
- change in power relations of an organisation
- the outcome of the socialisation process would be less predictable.

Problems of order in collection and integration codes

The collection code allowed staff in different subjects to decide what sequence they wished to teach material, how they taught it and the relationships that they adopted with respect to pupils. Except for covering the examination syllabus, there was scope for autonomy within different departments. Order was determined from the separate organisation and control from each subject .

Bernstein observed that collection codes tended 'to create strong frames between the uncommon-sense knowledge of schools and the everyday community based knowledge'. This created a privacy for pupils and teachers - there was no need for pupils to bring their learning from experience into school life - and reduced the power of the socialising process of education. On the other hand, for many pupils much of their life would be seen as irrelevant to school life and if they were having difficulty in becoming socialised into school life this could be an alienating experience.

In reviewing problems of order for integrated codes he predicted that unless four conditions prevailed, there would be confusion. These four conditions were:

- there must be consensus about the integrating idea;
- the link between the integrating idea and the knowledge to be integrated had to be explicit;
- there is a need for a committee system of staffing;
- there is a need for multiple criteria for assessment (in order to assess the integrating ideas as well as the rest of the material which is being co-ordinated). (pp 64 and 65).

Changes of Educational Codes

As a result of his analysis of the classification and framing inherent in different educational codes Bernstein identified associated power and social relationships in the codes. He predicted that a change in codes 'will meet with resistance at a number of different levels irrespective of the intrinsic educational merit of a particular code', because to change a code is to change the power relations and the means of social control.

Bernstein claimed that because his concepts of classification and framing could be used at all levels, they allowed an analysis of different educational codes, highlighting the power relationships and the means of control within them. He argued also that it enabled one to move from the micro level of say a school organisation, to the macro level of how knowledge is organised and structured in a much wider range of institutions and how access to that knowledge was controlled.

He claimed that the analysis needed empirical evidence at each point, and maintained that at the time 'there was little *first* hand knowledge which bears upon aspects of framing...and no *first* hand knowledge of the day-by-day encounters realized by the various types of integrated codes'. In this thesis, I have used Bernstein's analysis to reflect on the day-to-day encounters reported in the case study at Duckworth School, in order to understand the 'reasons' behind what happened there (Chapter 5, pp143-4) and what happened to integrated science more generally (Chapter 9, pp 219-232).

Summary

There was a considerable gulf between the selective grammar schools and the secondary modern schools, both in their perceived raison d'etre in general and in the science provision in particular. Grammar School science was treated as the early training of science for potential scientists and this was interpreted as a thorough grounding in the separate sciences of physics, chemistry and biology. The pattern of science education for any one individual could however allow considerable narrowing of study after the age of 13 or 14, so that only one branch of science was studied. Where the study was not narrowed, students studied either a large amount of science, with typically about a third of the timetable time being spent on science, or they studied combinations, such as physics with chemistry or general science. In secondary modern schools, the 'training for a scientist' did not drive curriculum design. Courses were more likely to be embedded in everyday contexts and to start from technological applications than from pure science. The science would be drawn out of these more familiar and hopefully motivating contexts. With the increased use of external examinations by secondary modern schools, the curriculum of the top streams moved closer to the curriculum of the grammar schools, both in an increase in the number of subjects studied and in the type of science taught.

The rise of the new comprehensive schools, meant that the two traditions in science education would be brought together. In the context of the comprehensive schools, there was considerable interest in integration of subjects or in interdisciplinary studies. Bernstein predicted that a shift in the organisation of the way knowledge was transmitted would alter the distribution of power amongst the people who were involved and illustrated this in the case of what he called a collection as opposed to an integrated code. Some of the effects would be apparent in the case of integrated science.

CHAPTER 4

EMERGENCE AND IMPLEMENTATION OF INTEGRATED SCIENCE

a. What was integrated science?

'Integrated science' was becoming an established term at the time of my involvement in Nuffield Secondary Science. The first UNESCO international congress on the Integration of Science Teaching took place in 1968 and in 1969 UNESCO launched its own programme in integrated science teaching 'in response to requests from member states of UNESCO to devise science courses which contribute to the general education of all pupils' (Haggis, 1974, p14). UNESCO organised five international meetings on integrated science teaching between 1968 and 1977, with a sixth ten years later in 1987.

In her introduction to the third conference in 1973, Sheila Haggis described the move from 'general science to integrated science' as:

> The need to devise courses covering the whole range of the sciences in a balanced way was widely felt some 40 years ago. The teaching strategy then devised was to develop 'general science' courses. Such courses were co-ordinated surveys of physics, chemistry and biology. Only rarely was there unity in the presentation of the course.'
>
> (Haggis, 1974, p 15)

She identified four factors which had contributed to the shift in perspective in the design of science courses for schools. The first was major advances in interdisciplinary studies in science - 'molecular biology, geophysics, biochemistry and astrophysics, to name but a few'. The second was the curriculum development in the separate sciences (in UK in the Nuffield O level projects) which had drawn out the internal coherence of each subject and developed teaching approaches which encouraged a 'shift to 'let's find out by experiment''; further integration of science teaching seemed the next obvious step. The third was the 'growing awareness of the need to be concerned about the nature of the learner'. The fact that the 'logic of the child' may be very different from the 'logic of the subject' such that 'an attempt is being made to design courses related to the child's intellectual and overall development'. The fourth was 'a growing awareness that the influence of science and technology on society is so enormous that it cannot be ignored in general education.' (Haggis, 1974, p 15/16). I would add three more. The fifth was a sustained interest in incorporating what might be called 'scientific methods' into courses, with the purpose of pupils not only acquiring the skills of scientists but also appreciating the nature of science. The sixth was the desire to break what Fensham (1997) calls the 'hegemony of the curriculum legacy' i.e. that science in secondary schools was a preparation for further study as opposed to an end in itself. The last is what Roberts (1982) referred to as *Self as Explainer* so that pupils built up their confidence in scientific reasoning.

One single integrating idea of the sort envisaged by Bernstein did not emerge. UNESCO conference reports showed that a single concept remained illusive. At the second conference Blum provided a model for describing different forms of integration, using the idea of *scope* (the range of sciences and other subjects which were included in a course) and the *intensity* of integration measuring the extent to which different elements were woven together. The third conference had to come up with a working definition which allowed discussions to proceed. This definition was:

> Integrated Science has been defined as those approaches in which concepts and principles in science are presented so as to express the fundamental unity of scientific thought and to avoid premature or undue stress on the distinctions between the various sciences.
>
> (Richmond, 1974, p 46)

At the fourth meeting on evaluation of integrated science, Cohen (1977) commented that there were as many definitions as there were people writing courses and Tawney (1977) said that scrutiny of courses for definition of integrated science was one evaluation much needed. Welch (1977) in a hard hitting account produced a list of characteristics common to integrated science courses:

- traditional subject matter boundaries are phased out;
- the course usually lasts for two or more years and is sequential;
- the sequence tries to avoid duplication of content;
- the course usually serves a general education function (i.e. to develop scientific literacy);
- the course is organised around a selected unifying theme or topic.

Unexciting as this list was, it contains a point which is easy to miss: namely that these science courses were planned with an eye to the overall total experience provided rather than to the experience being allowed to be merely the sum of the parts: hence the 'lasts two or more years and is sequential' and 'avoids duplication'.

While I have not undertaken in the thesis to provide a comprehensive survey of all integrated science courses, I have selected six from the late 1960s to mid 1970s to illustrate the different emphases of the courses and the ways in which the course planners welded together previously separated elements. The six selected are: *Nuffield Combined Science* (1970, 1971); *Science for the Seventies: Scottish Integrated Science* (1970); *Nuffield Secondary Science* (1971); *LAMP (Science for Less Academically Motivated Pupils)* (1977/9); *Science at Work* (1979-1981); *Schools Council Integrated Science Project* (1973/4) and *Nuffield Science 13-16* (1979-1981) (originally CESIS - Curriculum and Examination in Integrated Science). The account, however, starts with a review of the curriculum renewal of the O level separate science projects. They would not count as integrated, but they did provide a greater coherence within their subjects than had hitherto been the case. They also represent part of the curriculum legacy to which those concerned with integrated science were seeking an alternative.

b. Integrated Science Courses in UK

The first large scale curriculum development projects in science were the separate science O level courses: Nuffield physics (1965), Nuffield chemistry (1964) and Nuffield biology (1964). They were developed by different teams who worked independently of each other. The Nuffield projects updated syllabuses and increased the role of class practical work. There was a drive to remove the ritual of 'Aim, Method, Result and Conclusion' and to introduce pupils to making their own notes so that teachers gained feedback as to what they were understanding. Practical work in the form of guided discovery was advocated so that pupils gained experience of arguments which linked theory to phenomena. The projects included the nature of science, some history of science, and took learners systematically through arguments which had lead to establishing scientific knowledge. Pupils were intended to understand how a particular formula had been developed as well as knowing how and when to use it. The emphasis was on pure science, and contentious social issues were on the whole avoided, although not entirely in the biology and chemistry projects. The elegance of scientific argument, and the involvement of pupils in being 'a scientist for the day' were seen as the main sources of motivation. There was limited attention paid to motivation which might start from pupils' own experience outside the school and laboratory.

The projects increased practical work available in schools, developing particularly in the case of physics, some new and, often expensive, apparatus. The introduction of detailed teachers guides, including experimental detail, was a new departure from the guidance of just a syllabus. Development of new examinations alongside the teaching materials was intrinsic to the project.

The quest for coherence was a form of integration *within* the subjects. Woolnough (1988) commented:

> So many existing courses had provided a collection of isolated topics, perhaps grouped under heat, light and sound, electricity and magnetism, which held no underlying rationale or unifying themes. Most of the content would have been familiar to a pupils studying physics in the schools of 1890....Nuffield sought for unifying themes and found them in properties of matter, waves and oscillations, energy and fields, and the modern quantum phenomena.
>
> (Woolnough, 1988, p 104)

The Nuffield O level chemistry team sought to exclude material because the syllabuses were over full; recommendations from the chemistry panel set up by the ASE produced schemes (ASE, 1963) where 'modern topics were included, but very little was omitted' (Halliwell & Van Pragh, 1967, p 332). The aim was to provide a course which integrated the theoretical and speculative nature of chemistry so that pupils would appreciate the nature of the search for chemical understanding as well as the knowledge itself. The course was based round five integrating themes of chemistry: *Getting new materials from those available; Looking for patterns in the behaviour of substances; Using explanatory concepts and knowing how to check theory by observation; associating energy changes with material changes; chemistry is the result of enquiry.* The course ended with study of the production of chemicals and their use in 'relation to the life of the community as a whole' (Halliwell & Van Pragh 1967, p 334/5).

Nuffield O level Biology similarly set out to up-date material, to remove from the syllabus a lot of material which required mere rote learning, and increase the study of investigations, particularly the role of control in biology, and the critical evaluation of evidence.

> there is a widespread feeling ... that a fresh approach was needed with an emphasis on experimentation and the critical evaluation of evidence rather than the tedious regurgitation of memorised facts. Indeed, as many teachers pointed out to us, much of what passes for biology teaching at present is positively anti-scientific, but is perpetuated by the prevailing examination system.
>
> (Dowdeswell, 1967, p 325)

The course contained not only a high level of experimentation to provide first hand evidence, along with accounts of other experiments so that second hand evidence could be evaluated. The biology course included attitudinal aims 'To encourage a respect and feeling for all living things'. It acknowledged the need for an understanding of chemistry, physics and mathematics; some topics such as photosynthesis were deliberately delayed until year 3 for instance to ensure that adequate physics and chemistry had been studied. Overall, it helped to establish biology as a more scientific subject akin to the 'hard sciences' of physics and chemistry.

Much was learned through these projects about the use of the supporting written material. The careful experiment guides, particularly in the physics, became used as the syllabus and a slavish adherence to them reduced an imaginative course to a tedious romp through experiments (Woolnough, 1988, p 107). Evaluations consistently showed that many teachers did not read the Teacher's Guides . Despite reservation of this sort, the project was seen as a landmark in English educational practice:

> The Science Teaching Project represents a major landmark in English educational practice, namely, the development of an articulated and comprehensive set of tested teaching materials in an attempt to achieve a co-ordinated and widespread reform in science and mathematics
> (Waring, 1979, p3).

As these O level courses were published, however, the number of comprehensive schools was increasing and many adopted a policy of 'progressive differentiation', similar to the pattern in the school where I taught. The pattern of general science in the first two years was more common than separate sciences, even in selective schools. In 1968 a small team was put together to prepare a two year course based on the first two years of the Nuffield O level courses. Nuffield Combined Science, published in 1970, was the result.

Nuffield Combined Science, 11-13 course, and Nuffield Themes for the Middle Years (8-12)

Nuffield Combined Science comprised a combination of material of the first two years of the O level courses. Overlapping material was removed, the remaining was grouped into ten topics (1. The World Around Us 2. Forces 3. Reproduction 4. Air, 5. Electricity, 6. Water, 7. Small Things 8. Earth 9. Insects 10. Energy) and the order of topics arranged to give coherence between them. The course was practical, with plenty of class experiments, guidance for which was provided by pupils booklets. These contained a vast array of questions to drive exploration, investigation and enquiry. The first unit of the course focused specifically on developing exploration and measurement skills.

Teachers' Guide 1 contained the aspiration to unity of outlook and method:

> Combined science ... is an attempt to recapture the unity of outlook and consistency of method which belong to the whole of science, and which enable us to make reasoned statements about the world we live in.
>
> In order to gain as much experience as possible of science as a method of enquiry, children must be actively and attentively engaged in laboratory work. In this way children will develop an appreciation of how to formulate, test, and modify hypotheses. To do this they should be given time and data to develop concepts'.
>
> (Nuffield Combined Science, 1970)

This course became was used by 75% of schools by the mid 1970s. It seemed to fill a niche, and released schools from having to write their own courses (Charles, 1976, Carter, 1977). It still, however, had the hall marks of the Nuffield O level projects and to some extent the significance of much of the material needed to be related to the overall aims of the O level courses; in other words it was not an end in itself but a preparation for later study. The revised version of the project materials, Nuffield 11-13, (Lyth, 1986) contained more material for pupils to read: their study was no longer driven only by questions and exploration. There was considerable expansion of material *about* science and scientists; much of which has survived in the next revision which was made in the light of the national curriculum. (*Nuffield Science Key Stage 3*, 1990)

Nuffield Combined Science materials were used in the increasing number of 8-12 and 9-13 middle schools, this turned out to be quite extensive but there was demand for more material, especially for the younger age group. A continuation project 'Nuffield Combined Science Themes for the Middle schools' was set up in 1974. This organised content round topics many of which had a primary flavour to them (Colour, Ourselves, Insects) which together covered a wide range of science. One innovation was the introduction of study cards, designed to act as a stimulus at the start of topics; they posed appropriate contexts and questions 'to show the broader implications of science, as well as to support and lead in to the investigatory work on the Activity Cards' (Bingham, 1976, p 15-18).

Scottish Integrated Science Course, 12-14 courses,

Whereas the Nuffield Combined course was considered as a preliminary study in science, the Scottish Integrated Science Course for 12-14 year olds, *Science for the Seventies*, had the dual role of being the 'last' science course which some pupils would take as well as the basis for later specialisation for a few. It was based on guidance from Scottish Curriculum Paper 7 (1969) and had four features: it was to be integrated, to use guided discovery, be appropriate for mixed ability classes and be objectives lead. It contained more content than Nuffield Combined Science and had pupils' books which contained information, questions as well as guidance to experiments, through sets of worksheets. Most topics were from the separate sciences; a few were interdisciplinary. There was an element of a spiral curriculum in the organisation. There was to be one teacher per class, and the teacher was exhorted to bring out the unity of all science through the teaching.

Despite the fact that this thesis focuses mainly on England and Wales Scottish Integrated Science has been included because it was used extensively in England and Wales, and because research on its implementation has relevance to this study. It remained popular and was re-published as *Science for the Eighties*.

Nuffield Secondary Science , 14-15 and 14-16 resource

Nuffield Secondary Science (NSS) (1964-1971) had its origin in the first Schools Council Working Party Paper *Science for the Young School Leaver*, (1964) (nearly a decade before the raising of the school leaving age in 1973) which was concerned with 'those of average and below average ability between the ages of 13 and 16, i.e. the Newsom pupils'(p1). The writers argued that:

> the course should be broadly conceived, using material from the environment which will lead to important generalisations and exemplify major principles...interest of two kinds is essential; an immediate, intrinsic interest in the work in hand, and the broader interest of relevance to the modern scene so that it is apparent to the pupils that the knowledge which they are gaining has a real and current value to them'.
>
> (Schools Council, 1964, p 1)

The studies had to be relevant to the pupils' lives, both immediately and in the future. The key word for the project was 'significance' raised through questions from immediate experience such as "'What makes metals corrode?', 'Why does our breathing rate change when we move fast?'". In addition there would be questions from 'fundamental issues' such as "'How fast are we using up available sources of energy? Do we waste valuable fuel on our congested roads?'" (Teachers Guide, 1970, p 18). NSS contained topics such as agriculture and electronics as well as pure science, included earth sciences as well as biology, physics and chemistry. The material was organised under eight broad themes, *Interdependence of Living Things*, *Continuity of Life*, *The Biology of Man*, *Harnessing Energy*, *Extension of Sense Perception*, *Movement*, *Using Materials* and *The Earth and its Place in the Universe*.

Bollen, writing about Science at CSE (Bollen, 1967), made an interesting observation about the proportion of the different areas of science which appeared in Secondary Modern Syllabuses:

> Although accurate generalisations on this matter are impossible, my experience has been that, before external examinations upset the balance, the content of most secondary modern courses was roughly of the order:
>
> biology: physics: chemistry = 3:2:1
>
> This also approximates to the content of the themes suggested in Science for the Young School Leaver.
>
> (Bollen, 1967, p.357)

Pupil practical work was seen as important to enable pupils to observe accurately, deduce generalisations. A key feature of NSS was 'the circus', a set of practical activities based on the same idea, so that pupils would have several linked experiences which would aid their ability to make generalisations. There were suggested worksheets in the teacher's guides to support the circuses, so that pupils could work at their own speed. In addition pupils were encouraged to identify their own problems in which they were interested and design simple experiments and investigations to find answers. There was a strong emphasis on involving pupils actively exploring for themselves as opposed to taking in 'received knowledge'. Standard school science equipment did feature in the course but there was considerable emphasis on home-made items; and a greater use of pupils making their own working models to learn science.

The project team began without any intention of producing an examination syllabus, following the tradition that these pupils should be free from the constraints of external examinations. The material was to be a resource on which teachers could draw in order to construct an appropriate course. Suggestions for 'routes through' were supplied in the Teachers' Guide (Misselbrook, 1971). Hilda Misselbrook delayed consideration of examination at CSE for as along as possible, obviously wary of the distortion of teaching by written examinations. Pressures from schools eventually persuaded the project to produce *Examining at CSE* as a guide for constructing examination syllabuses under mode 3 regulations.

> Teachers in trials schools found the Nuffield Secondary Science material was eminently suited to the needs of pupils who had the ability to achieve CSE grades. Because of its integrated nature it is impossible to use Secondary Science for Mode 1 examinations based on the separate sciences nor does its approach fall in line with traditional General Science Syllabuses.
>
> (Misselbrook, 1972, p1)

Integration which was visible in the project, was the use of the broad content themes, which took their justification from the world outside school and the laboratory rather than from the internal coherence of the subject. Having said that, the organisation of the 'fields' within the themes, were relatively subject focused and appeared in the teaching more like a set of topics. It was not clear that the overriding themes which were visible to the curriculum planners and to some extent to the teachers, were also visible and meaningful to the pupils.

It was difficult to estimate the use of the project because it was such a large resource, but from a survey carried out by HMI in 1975, about a quarter of non-grammar schools seemed to be using it, although only 8% claimed to be 'doing it'. (Booth, 1975)

The Schools Council Integrated Science Project; SCISP, the first double science O level course for the 13-16 'academic streams'

Whereas the 1950s and early 1960s had seen increased pressure and enthusiasm for science, there began to be concerns about the number of scientist and technologists the country was producing. The Dainton Committee was set up in 1965 to report on the flow of candidates in science and technology into higher education. Its first interim report of 1966 (Dainton, 1966), was confident about the quality and numbers of people studying science, but its later one in 1968 raised concerns about a 'swing away from science' (Dainton, 1968). To stem the swing it made a range of recommendations. Of relevance here are the ones concerning the need to have a secondary education which delayed the choice of career as late as possible (Recommendation 1), and the need to infuse both the curriculum and the teaching with 'breadth, humanity and uptodateness' (Recommendation 3).

This 'swing from science' was the context in which the Schools Council Integrated Science Project (SCISP) was set up in 1969; one of the justifications of the project was that it would allow pupils to keep career options open. The development team was given the brief to prepare an integrated science scheme for the top 20% of 13 - 16 year olds which occupied only one fifth of the timetable and hence lead to a double certification O level. It had to provide, in the limited time, an adequate preparation for all three A level sciences. The team was not to develop more specialised equipment but to use those developed in the Nuffield O level science courses. In 1969 one third of secondary schools were comprehensive and the number was rising. The team put a proposal to the Schools Council to prepare a course not only for the top 20% of pupils but also a complementary course for other pupils; this was, however, turned down.

The course which emerged in 1973/4 (*Patterns*, Hall et al., 1973-4) satisfied the brief of 1969. In addition it had a range of novel features: it was based on a learning model; it had a syllabus specified as a list of 78 patterns; the project model linked both content and processes; the aims encompassed attitudes, processes, communication skills, as well as knowledge and understanding (figure 4.1); *all* of were to be assessed; 20% of marks for GCE were to be awarded by teachers. There was also a national 'aftercare' system set up. Unlike NSS the summative assessment for GCE was an intrinsic part of the development. The project team received considerable help from people with academic backgrounds in assessment to develop appropriate tools to accommodate the novel features of the course.

The writers used seven 'principles' to select and organise course elements:

- the way in which pupils were likely to use their science education,
- the extent to which science is embedded in a wider range of activities,
- the nature of science and the skills of scientists,
- a model of learning, with elements akin to the 'methods of science'
- three 'integrating' themes: building blocks, energy and interactions
- the relationship between assessment and teaching objectives,
- the need for a balanced curriculum

The first 'principle' lead project leaders to argue that a relatively small proportion of pupils studying O level sciences continued science studies after the age of 16. Hence for the majority, school courses formed the last formal education in science and the last contact with science laboratories. Science was subsequently be encountered through radio, television, technical literature, hobby interests, newspapers, visits to doctors opticians and dentists, discussion with friends, family and colleagues, and through the availability of new gadgets. Science in schools, therefore, had to link with science in these contexts.

Figure 4.1 The aims and assessment objectives of the SCISP course

Aims (and assessment objectives) of SCISP

Skills

Pupils should be able to demonstrate their degree of competence in:

1 (a) recalling and (b) understanding those concepts which would enable them to pursue science (courses in physics, chemistry, biology or physical science) to a higher level or as a hobby

2 (a) recalling and (b) understanding those patterns which are of importance to the scientist

3 making critical appraisal of available information, from whatever source, as an aid to the formulation or extraction of patterns

4 using patterns in making critical appraisal of available information in order (a) to solve scientific problems and (b) to make reasoned judgements

5 organising and formulating ideas in order to communicate them to others

6 understanding the significance, including the limitations, of science in relation to technical, social and economic development

7 being accurate in the reporting of scientific work

8 designing and performing simple experiments, in the laboratory and elsewhere, to solve specific problems and to show perseverance in these and other learning activities.

Attitudes

Pupils should:

9 be willing to work (a) individually and (b) as part of a group

10 (a) be sceptical about suggested patterns yet (b) be willing to search for and to test for patterns

11 be concerned for the application of scientific knowledge within the community.

The minority of students who did go on to study science needed an adequate base for A level studies. This was provided by a well defined syllabus from physics, chemistry, biology, geology and astronomy which was listed as 78 'patterns' and the related concepts (see appendix 2, figure A2.1 for examples).

The second 'principle' was to embed science in activities in society. Environmental concerns were included. Aims included the development in pupils of 'concern' for the environment and for 'appropriate' use of science and technology. The treatment, in the sample scheme, of scientific and technological enterprises, can be divided into five categories:- scientific processes involved in production and use of a product (dialysis in kidney machines; depth sounding in the search for oil); financial aspects (marketing issues following the discovery of polythene); historical perspectives (harnessing of energy resources over centuries); unexpected side effects (both beneficial and detrimental); the range of decisions which have to be made (scientific, social, environmental).

The third 'principle' which drove the development was derived from a picture of what scientists do. Scientists work on their own and as part of groups. They planned investigations to solve problems and sought patterns in data. The writers used 'pattern finding' as a feature of all areas of science from the more precise areas of physics to the less easily bounded areas such as geology and even psychology and social science (*Teachers Handbook*, 1973, p 15). 'Pattern finding' therefore became one of the integrating themes.

The fourth 'principle' was a learning model derived from the work of the psychologist Gagné (1965) who developed a hierarchical model of learning with eight levels specifying the conditions necessary for each type of learning. The writers of SCISP used a model with four levels. According to this model the first level was gathering <u>information</u>. The next level, <u>concept formation</u>, occurred when the bits of information were actively or passively processed into distinct groups called concepts, which involved identifying common features in apparently isolated information. When links were identified or created between concepts then the third level, <u>pattern formation</u> occurred. The fourth level, <u>problem solving</u> used concepts and patterns learnt earlier.

The learning model was used explicitly in the arrangement of teaching material. Investigations were selected to give pupils experiences necessary to develop concepts and then patterns. Links between experiences, concepts and patterns, and the respective problems were indicated on a flow chart at the start of each chapter. (see appendix 2, figure A2.2 for an example from *Patterns 3*, p76/77). The model was explicit to both teachers and learners. The course started with exercises on pattern finding. Subsequently exercises on pattern finding and problem solving were clearly marked in the text throughout the scheme with appropriate logos.

The books represented only a 'sample scheme'. Teaching sequences, investigations and problems could be changed; only concepts and patterns could not. Many people found the model useful, basically as a reminder about interlocking concepts which underpin a particular law or theory. Other teachers tended to ignore it and to teach the material in their own way. The model was criticised because it avoided the issue of how concepts and patterns would be formed and might imply that the route from information to concept to patterns was non-problematic.

The fifth 'principle' involved the choice of integrating themes for the content. Content was divided into manageable units or topics, called 'building blocks'. These were systems, ranging from very large systems like the solar system, to very small ones like atoms and molecules. Pupils studied these systems, the parts of the systems and the interactions between parts and between systems. Interactions involve energy transfer, so there was a major section devoted to energy transfer and this was another of the main integrating themes. SCISP therefore claimed, at least in the rationale for its construction, four integrating ideas: pattern finding and problem solving as activities relevant to all areas of science, building blocks (systems), interactions and change, energy. The team spent time thinking about a uniform approach to the teaching of energy across the sciences. They eventually dropped 'types of energy' in favour of 'energy' (Teachers Guide 3).

The sixth 'principle' was that there must be a one to one relationship between teaching and assessment objectives, otherwise aims and objectives not included in assessment would be omitted in teaching. The types of aims selected, however, required assessment techniques to be extended beyond conventional written examinations. Those that required other techniques were: communicating orally; being accurate in reporting of scientific work, performing simple experiments; being willing to work individually and as part of a group; being willing to search for patterns; and being concerned for the application of science and technology in society. Essentially teachers were to assess these as a routine part of their teaching and to mark pupils against a five point scale in the form of 'pen sketch' criteria (see appendix 2, figures A2.3 and A2.4).

Written examinations required questions which tested candidates understanding of the interactions of science and technology on society, as well as the more conventional areas of understanding of scientific concepts and principles. (See appendix 2, figure A 2.5 for an example). The project team insisted on setting contexts which were novel, so that pupils had to have their wits about them and apply their knowledge in answering questions. This practice caused considerable anxiety amongst some teachers.

Relative weights given to aims is shown in appendix 2, figure A 2.6. The figures can be used to give an indication of the shift that this syllabus and examining system made. Aims 1-4, were similar to aims from say the separate science courses, although couched in different terms. These were given 62% of the marks. Understanding of science and society was given 10%, science investigations 9 %, communication skills 12%, and attitudes 18%. Given the climate of the times, the project team was surprised to have won as much as 20% for the teacher assessment component.

The double award was profiled not on content (e.g. physical and biological science) but on process, with one award (Integrated Science A) being given for *principles and problems*, and the other (Integrated Science B) being given for *principles and applications*. I am not sure of reasons for choosing this particular profiling, although some labelling to maintain an integrated course was needed. The way in which individual papers contributed to the final awards is given in appendix A 2.7. Explicit information about examination procedures, marking, weightings etc. of the sort given in A 2.7 were not exclusive to SCISP, of a general trend in assessment techniques.

The seventh 'principle' was the need for a balanced curriculum in science - balanced across the sciences, to provide an appreciation of the scope of science, an understanding of scientific methods and the context of science, and to keep options for candidates open as long as possible.

The pupils, teachers and technicians books published in 1973/4 represented a *sample* scheme, to show how the principles could be used to organise an appropriate course. There was encouragement for teachers to develop their own course.

LAMP - Science for Less Academically Motivated Pupils

In the year that SCISP was published, the school leaving age was raised from 15 to 16, and the group that had to stay on 'for an extra year' were referred to as 'RoSLA pupils', for several years afterwards. This heightened efforts to think through appropriate courses and projects for this group.

LAMP (Science for Less Academically Motivated Pupils) was one such project. It was developed by groups of schools responding to the need for material which supported the very slow learners particularly in the 14-16 age group. Nuffield Secondary Science, although based on *Science for the Young School Leaver* which targeted the bottom 50%, had proved too difficult for some children without major modification. The group who developed LAMP considered that the pupils needed shorter topics (six weeks), and far greater support. They were unlikely to be able to cope with the generalisations which were expected to emerge from the circus of activities. The work was organised under a series of topics: Fuels, Heating and Lighting in the Home, Pollution, Materials, Photography, Gardening, Health and Hygiene, Space and Space Travel, Paints and Dyes, Flight, Science and Food, Science and the Motor Car, Problem Solving, Fibres and Fabrics, Electronics - each with an 'everyday', easily recognisable title. The materials were published by ASE between 1977 and 1979 (ASE, 1977-9). Progress reports, pleas for help and reviews appeared regularly in ASE publications (*Education in Science*, June, 1977, p19; *Education in Science*, September, 1977, p20, Martin, 1977).

Science at Work

A project developed for a similar group was *Science at Work*, under the direction of John Taylor, the Senior Science Inspector for Manchester Education Authority. The pupils' books were context based. It adopted a double page layout for each lesson, so that by opening the book at any place the instructions for simple investigations and photographs of relevant contexts were side by side. The project had a language consultant, so there was also careful attention to reading levels. The topics were: Fibres and Fabrics, Electronics, Forensic Science, Gears and Gearing, Cosmetics, Photography, Pollution, Food and Microbes, Domestic Electricity, Building Science, Body Maintenance, Dyes and Dyeing. The publications came out between 1979 and 1981, and included full Teachers' Guides for each topic and advice about constructing a mode 3 CSE syllabus and examination based on the material. This series was widely used and became the basis of modular CSE science (or integrated science) courses and for modular GCSE courses later in the decade.

CESIS - Curriculum and Examination System in Integrated Science

As mentioned above, the SCISP team had put, unsuccessfully, a proposal to the Schools Council to develop material for both CSE and GCE. It had consequently been left with developing a course for one section of the population, at a time when teachers found the need for courses and examinations to cover both O level and CSE. In 1974, Professor Kevin Keohane, won money from the Nuffield Foundation to develop a Common Examining System in Integrated Science (CESIS). The project leader was Beta Schofield. Discussions early in the project's life:

showed that the construction of a curriculum framework, with references to Nuffield Secondary Science and SCISP, would not only be a welcome contribution to resources at the disposal of science teachers, but an essential precursor of any attempt to propose a system of examinations.

(Schofield, 1981, p 9)

She changed CESIS to 'Curriculum and Examination System in Integrated Science' and formed an interpretation of a common core in science based on a core plus options model (Waring and Schofield, 1981), because

what was needed was a project to help teachers to make best use of those (resources) already available: that is to tailor them to suit their own pattern of school organisation.

The lack of pupil material for the non-O Level group was an issue:

...the lack of suitable printed material for pupils of average ability became more and more obvious. It was to fill this gap that Nuffield Science 13 - 16 was developed

(Schofield 1981, p 1)

CESIS, publishing under the title *Nuffield 13-16* (1981-3) produced a set of units, of four different categories (basic units to be covered by everyone in the third year, a further set of S units for those who would study just a single science subject, additional D units for those who would study double science and a set of optional (X) modules if there was time (see appendix 2, figure A 2.8). The units were based on titles of chapters in SCISP so that O level candidates could enter for the AEB examinations. A group of teachers in Hertfordshire developed single and double science courses and examinations based on it for both CSE and O level. The respective mode 3 examinations were submitted to both East Anglia Board and Cambridge Examining Board. When these two boards became part of the Midland Examining Group (MEG) the experience of the Hertfordshire scheme was used in the development of MEG's double and single 'Science' syllabuses.

Beta Schofield saw CESIS as a compromise between the two original projects. The offspring of the two parent schemes 'lost some of the more attractive features of each'.

As it developed it moved further away from the loose structure of the eight themes of Nuffield Secondary Science, which had encouraged pupils and teachers to follow their own interests. A comparable result arose from the attempt to relate the framework to the 78 patterns of SCISP and to the resources already available in the sample scheme 'Patterns'. This tended to emphasise concepts at the expense, for some pupils, of some of the other aims of the SCISP project. Looking for patterns, for example, is an activity which becomes unprofitable for many pupils as soon as the context becomes in the

> least abstract. Perhaps such compromises are inevitable in the interests of a common framework
>
> (Schofield, 1981 p3)

c. Evaluation and Implementation of Integrated Science

What evaluations were done of integrated science? The fourth UNESCO meeting on evaluation of integrated science teaching (Cohen, 1977) indicated that in fact only limited work had been done in this area. I have drawn on the limited evaluations of the projects, research which was done in Scotland and the aftercare system of SCISP. The latter two were particularly useful in identifying constraints on implementation.

In considering evaluation of curriculum projects generally, Eraut (1976) distinguished between 'reforming' and 'initiating'; the former referred to projects which took an existing subject, updated the material and reformed the teaching; the latter referred to a new subject or a new timetable slot. *Nuffield Combined Science* and *Science for the Seventies* fitted existing timetable slots as some form of combined or general science was used in a large number of schools. The *Nuffield O level* projects were also reforming projects. SCISP, on the other hand, required a new timetable slot and this respect, as well as many of its other features, made it an initiating project. Eraut described *Nuffield Secondary Science* as 'transitional' because where science was on the timetable for this group, the time devoted could be minimal. Whether a project was reforming or initiating could be a factor affecting the extent of implementation.

Nuffield Secondary Science and Nuffield Combined Science

There was an evaluation of *Nuffield Secondary Science* between January and December 1969 by Dorothy Alexander, chief science adviser for London. She attempted to find out how much 'relevance' had been used in selection of teaching material, whether teachers had made significant changes to teaching approaches and whether attitudes of pupils to science and to their teachers had changed. The results were, on the whole, inconclusive. Slight positive factors emerged 'after one year of use, the teachers' interest in the material has been maintained; the pupils' attitudes towards their teachers has improved and the teachers' style of teaching has been modified.' A disappointing result was that implementation seemed to have effected a 'deterioration in pupils' attitudes to the social implications of science'. One interesting part of the report is a set of comments which schools had received from parents (pp 10/12). While in research terms they are not significant they do give a flavour of the times. Concern about whether there was a qualification to go with the work was made time and time again. Other comments ranged from appreciation that the non-examination stream had not been forgotten, to parents wishing that their science had been like secondary science, to them becoming involved in supplying 'make-do' equipment and coping with interesting questions children brought home.

Two studies on Nuffield Combined Science already cited (Charles, 1976, and Carter, 1977) revealed its popularity and wide spread use. A cautionary note was sounded by Michael Shayer in his analysis of the curriculum materials from a Piagetian levels point of view (Shayer, 1978). He argued that much was too difficult and that many children for whom Nuffield Combined Science was used would not understand concepts and test hypotheses in the way expected.

More extensive research on the implementation of integrated science was done in Scotland by Sally Brown and colleagues and this is reported below. It is followed by material gleaned from the twice yearly meetings of the area co-ordinators from the aftercare system of SCISP. While this was not research, it provides information about the implementation as well as showing some of the changes in contexts that were occurring in the 1970s .

Research into Integrated science - the work from Scotland

Three studies related to integrated science from the University of Stirling in the 1970s give a perspective on developments and on how they were perceived by teachers. The first study was of teachers' views on the reasons for accepting or rejecting the innovation of Scottish Integrated Science (Brown, McIntyre, Drever and Keri Davies, 1976). There were the four features which researchers asked about: integrated science; mixed ability teaching; discovery learning; objectives led teaching.

Reasons given by teachers for acceptance of integrated science fell into four categories: the improvement for pupils; appeal of the courses to teachers; amelioration of shortages of teachers; and the pressures from outside. Improvements for pupils comprised the greater security in working with one teacher, and the value of having a common course for everyone. The appeal to teachers was that they found the broad range of science more interesting than repeating the same narrow range of topics year after year, they enjoyed broadening their knowledge and learning new material. They also commented that teaching mixed ability classes meant that one teacher did not have to teach a class made up of low ability. One teacher per class helped where there were staff shortages in a particular subject, because any science teacher was deemed able to teach the course. Teaching science 'as a whole' solved the problems of limited time allocation for science among separate science departments. Some teachers reported accepting the innovation because it was the policy of the school, or the Scottish Education Department, or the local inspector and these outside pressures were influential. The researchers found little evidence that teachers thought that the course could produce a more scientifically informed population or that the course provided more opportunities for displaying characteristics of science as envisaged by the curriculum planners.

Teachers who rejected integrated science focused on teachers' feelings of their inadequacies, the inappropriateness of the course for later work and resource constraints. Teachers explained their own inadequacies in terms of their specialist training which was unsuitable for integrated science. The integrated science course did not provide the necessary background for pupils to make the choice of subjects suitable for O grade (how would pupils know what physics was if they had not studied it as a separate subject?). The common course was considered not to provide appropriate coverage for the most able and to be unsuitable for the least able. The resource constraints that teachers mentioned were the fact that several classes could need the same apparatus at the same time and there was insufficient. Integrated science courses were unsuitable for accommodation that was widely dispersed because of the transportation of apparatus from place to place, or the expensive duplication of apparatus in several places.

A second piece of research was Sally Brown's article 'A Review of meanings and arguments for Integrated Science' (Brown, 1977). She drew on literature from UK, the States and Australia. She found the meanings of integrated science could be categorised under four headings:

1. the unity of all knowledge
2. the conceptual unity of the sciences
3. a unified process of scientific enquiry
4. interdisciplinary study.

Interdisciplinary studies could have either extrinsic or intrinsic foci. Extrinsic were those that took a topic like public health or food production and studied it from different perspectives. Intrinsic foci were where another subject was automatically necessary for its study such as mathematics in physics; physics and chemistry in biology.

Unified processes of science such as the pattern finding and data interpretation of SCISP were cited but she found that while there might be agreement at a very general level this did not continue to the detailed level, where the processes required for the different areas of science showed marked differences.

The conceptual unity was equally elusive. There were no agreed concepts which spanned all the sciences. Those of SCISP she found unsatisfactory; energy did cross the subject boundaries, but 'building blocks' seemed 'too contrived' and 'interactions' too all encompassing. The unity of all knowledge was not in fact used as a guiding principle for any curriculum.

She explored the reasons which people gave for why integration of one or all of these forms was justified. She listed six reasons:

1. outcome demands by society
2. resource constraints imposed by society
3. political constraints imposed by society
4. the condition pupils require for learning
5. the conditions teachers need to teach effectively
6. constraints imposed by the nature of science

She found none of them fool proof. The outcome demands from society included the need for trained scientists, and for a political leadership and a general public which is informed on scientific matters. Breadth of understanding, including the interaction of science, technology and society were necessary. Courses often reflected political priorities (such as teaching about conservation of fuels in the oil crisis of the 1970s) but these could be transitory, which was a problem for curriculum planners.

In the resource constraints she focused on time, resources and staffing which teachers are allocated. They have to work within these constraints and integrated science might help or hinder in the ways indicated in the previous study.

The political constraints imposed by society were the outside pressures which she had mentioned previously. She pointed out that Bernstein had argued that integration would break down internal structures within a school. She drew attention to

Musgrove's comment that integration can shift power to the top, so that a strong leader might prefer integration because he/she could control everyone through control of the curriculum (Musgrove, 1973).

The advantages quoted for pupils were diverse. One was that curriculum planners could start from scratch without any pre-conceived notion about what *had* to be included and hence could keep material to be learned to a minimum. There were arguments that the motivation of pupils would increase with thematic organisation, but she quotes Kirk (1973) as arguing that motivation is more to do with the teaching than the syllabus. Transfer of learning across the science subject boundaries was claimed to occur more easily so that learning would be more effective. There was a claim that learning would be easier because the course could be built up from basic concepts to complex phenomena. This did not necessarily hold especially if the basic concepts were abstract and the complex phenomena were more concrete. There was Bernstein's claim that the boundary between school knowledge and everyday common sense would decrease and hence increase interest. She quotes Kirk again as arguing that this was not so, that interest and ability to make links depend essentially on the teacher but admitting that there was a greater chance particularly of links being made in an integrated rather than narrow subject course. There were again claims that it was easier to build a good relationship with a teacher who was seen many times. Research in the states at the Centre for Unified Science Education had not revealed any evidence that motivation and interest increased in integrated courses.

The conditions for teachers to teach well reiterated the interest for teachers generated by learning new science and that on the whole this outweighed the feelings of incompetence. Bernstein had argued that there were likely to be more collaborative relationships between staff. She again quotes the work of Kirk in refuting this.

> Kirk (1973) has argued that the social relationships, in this case between teachers, are independent of the organisation (integrated or collected) of the curriculum and depend on the personalities and behaviour of the teachers concerned i.e. 'tender-minded democrats' or 'martinets'.
>
> (Brown, 1977, p 55)

When considering the arguments about the complex and interrelated nature of science she quotes both Eggleston (1974) and Jevons (1969) in arguing that the map of science may be difficult to navigate even if it is drawn. In addition if a complicated diagram is drawn showing all the interconnections this does not in any way imply how it should be taught. The organisation of the curriculum need not necessarily mirror the fundamental categories of knowledge.

She concluded her article with the comment that what should be integrated and how it should be integrated were so far only tentative. The justifications given for why one should bother were based more on assumptions than hard evidence. What was striking about the justifications was that the teachers rarely mentioned the outcomes for society or the nature of the subject. They took courses as they came and got on and taught them.

The third study from Stirling was the study of the ways in which the attitudes to an innovation of individual members of staff were affected by the attitudes of the department as a whole (Brown and McIntyre, 1982). To me the most significant point from this was the distinction the researchers made between the *pedagogical innovations* and the *organisational innovations* required by the new science courses. The innovation was still the Scottish Integrated science course which had four new features already mentioned, namely:

1. the integration of previously separate subjects
2. the grouping of pupils in mixed ability classes and taking account of differences between them
3. new teaching methods (guided discovery)
4. teaching towards specific objectives.

Teachers talked more of the organisational changes than the changes to teaching method, and this gave rise to the researchers drawing the distinction. Integrated science became equated with "all science is taught by one teacher" and mixed ability teaching with "grouping pupils in classes without reference to ability", both focusing on organisational features. The writers argued that this probably happened because organisational changes were clear and distinct and easy for an institution to control. It was difficult for an individual teacher to abandon such a change and once a change had occurred each teacher had little option but to comply. There was also striking success in the speed of the institutional changes. In the two years since the introduction of Scottish Integrated Science 80% of the schools were teaching the course.

Pedagogical innovations on the other hand were less clear, the choice of implementation lay with individual teachers and was not seen as a matter for departmental interference. Teachers were not accountable for teaching methods to the rest of the department. The evidence which teachers provided of instances of the effective implementation of pedagogical changes was limited.

The writers concluded with thoughts about effecting pedagogical change:

> Possibilities for pedagogical change depend on making it rewarding, rather than threatening, for teachers to engage in rational ongoing debate on their day to day practices...
>
> One way in which teachers' work could become more satisfying might be through them having greater independence in deciding on the content and structure of courses....
>
> (Brown and McIntyre, 1982, p 49)
>
> Teacher educators might contribute to the development among teachers of the necessary critical consciousness of their working lives and of the conditions which shape them, if they were to place much more emphasis on reflection in practice.
>
> (Brown and McIntyre, 1982, p 50)

These are all points which I want to refer back to later in the thesis.

The implementation of integrated science courses for 13-16 - a view from the SCISP trials and after care project

Trials for SCISP had started in 1970 with twenty schools (phase 1 schools) and continued in 1971 with another ten schools (phase 2 schools). In 1973, the third phase, the dissemination phase, started with one hundred and twenty new schools. There was a slow but positive recruitment in the next few years but from 1978 onwards the number of schools involved remained static at around 200 contributing to about 1% of the GCE population (roughly) 4000 candidates. SCISP was essentially, therefore, a small enterprise if considered in terms of numbers.

The aftercare system provided significant information about dissemination and implementation. Dissemination reports for the first two years were written by project co-ordinators (Landbeck, 1974 and Lyth, 1975). Subsequently area co-ordinators met as a group with the national co-ordinator every 6 months and meetings were minuted.

Concerns which surfaced both in the trials and the aftercare system were:- third year problems; related CSE courses and subsequently 16+ developments; the acceptability of SCISP to universities and employers; the suitability of SCISP as a basis for A level; teacher assessment; safety in SCISP teaching; O level examinations.

Growth of mixed ability teaching in the early 70s and further development of comprehensive schools presented problems for schools using SCISP. About a fifth of schools in the early trials used it for a wider ability range than the top twenty percent intended (Landbeck 1974). It became clear that 'SCISP as specified by the 1969 brief has been overtaken by accelerating change.' (Lyth 1975)

> More likely than not today's SCISP teacher will be faced with 13+ or 14+ groups of far wider ability range than that envisaged by the original brief. The 13 + groups will have been unselected for the previous two years and the information the teacher needs to select the 'top twenty per cent' group will be hard to assemble. He may not wish to make this selection at all. Information will be equally short if he receives 14+ groups from a middle school. If he receives pupils from several middle schools, the preparation they have had may differ considerably. He will find the pupils' books and topic books too hard for many of the pupils in such wide ability groups.... Like it or not SCISP is no longer an exclusive course for an exclusive group. It is part of the curriculum development pool. If it is to be disseminated at all, the basis must be 'what it can be' not ' what it was'.
>
> (Lyth 1975)

The 'third year problems' (14+) manifested themselves in frequent requests for further resource material for lower ability third year groups. The third year seemed to be a strange 'no-man's land' for a while: the exploratory approach of the first two years began to reach its limits. The knowledge and understanding built up became crucial for the next stage, so that what could or could not be explored depended increasingly on what had already been understood in the first two years. Teachers may have widened the use of the project because they liked the course and wished to extend it to all pupils. Schools were desperately trying to avoid choice of course before the age of 14. The case studies of SCISP schools in Teachers *Handbook* bore this out (Hall, W. 1973, pp 61-69).

Concern to develop courses for a wider ability range continued into the 4th and 5th year. A survey in 1974/5 revealed that over three quarters of the 147 schools using SCISP had developed mode 3 CSEs and that 58 were involved in group CSEs (Craven, 1976). Even in schools where an appropriate group of pupils had been selected for SCISP, staff wanted pupils to be able to transfer to CSE as a 'safety net.' Most examination boards accepted proposals, but there were some difficulties, with boards insisting on titles such as 'physical science' and 'biological science'; others insisted on 'tandem' (the same grade for both certificates) rather than 'dual' (profiled grading) certification. By May 1974 the following titles had been accepted:-

Integrated science A and Integrated science B (dual)	4 proposals
Physical science and biological science	3 proposals
Integrated science (tandem)	2 proposals

Integrated science, Problem solving: Integrated science, Community science (dual)	1 proposal
Integrated science I & II (dual)	1 proposal

Both tandem certification and profiling on content terms were fought by both national and area co-ordinators, as well as by teachers concerned. Tandem certification could have serious disadvantages for pupils

> A grade 1 pass is less likely because an averaging effect occurs. The profiling significance of the separate grade is lost. Since no single pass is available a pupil has to pass both or fail both. Such a decision by a CSE panel could only be supported if the proposed scheme and form of assessment differed widely from SCISP.
>
> (Lyth, 1975, p).

Mike Lyth defined criteria for the 'SCISP-ishness' of a mode 3, in a letter to all CSE examination boards early in 1976. (Advisory Group 11.2.76, letter sent 31 March 1976). The letter provoked extended correspondence with the Midland Examination Board; problems were not resolved until a year later after considerable exchange of letters and meetings. (Reports to Area Co-ordinators meeting 17.11.76, 8.7.77.). Whereas SCISP had worked with an examination board (AEB) for O level it had no authority over the CSE boards. The project was effectively challenging the autonomy of the examination boards.

In a later survey of 78 SCISP schools (Dorling, 1981), 45 offered a CSE based on SCISP with 34 operating a mode 3. This enabled most schools to leave the decision about which candidates to enter for which examination until after the 'mock' examinations in the first term of the fifth year. The main modifications to the course to make it appropriate for CSE were reported as:

- general simplification of treatment
- less mathematical treatment
- additional topics for CSE
- removal of optional material

A working party to develop a 'model common system' based on the experience of SCISP teachers was established in March 1976. Its aims were:

1. to collate, formalise and develop the work of many SCISP teachers who have created mode III syllabuses and examinations based on SCISP;

2. to review and extend the structure of the existing AEB examination ;

3. to provide an examination model in integrated science which would reflect the distinctive features of SCISP in preparation for a change to a common examining system at 16 +.

(SCISP 16+ model, 1979)

The working party concentrated on: producing assessment objectives from the aims, defining the weightings of the objectives; clarifying content to be examined, accommodating the wider ability range; foreseeing the fate of a candidate who chose the wrong alternative paper; deciding on the form and frequency of teacher assessment; producing means of standardising the teacher assessment given the much larger number of teachers that would be involved compared with the number in SCISP. (SCISP 16+ model, 1979). It began a 'patterns expansion' in which more information was given about the level of understanding expected in each pattern. (See appendix A 2.9, for a sample). All SCISP schools had copies to enable teachers to select appropriate parts for different groups. The assumption was that more theoretical patterns would feature in the learning for those who would gain high grades.

The Southern Examining Group subsumed AEB in 1986, when GCSE began. SEG's two syllabuses for integrated science in 1988 (Integrated Science-Applications and Integrated Science-Principles - dual certification; and Integrated science - single certification) were referred to as 'offspring' of SCISP. The single award was a late development, which had been suggested by the SEG working party in 1981 but co-ordinators had been concerned that a single subject could not cover adequate ground. It was shelved in 1982 for later consideration but eventually reappeared in 1988 as a SEG examination. In both double and single GCSE syllabuses in 1988 original features of SCISP were retained (SEG 1988). Most SCISP aims could be traced in assessment objectives except for *perseverance*, *willingness* to work individually and as part of a group, *willingness* to search for patterns, and *concern* for the application of scientific knowledge within the community.

Apart from the 16+ development, acceptability of SCISP was probably the most urgent topic. In his first dissemination report of 1974 Roger Landbeck emphasised the need to devote time and effort to discussing the new course with parents and employers. Dorling's survey (1981) showed that the group most clearly singled out for formal contact was parents:

> 66 out of 71 (schools) report formal contact, and of those 56 had held meetings. The group faring worst overall were employers. A third group 'other staff' relied on informal contacts more than anything else.

Concern over acceptability of the double certification as an entry qualification to universities, apprenticeships and to specific jobs as well as suitability as preparation for A level was raised throughout the aftercare phase. It was clear from the correspondence that worries about acceptably were deterring schools from taking up SCISP, and were giving SCISP teachers cause to think about withdrawing

> Acceptability of the double certification in 1976 was summarised in *SCISP in Brief.* The Standing Committee on University Entrance (SCUE) effectively recommended that two passes in SCISP O level be counted as two passes in any other 2 natural sciences; CNAA gave a similar recommendation for entry to degree courses in polytechnics and, with the Joint Committees for professional Institutions, for entry to a range of ONC and OND courses. Eight other national bodies accepted SCISP O level as a double or single pass in natural sciences for entry into their apprenticeships.
>
> (Lyth, 1975)

Acceptance of qualifications by national award bearing bodies, did not necessarily extend to local institutions, employers, careers officers, nor to faculty staff and admission officers in individual universities and colleges. Project headquarters found problems with the latter were usually one of communication and letters to individuals explaining recommendations from national bodies were all that were needed. A minority of medical schools, however, presented particular problems which SCUE followed up on behalf of project headquarters in 1976. By November 1978 area co-ordinators had copies of replies from all forty medical schools in the UK showing that there were difficulties with only two. Such evidence was important to allay fears which often out of proportion to actual problems.

Another case in Gloucestershire highlighted the same point. There had been difficulties with 6th form colleges not accepting candidates with SCISP qualifications instead of physics for engineering courses. Neil Stears, area co-ordinator, found that colleges did not mind by which of the eight O level examination boards prospective candidates had been awarded physics qualifications. Subsequent study by a group of school and college teachers of what was *common* to all physics O level syllabuses and a comparison of this common element with SCISP, identified the following three items missing from SCISP:-

a) the words 'conduction' and 'convection' as specific words linked with kinetic particle phenomena;
b) characteristics of and calculations on series and parallel electrical networks,
c) knowledge, understanding and calculations on internal resistance in primary and secondary electrical cells.

Gloucestershire SCISP schools undertook to cover these while colleges agreed to accept candidates with SCISP passes providing they had learnt these three extra things. This simple example indicated the labour involved and the need to identify the precise problem which was causing concern.

Dorling found that about 40% of schools had experienced 'some difficulties' with FE establishments. Difficulties with local employers were not always easy to solve and usually occurred with small firms, but only 55% of schools in Dorling's survey had had 'some problems'. Solutions included preparing letters of explanation that pupils could take with them to interview and teachers holding meetings with local employers or visiting firms and talking with relevant personnel. Project headquarters helped organise two large meetings for industrialists in Gloucester and Leeds in 1976. One quite notorious case arose however not with a small firm but with the Electricity Council over the refusal of the East Midlands Electricity Board to accept O level SCISP as an entry qualification for a student apprenticeship in place of O level physics.

The other area of concern was the suitability of SCISP for preparation for A level studies. The aftercare phase produced only limited hard evidence to confirm or allay anxieties. Early studies were on too small a sample to be of much help except as pilot studies. Reports from co-ordinators indicated few difficulties for students in 11 - 18 schools, where A level teachers knew the O level course well. More problems arose where pupils transferred to 6th form colleges for A level studies (Lyth 1975). Dorling found the 'predominance of *Nuffield* A level science courses which for ex-SCISP pupils were represented much more strongly than in the national pattern'

Concern over preparation for A level chemistry seemed to be mentioned more often than for A level physics and biology. A small study undertaken by John Milbourn, co-ordinator for area 2 was of particular interest. He persuaded a group of teachers from 6th form colleges and schools to identify parts of O level chemistry courses essential as preparation for A level chemistry, and then to identify which of these were not in SCISP. As with the Gloucestershire study topics missing were few and could easily be taught in the period after examinations at the end of the 5th year. Schools in the locality agreed to do this for relevant pupils.

Questions of acceptability and suitability were highlighted in October 1977 by the resignation of Mr Mathews as Chairman of the Associated Examining Board's Standing Advisory Committee for Integrated Science. His letter of resignation was widely circulated and contained criticism of SCISP as not giving adequate coverage for A level, of there being far reaching problems with acceptability and because SCISP has failed to promote 'education for social responsibility'. This certainly caused unrest in many of the SCISP schools and one teacher writing about the event argued that the event was ignoring 'the fundamental area about which the real conflict has now risen. SCISP has now become the battle ground for those involved in the wrangle between content and method in the teaching of science'. (Ellington, 1978). The retention of the aftercare system at this point was essential because of the unease which was caused.

A later evaluation was published in 1992, giving a report of a study of candidates going on to higher education from SCISP (Macfarlane, 1992), with the conclusion:

> In all these comparisons the students from balanced science background obtained A level results comparable to, or better than, those gained by students from a single science course.
>
> The underlying theme of staff responses to these findings was that A level results depend more on colleges' willingness and ability to adapt to the needs of students than upon the students' learning experiences before starting A level.
>
> (Macfarlane, 1992, p2)

Standardisation of teacher assessment required teachers to attend standardisation meetings if examination entries were to be accepted by the board. Criteria for awarding grades set up in 1973 were regarded as experimental but remained in use unaltered until O-level was superseded by GCSE in 1988. At standardisation meetings pupils' written work and pen-sketches of pupils' skills were supplied to teachers, who were asked to grade the pupils using the criteria. Grades allotted were made public at meetings and discrepancies between markers discussed. There were three sources of discrepancies, viz.:- marking for a different but related skill; interpreting criteria differently; holding different standards. Discussion went some way to clarifying most points and teachers who found themselves marking consistently either more harshly or leniently from others were trusted to bring subsequent marking into line.

Materials used for these meetings were initially collected from local teachers. In 1979, project headquarters prepared a pack which was used nationally. These packs allowed comparison of marking for the whole country; the measure of agreement revealed was high. Video recordings of pupils were also used. Meetings had an important function as inservice education. For new teachers they were essential because criterion referenced tests were still comparatively new to schools. Some teachers who had attended meetings for years were an important resource; they were prepared to initiate discussion, and could share with others ways, in which they conducted assessments to avoid them becoming an onerous task.

Time allocated for SCISP also became an important focus of discussion; people were mindful of how easy it was to cut short time for SCISP because it looked like one subject, just as general science had been decimated by being implemented in limited time. Time allocated for SCISP varied with an average of 260 minutes per week less than the 280 recommended in Patterns Teachers Guide. (Dorling, 1981 - evidence collected in 1979/80).

A persistent critic of Integrated Science

It would be a mistake to leave this section without mention of Bryan Chapman's attack on integrated science under the heading of 'Integration of the sciences or disintegration of science education'. (Chapman, 1976). Underlying the article was the question about who controls the curriculum. He argued that if many of the justifications and models for integrated science are extrinsic to science, then there is the danger of people outside science determining what is taught.

> The schemes that emerged (Nuffield O level) were essentially reformulations of the separate sciences from within. By contrast the curriculum changes which have occurred in projects such as SCISP have imposed extrinsic integrative principles.... In the various engineering and applied science schemes which have been developed the motivation is clearly extrinsic. ... Radioactivity is of interest not because of what it tells us about the atom, but because it gives us a means of measuring thickness of thin films, of monitoring liquid levels, of testing the efficiency of mixing processes and because it has created a whole new set of pollution problems to solve.
>
> (Chapman, 1976, p135)

He systematically challenged every assumption which underpinned integrated science; unity in science was illusive and beyond the conceptual range of a teenager; the fact that boundaries between science were difficult to define was not a reason to ignore them altogether; teenagers could decide what they wanted to study at 14 and there were mechanisms for coping with any who had made a disastrously wrong choice; the background of many teachers did not equip them for teaching all the sciences well at O level.

He argued that the 'primary reason for exposing the nonsenses that characterise 'integration' is that integration has a powerful ally whose name is 'administrative convenience''

> Schools, partly because of their size and partly because of the diverse academic and social ends which they are increasingly expected to serve, find it necessary to operate within an increasingly bureaucratic framework. Those who succeed in controlling that framework, will, needless to say, control the schools. Changes may well occur much more quickly than we anticipate.
>
> It will scarcely come as any surprise therefore to realize that any proposal to change the curriculum which has administrative convenience on its side is going to be hard to resist. Consider therefore the administrative conveniences that arise from any decision to integrate the sciences. First, timetabling problems are significantly reduced; second, any imbalance between expertise in a science department (e.g. a surfeit of chemists or a shortage of physicists) is hidden; third, advertising for and recruiting new science staff will become less specific...; fourth, laboratory requirements become more uniform and less expensive; and fifth, the problem of uneconomic or imbalanced classes due to elective choices is eliminated.
>
> (Chapman, 1976, p144)

A rather different commentary on the integrated science debate came from Norman Booth at the fifth UNESCO conferences on the teaching of integrated science:

> It is my personal opinion that the enthusiasts for all-out integration of science in secondary schools - a core of science, unified in itself, and cross-linked to other subjects - will for several if not many years to come have to take comfort from a trend that is already becoming evident. Feeling themselves under threat, teachers of the specialist subject disciplines are more and more broadening their perception of what constitutes 'biology' or chemistry or physics at school and indeed elsewhere and moving towards the more comprehensive aims of the integrationists.
>
> (Booth, 1975, p19)

d. Patterns of courses in secondary schools

Chapman was writing in the same year as the 'The Great Debate' about education. This focused on the purpose of education, the nature of the curriculum and whether there should be a 'core' of studies for all pupils to the end of compulsory schooling. Of particular concern was the curriculum which students followed after the age of 14. Choices which pupils were making in the so-called options systems after the age of 14 years were often closing doors for further study in a wide range of areas, were providing an unbalanced curriculum and were not preparing them for life. The HMI report *Aspects of Secondary Education* based on survey information from 1975-8 which was focused particularly on the 14-16 age range, drew attention to the confusion for parents, teachers and pupils alike of the diversity of options and the organisational problems which they gave the schools (DES, 1979, chapter 3).

Science was emerging slowly as one of the areas of the curriculum which began to be accepted as important for everyone, justified on economic grounds (the need for scientists and technologists to maintain and improve the economic position of the country), on utility grounds (needed by people to be able to live in a society dominated by science and technology), on democratic grounds (the need for citizens to be able to participate in debates about the use of science and technology) and on social and cultural grounds (it was part of the culture which needed to be passed on).

In 1977, HMI wrote:

> these subjects (Mathematics, Science and Modern Languages) have significance for national economic efficiency as well as for the cultural and social well being of individuals.
>
> (HMI, 1977, January, Introduction)

National and local surveys at the time indicated the extent of science education in the 14 - 16 age range. Information was given with the added opinion that it was 'a matter for concern' that not all students were studying science, or that they were studying only one science subject, which made their science studies unbalanced.

> Nevertheless it is a matter for concern that in this sample of schools, 9% of the boys and 17% of the girls did no science in their fourth and fifth years, and about 50% and 60% respectively were studying only one science subject. (HMI 1979, p165)

A survey of ILEA schools revealed a pattern similar to the national picture

> between 15% and 20% of boys in non selective intake schools (NSI) do no science at all after third year and that the corresponding figure for girls is between 25% and 40%. It must also be a cause for concern that the current timetables of between 70% and 80% of all NSI schools allow pupils to do no science after third year.
>
> (*Science in ILEA schools* 1978, p 48)

Concerning the wide variation of science subjects studied, HMI wrote:

> In all types of school, girls are much more likely to select biological sciences and boys to select physical sciences. It is sometimes claimed that a higher proportion of girls do physics in single sex than in mixed schools. The figures show this to be so only for single-sex grammar schools; there were too few single-sex comprehensive schools to allow valid comparisons to be made. The infrequent uptake of physics by girls in girl's modern schools reflected traditional attitudes to this subject in some of the schools.
>
> (DES, 1979, p168)

This concern did not extend to the first two years of secondary schooling where science education was regarded less problematic. By 1979 most secondary schools taught some form of combined science course to 11 and 12 year olds and it was part of the compulsory curriculum. Science subjects for 4th and 5th year pupils were however usually entirely within option systems and in some schools as many as 9 different science courses were offered (HMI, 1977, p4 of the report on science). The third year courses (often bridging or transition courses from the combined science courses in the first two years to the examination subjects in 4th and 5th years) ranged from an extension of the combined science courses of the earlier years, to separate courses in physics, chemistry and biology, to allow students to have an opportunity to understand the nature of the different subjects so they could make realistic choices at the end of the year.

Tall (1979) summarised patterns of science courses which were found in secondary schools based on a survey in the Birmingham area. He reported that more than one pattern was found in any one school. He drew attention to the imbalance in the science education of individuals, exacerbated partly by the choices available to them.

> Thus while the rise in importance of biology as a boys subject is to be welcomed the very slow increase in uptake of physics and chemistry by girls is disastrous both to industry and to the cause of female emancipation. The decline in general science because of its poor scientific image has not been matched by a comparable increase in other combined science alternatives such as JMB double science and SCISP. As a result it is inevitable that the proportion of pupils taking a balanced science course must have been declining for a number of years. If balanced or unified science courses are to be given to all pupils leaving schools then considerable heart searching and thought is required by all partners in education.
>
> (Tall, 1979, p 264/5)

Questions within science education, therefore, focused increasingly on 'what science was appropriate for all?' and on ways of moving to a situation where all students studied science until the end of compulsory secondary schooling. ASE initiated its own consultation through its document *Alternatives for Science Education - A Consultative Document*. (ASE 1979). The working party proposed three models of organising the science curriculum. All contained reference to breadth of science in terms of chemistry, physics and biology, with additions of applied science, history and philosophy of science and science and society. Their model 3 was the most radical with a proposal that history and philosophy of science could be an alternative course for 4th and 5th year pupils. They acknowledged that all the solutions were being made on the assumption that 'education is the prerogative of schools; that science education will always be concerned basically with supporting "big" science and "high" technology; and that the essential purpose of education is that of preparing people for a life at work. Even the most casual review of current social, economic and political thinking leads one to appreciate that each of these assumptions can be and is being questioned'. (ASE, 1979, p 50/51)

Publications from HMI were less radical. They valued all three strands of science education (physics, chemistry and biology) and hence suggested all be included in a 'unified science' course. In 1977 they wrote of the need for pupils to learn scientific facts, generalisations, concepts and theories and experimental techniques; to understand the 'utilisation value' of science and to experience the challenge it poses. The phrases 'science for the enquiring mind', 'science for citizenship' and 'science for action' became means of trying to sum up the different facets to which science education could contribute. Precise content was not specified by HMI and 'unified science' of the 1977 publications was replaced in the 1979 publication by the phrase 'balanced science'. HMI focused especially on the time for science, acknowledging that their proposals included not only the need to *increase* the time for science for a large number of pupils, but also the need to *decrease* time for others.

Summary

Integrated science courses emerged in the 1960s. There was a rapid rise in these from the late 1960s until the mid 1970s, not just in the UK. There was a range of frameworks and guiding 'principles' used by course developers to organise the content, and approach of these courses. As a minimum there was an intention to reduce the distinctions between the sciences, by finding links between different components or by finding themes common to them all. The justifications for wanting to find common threads were sometimes intrinsic to science (scientists have similar approaches; the boundaries between one science and another are 'leaky'). Sometimes they were extrinsic to science (people encounter science in technological everyday situations which are intrinsically complex and multidisciplinary). Integrated science courses were characterised in varying degrees by:

- having breadth across the full range of the natural sciences, including geology and astronomy
- being extended into selected parts of psychology and sociology
- involving the application of science in everyday familiar contexts;
- linking science and society in a variety of ways;
- fostering a study of the nature of science;

- teaching children to be scientific and use scientific approaches and methods;
- encouraging problem solving - either scientific or technological
- being taught by one teacher (especially in the 11-13 age range)
- supporting environmental education
- addressing the social responsibility of the scientist.

No one definition or integrating theme emerged. Courses were constructed which used a mixture of the list above as organising themes. Each course in UK was developed with a very specific population in mind: 'the potential scientists'; 'the younger pupils just starting science'; the 'middle ability groups'; 'the less able', and the foci selected reflected the developers' perception of the needs of these pupils, as well as their image of science.

Each course had its own specific context in which it was implemented. Nuffield Combined Science and Scottish Integrated Science were designed for contexts where existing practice did not make the implementation too difficult. Nevertheless constraints on teachers' ability to cope with the wide range of science were evident in some cases, while other teachers found the range made the job more interesting. Nuffield Secondary Science was provided for a population which were increasingly moving from the non-examined group, to the examined group. It was therefore up against the pressures that the secondary modern syllabuses had previously faced: that as examinations loomed syllabuses looked more like the academic syllabuses of O level courses. Its ideas survived however in later courses such as Science at Work which appeared in the 1980s.

The Schools Council Integrated Science Project was a small enterprise in terms of number. Nevertheless it provides useful information about problems of implementation. It was designed for the group of students where science was best established (the O level cohort) and where there was a tradition of separate sciences. The concerns teachers had about expertise in the Scottish Integrated Science course were enhanced in SCISP as the material was more difficult and the students increasingly more challenging. The solution of two teachers per class was the norm, but this required a level of collaboration and co-operation which was not typical of patterns of working of most teachers. The course inevitably ran into problems of acceptability from the universities and from employers. The unfamiliarity of its certification titles was a contributory factor. The course did, however, break new ground, and provided evidence of how a wider range of aims could be assessed, not only by written examination papers but by teachers assessing students as an intrinsic part of the teaching.

The raising of the school leaving age, the introduction of CSE, and the mounting acceptance of science in the curriculum, meant that there were far more children sitting science examinations in the 1970s compared with the 1960s. Surveys towards the end of the 1970s however indicated great variation in the amount and type of science being studied, with a marked gender difference. A solution to this was seen as an administrative one: make it policy for everyone to have about 20% of their time in the fourth and fifth year on 'balanced science', no more time and no less. While balanced science was not necessarily integrated science, the justification for many of the integrated science courses, were the same as the justification of balanced science. Suggestions from HMI on what constituted balanced science had much in common with the framework of SCISP.

If schools were to be guided by this policy (and in the late 1970s it was only a suggestion from HMI, not official policy) then this would involve a major rationalisation of courses in schools' option schemes. Duckworth School, which I studied from 1977 - 1980, was a school undergoing such a rationalisation. The case study of this transition, which appears in chapter 5, gives an insight into the intricacies of implementation of such a policy at the level of the school. These complement the more general insights on implementation which have emerged in this chapter.

CHAPTER 5

INTEGRATED SCIENCE AT DUCKWORTH SCHOOL, 1977-1980

a. Changing the Pattern of Courses

Introduction

The account of Duckworth school during the two and a half years that I monitored the change in the pattern of courses was agreed by the staff of the science department. This part is marked with a line down the left hand margin to distinguish it from my reflections on what happened.

Duckworth school was a large mixed comprehensive school which opened in 1967 when Duckworth grew from a small village to a town with a population of about 20,000 and the school changed from being secondary modern to comprehensive. It was on two sites. What had been the secondary modern school housed the 11 and 12 year old children on one site. There were extensive playing fields as well as a small rural studies unit on this site. A newer building constructed for the opening of the school housed the rest of the school, and was about a quarter of a mile on another site. Some older pupils used the lower school building for a few lessons so there was movement of both staff and students between sites. In 1973 the school had 2,000 pupils, rising to 2,400 in 1974, when temporary mobile classrooms had to be used at the upper school. Sixford school opened in a nearby town in 1974 and Duckworth's roll began to fall, to 1,840 in 1977/8 and to 1,740 in 1978/9.

By 1977 the school had a core curriculum for 4th and 5th year pupils consisting of mathematics, English, humanities and physical education. In addition pupils had to select one science subject from one of the option lists.

Science courses 1970 - 1980

In 1970 Duckworth school had been a phase 1 school for trials of SCISP. Staff had selected one class of third year pupils who remained in the trials through their 4th and 5th years and took the special project examination in 1973. From 1973 SCISP became an established course in the school. Initially staff selected one group of 'the most able third year science students' on the basis of results in second year examinations for the SCISP course in the third year while the rest started courses in chemistry, physics and biology. The school had been large enough to offer courses in physics, chemistry and biology alongside SCISP. Similar third year groups were selected in each of the following two years so that by the start of the academic year 1975/6 there were SCISP groups in years 3, 4 and 5. The first group (other than the original trial group) entered for public examinations in 1976. Most were entered for the O level examination but a few for a double certification CSE examination which the department, in conjunction with staff from another SCISP school, had devised and submitted to the South East Region Examining Board (SEREB) under mode 3 regulations.

During 1975/6 the science staff wrote a third year course in integrated science so that in the academic year starting September 1976, all third year classes embarked on this course. Selection for SCISP was therefore delayed until the *end* of the third year, after 1976.

Figure 5.1 Science courses at Duckworth school 1976/9

Science courses at Duckworth School 1976/9

Year	Courses	hrs/ fortnight	Level	no. of teachers per class
1976/7				
1&2	General Science	5	mixed ability	1
3	Integrated Science	8	mixed ability	2
4&5	SCISP	10	O(2) & CSE*(2)	2
	Physics	5	O(1) & CSE(1)	1
	Chemistry	5	O(1) & CSE(1)	1
	Biology	5	O(1) & CSE(1)	1
	Environmental sc.	5	CSE*(1)	1
	Rural science	5	CSE*(1)	1
	Sc. comp 5th yr. gen course	5	no exam	1
1978 onwards				
1&2	General Science	5	mixed ability	1
3	Integrated science	8	mixed ability	2
4&5	Int.Sci.(double)	10	O+(2) & CSE*(2)	2
	Int.Sci.(single)	5	CSE*(1)	1
	Sc. comp 5th yr. gen.	5	no exam	1

*mode 3
+SCISP O level examination
NB. 5th yr. students in 1978 were of course still following the earlier pattern of courses. This was the last year of the 'non-examination' group in science.

Early in 1976 it became clear that with falling rolls teaching groups would be smaller than usual and viability of some options was questioned. After discussion within the science department and with other teachers, the department decided to offer only integrated science in the fourth and fifth years, starting in 1978. Figure 5.1 shows science courses in 1976/7 and 1978/9. Teaching of integrated science courses was split between two teachers for each class, one with a strength in physical science and one in biological science, the same pattern of staffing that had been used since the introduction of SCISP into the school in 1970.

Changing from separate science to integrated science 1977 - 80

The school changed, effectively, from having separate science courses up to 1972 to having only integrated science courses for everyone up to the age of 16 in 1978. I was able to create only a sketchy picture of how decisions to change had been made. There were several factors reported which made staff aware that modifications were necessary. Reduction in the number of pupils in the school has already been mentioned. More boys chose only physical sciences and girls only biological sciences. Separate science groups did not have the most able pupils because these were strongly recommended to take SCISP. Some members of department believed SCISP 'philosophy' should be available to all pupils, others had been uneasy about the decision to drop separate sciences but were prepared to go along with the majority and contribute to the development of the new courses.

From 1978 the school's core curriculum for fourth and fifth years changed to English, mathematics, double humanities, science and physical education, making science a component for the first time. Science teachers had originally hoped that a double subject course would be compulsory for all but this was turned down by the headmaster. They had to settle for 10% of the timetable being available for science within the core and a further 10% being available for 'double scientists' within the option system. They decided that the double course would be available at O and CSE level, but the single science course would only be available at CSE level. More able pupils were to be channelled into the double science course.

There were fifteen months between the decision to change courses (May 1977) and the time when staff had to teach them (Sept. 1978), and a further 15 months before entries for appropriate O level and CSE examinations were sent in, ready for candidates sitting the papers in summer 1980. This committed the science staff to complete within two and a half years, two new science courses, (the single and double). Course material, once devised, had to be typed and duplicated for all members of staff. CSE courses and assessment procedures had to be approved by the

Figure 5.2 Science Teaching Staff at Duckworth School 1976 - 1980

Science staff Duckworth School 1976 - 1980

Pseudonym	**Date app.**	**1976-7**	**1977-8**	**1978-9**	**1979-80**
Martin Jameson	Sept. 1974	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Peter Bardsey	Jan. 1975	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Frank Clegg		✓✓✓	✓✓✓	✓✓	
Sandra Harmsworth	Sept. 1971	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Tom Ackroyd	Sept. 1972	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Kenneth Pines	Sept. 1972	✓✓✓	✓✓✓	✓✓✓	
Helen Talbot		✓✓✓	✓✓✓	✓✓✓	✓✓✓
Betty Pack	Sept. 1973	✓✓✓	✓✓✓	✓✓✓	
Marion Simonds		✓✓✓	✓✓✓	✓✓✓	✓✓✓
Philip Hilman	Jan. 1978		✓✓	✓✓✓	
Jane Page	Sept. 1979				✓✓✓
Margaret Shaw	Sept. 1979				✓✓✓
Brett Laybrook			✓✓✓	✓	
David Green	Sept. 1971	✓✓✓	✓✓✓	✓✓✓	✓✓
Alan Hull	Jan. 1978		✓✓	✓✓✓	✓✓✓
Colin Race	1955	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Bevan Olden	Sept. 1979				✓✓
Terry Donne			✓✓✓	✓✓	
Geoffrey Thorburn			✓✓✓	✓✓	
Barry Barber	Sept. 1977		✓✓✓	✓✓✓	✓
Alfred Manes	Apr. 1980				✓

Figure 5.3 Responsibilities of science staff at Duckworth School in September 1977

Responsibilities of science staff at Duckworth School in September 1977

Pseudonym	**Pay Scale**	**Responsibility in the department**
Martin Jameson	ST	Head of faculty of science and maths.
Peter Bardsey	Scale 3	Head of Biology
Frank Clegg	Scale 3	Head of Chemistry
Sandra Harmsworth	Scale 3	Head of Physics
Tom Ackroyd	Scale 2	I/C SCISP
Kenneth Pines	Scale 2	I/C third year
Helen Talbot	Scale 2	I/C environmental science
David Green	Scale 2	I/C lower school
Betty Pack	Scale 1	
Marion Simonds	Scale 1	
Brett Laybrook	ST	
Colin Race	ST	
Terry Donne	Scale 1	
Geoffrey Thorburn	Scale 1	
Barry Barber	Scale 1	

ST stands for senior teacher, a salary scale above scale 4. Brett Laybrook and Colin Race were STs for responsibilities outside the science department.

examining board. Laboratories had to be reorganised, apparatus re-catalogued, filing systems established, and visual aids put into a central collection. The new science courses had to be timetabled within the whole school curriculum. The teachers involved over the period of course development are shown in figure 5.2, with their responsibilities at the start of the change shown in figure 5.3.

Writing courses

Writing the third year course

The third year course was an 8 module course (see figure 5.4), based on *SCISP Patterns 1*. Keith Pines and Tom Ackroyd had originally planned and written a reasonably detailed scheme of work for the third year course for 1975/6 and 1976/7. In 1973/4 they had introduced four SCISP modules into the existing third year courses. In 1976/7 several teachers had written teacher's guides and pupil material for modules in more detail; when I arrived there were eight well produced and neatly bound teachers' guides, with related worksheets for students, prepared, duplicated and filed.

Each module had a test, comprising mainly multiple choice questions. Results from tests combined with an overall mark for coursework (routine homework marking on five pieces of coursework) and a comment from the teacher on progress generally, were used to decide on achievement and on which courses students should follow in the fourth and fifth years.

Figure 5.4 3rd year science course in 1977/8 through to 1979/80

Modules in Duckworth 3rd year science course 1977/8

Classification
Communities
Man And His Environment
Particles And Electricity
Energy
Magnetism
Chemical Nomenclature
Only One Earth
The Earth And Its Evolution

Designing and writing the double science course for 4th and 5th years

Initially every member of the department participated in discussion relating to aims and content of the two new courses, but trying to involve everybody proved slow. Hence two sub-groups formed, one for the double science and one for the single science course. Groups worked independently of each other and no one person was a member of both.

It was April 1978 when staff finally agreed on a framework for the double science course, nearly a year after the decision had been taken to have new courses (May 1977). Three factors contributed to the delay. First, consideration of who should be responsible for the course did not take place until a staff meeting in December 1977; second, deciding on the outline took four months; third, the curriculum change began to affect the structure of the science department and associated problems had to be resolved. The staffing issues are reported in part b. of the chapter.

At the meeting in December 1977 a 'double science' team was established consisting mainly of the three heads of subjects, with Tom Ackroyd and Kenneth Pines in January 1978. The team requested it have authority to make decisions without going back to the department, and this was agreed. Meetings were to be open so that anyone could attend, but after the first week only the central team met.

The three heads of chemistry, physics and biology and Tom had met previously in November 1977 to consider the structure of the new course. They decided that it should be broken into self contained but linked units, in a way similar to the structure used for the third year course. A possible framework for the double science course existed in the form of the guide for SCISP that Tom had written in July 1976. This guide gave staff an indication of time to be spent on different sections, which investigations from SCISP books had to be included, and how the course could be divided between two teachers. In addition there was a mode 3 double certificate CSE syllabus and examination specification available. This guide was, however, not used at this point.

A period of discussion and rethinking occurred. Geoffrey presented a paper to the department meeting in December 1977 in which he had divided the SCISP patterns into topics easily identified as physics, chemistry, biology and geology. Other teachers had reservations about this on the grounds that the essential SCISP 'flavour' would be lost. Geoffrey's paper did not emerge again. The next day three of the teachers met to list all the 'patterns' that had to be included in the new double science course. Over the Christmas holidays Frank tried different ways of organising the patterns but found that if he did not keep to a structure similar to SCISP some aims would be lost. At the end of January 1978, Tom produced a paper in which he listed the investigations in his current 4th and 5th year course, identified the subjects that each traditionally belonged to (physics, chemistry or biology) and included notes from his own experience of teaching such as 'rewrite necessary', 'remove from this point in the course, too difficult (e.g. the chemical mole)'. Subsequently staff from the three subject departments studied their parts of the course, decided the conceptual level of the work (which meant deciding the year in which it should be taught) and added notes and suggestions such as 'needs a specialist to teach it', 'well integrated'.

In February 1978, a group of eight of the science teachers went through the relevant SCISP books (*Patterns 1–4*) and decided whether a section was well integrated; which parts needed rewriting; whether parts were out of place because of conceptual difficulties or because of the mathematics required; and whether a specialist was needed. Many people doubted the need for a specialist but Tom insisted that there would be poor teaching if say the unit on motion were taught by biologists. He chose a particularly poor example because Kenneth, another biology graduate, had successfully run an inservice session on the third year unit on motion. The matter was left unresolved. By having meetings this group eventually produced a list of 26 units in an appropriate order. These units are listed in figure 5.5.

The final list of units and the way in which they were to be taught was similar to the framework which Tom had written in 1976, but this process of discussion over four or five months was essential. It enabled a wider group of staff to become familiar with ideas in SCISP and hence contribute meaningfully to planning the new course. (Some of the staff, e.g. Peter, had never taught any of SCISP and so had had no pressing reason to read the books; other staff had taught only half the course.) It also allowed everyone who had a vested interest in the course to contribute to it. In retrospect, it is possible to regard Tom's strategy of having the course considered in detail by specialist groups as eminently wise. It did not threaten colleague's autonomy within their subjects and began the move towards subject consultants (see chapter 5 part b.).

The framework of the course was complete and agreed by April 1978. Although each unit was associated with a section of SCISP, teachers decided that the units must be rewritten to accommodate the wider ability range. Also teachers who had already

Figure 5.5 Progress made on preparing the double science course by September 1978

Progress made on preparing the double science course by September 1978

Unit		Chapter	Year	Writer	State	Subject
A	Introduction to patterns	1.1	4	FC	complete	IS
B	Galaxies and Earth	1.2	4	TD		A,G,B
C	Communities and popn... competition & predation	1.3 2.9	4	KP,TA,PB	complete	B
D	Organisms, cells	1.4,1.5	4	BP,PB,TAP	complete	B
E	Molecules	1.6	4	FC	complete	C
F	Atoms and Giant structures	1.7	4	FC	typed not printed	C/P
G	Electrons, ions & giant structures	1.8	4	AH(BP&TA)	typed not printed	C/P
H	Particle interactions	2.10 3.2	4	BB	typed not printed	P/C
I	Motion	2.13	4	SH		P
J	Electrical interactions	2.11	4	BB	typed not printed	P
K	Classifying building blocks	2.14	4	AH,TA		IS
L	Energy transfer, work and machines	3.1	4	BB		P
M	Waves	3.1	4	BB		P/G
N	Sources of Energy	3.4	4	PB,TA		IS
O	The Mole	1.6	5	FC,AH		C
P	Electricity	3.3	5	DG		P
Q	Efficient Use of P/IS/STS energy	3.5	5	DG,TA		
R	Changes in acidity	4.3	5	AH		C
S	Changes in motion	4.7	5	SH,BB		P
T	Changes in organisms	4.6	5	PB		B
U	Changes in atoms	4.8	5	SH		P
V	Changes in molecules	4.9	5	AH		C
W	Changes in populations	4.10	5			B
X	Stability	4.11	5			IS
Y	Changes in Environment	4.12	5			IS/STS
Z	Changes in Society	4.13	5			IS/Soc.

Sections 2.15. 4.1 and 4.2 from the SCISP sample scheme were omitted.

Code: A astronomy; B biology; C chemistry; G geology; P physics: IS all sciences; STS - science, technology and society; Soc. - sociology

taught SCISP reported that they had found it difficult at first, and thought they could help colleagues by documenting 'wisdom' accumulated by hard experience. In particular experienced staff had found ways of economising on time which was necessary because it was difficult to complete the course in the time available. The figure shows an interesting feature, namely that the chapters of SCISP in the fifth year were less integrated across the sciences than in the previous two years. This had been a deliberate policy on the part of the SCISP development team, to give a clearer identity to the separate sciences in the fifth year, for pupils wanting to select subjects for A level.

Writers set unrealistic dates for completion, hoping to have all fourth year units ready by the end of the summer term 1978. In the event only one unit was completely typed and duplicated by the start of the academic year 1978/9. Figure 5.5 shows progress made by September 25 1978. By December 1978 teachers produced units as they were needed for teaching and this continued for another year. By March 1980, however, one member of staff reported that he had just handed in Unit R which he had finished teaching in the morning and he was in the middle of writing unit V which was wanted the next day by one member of staff. Some of the final units were inevitably taught from the original SCISP books with individual teachers making their own adaptations for different ability groups.

Writers found their task far from easy. Only a few teachers were familiar with the complex network of ideas in SCISP. Writers frequently had to *learn* new material before they could include it in a unit. Even where writers were familiar with a topic they had difficulty in judging the background knowledge of colleagues and deciding how much detail to include. Above all, devising teaching material and assessments to match specific objectives was a difficult exercise. Writers commented on the lack of time available. No extra free time was allowed and staffing difficulties made the situation worse.

Units were usually written by one person, although they were planned by two or three. Sandra commented that when people worked entirely on their own it often represented their confidence but not necessarily their competence! She also reported that it was possible to forget what she had written. She once came across some worksheets for a unit in her handwriting but had forgotten that she had written them. Tom checked units for safety and for whether they fitted the course aims before they were typed. Typing was done by the writer of the unit, one of the laboratory technicians or by two of the teachers' wives. There was no secretarial help available to the department except from within its own resources. Appointing a laboratory technician who had typing skills had been a deliberate move on the part of the head of department but he reported that it was not a practice approved by the Local Education Authority.

Units were produced in typed booklets of about 20 pages with coloured cover sheets, containing lesson titles, lesson notes and time allocation. Where appropriate there were revision sheets for work from year 3. Notes contained experimental details, worksheets, homework sheets, resources for the teacher other than equipment i.e. books, visual aids, pamphlets, and resources for pupils. Multiple copies of worksheets and homework sheets were prepared and stored elsewhere for easy access by all members of staff. Initially only enough worksheets for one year were duplicated as staff planned to improve the fourth year course the second time round. In the event this improvement had to be delayed for another year.

Summative Assessment procedures for double science

The course had to fit both AEB's O level examination for SCISP and the school's mode 3 CSE. Assessment objectives and assessment procedures for O level were described in chapter 4. Examination objectives for the mode 3 CSE double integrated science course are listed in figure 5.6 and were grouped under knowledge (K) and skills (S). K1 focused on understanding concepts and information across the sciences; K2 on the ability to use patterns to solve 'pure' science problems. K3 had the STS element. S1 focused on experimental skills in designing and setting up; S2 on communication of both events (reporting) and of evaluations of experimental procedures; S3 on interpretation of experimental evidence. They were similar to SCISP aims but the objective 'skill to work on one's own or as part of a group' was omitted along with attitude objectives. The two CSE subjects were called: *Integrated science - problem solving* and *Integrated science - community science* and the weighting of the syllabus is shown below in figure 5.7. With the exceptions of aims K2 and K3, the objectives were evenly distributed between the two awards. Assessments of the 4th and 5th year syllabuses each contributed equally to the final assessment. No questions were set on the third year syllabus.

Three assessment tools were used for CSE: written examinations (E) (contributing to 50% of marks), assessed coursework (C) (contributing to 30%) and practical tests (P) (contributing to 20%). Figure 5.8 summarises how these were used to assess individual objectives. For each subject there were ten assessed pieces of coursework, six practical tests and a two hour examination. Each piece of coursework was of 'one hour's duration and was either a test, classwork or homework in the ratio 6:2:2.'. Practical tests each lasted an hour. The marks for tests set by the school were standardised, each one having the same total and standard deviation.

CSE candidates were judged on performances throughout the 4th and 5th years whereas O level candidates were judged in the 5th year only. Consequently if an O level candidate showed steady progress throughout the course, the best achievement near the end would be recorded as the final mark. For CSE candidates an average over the two years was taken. The course was edging close to the structure of a modular course. The type of assessment, with a predominance of tests with fixed mark schemes, gave greater uniformity across the department. It reduced the requirement for individual teachers to exercise professional judgement in coming to a final grade. Grade boundaries would be moderated by an outsider for the group as a whole.

Figure 5.6 Mode 3 CSE double integrated science examination objectives

KNOWLEDGE

1. To recall and understand information that will enable a candidate achieving a double grade 1 CSE pass to follow any of the Sciences - Biology, Chemistry or Physics to A level (K1)

2. To understand the importance of patterns to the Scientist and to see their importance in solving problems. (K2)

3. To understand some of the relationships of Science to Technical, Social and Economic development, and to be appreciative of some of Science's limitations. (K3)

SKILLS

A. To be able to organise and use apparatus to construct experiments which help in the formation of patterns. (SA)

B. To have learnt to report scientific work accurately and to be able to discuss and possibly explain sources of errors in results. (SB)

C. To be able to link experimental work into patterns and use these patterns to solve some problems. (SC)

(This will not be examined but will be taught)
D. To be able to select and use other available resources, such as books and articles which are relevant to a problem. (SD)

Figure 5.7 Weighting of objectives for CSE double integrated science course, *Integrated Science: Problem Solving* and *Integrated science: Community Science*

Objective	Problem solving SO2	Community Science S15
K1	40%	40%
K2	30%	
K3		30%
SA	10%	10%
SB	10%	10%
SC	10%	10%
Total	100%	100%

Figure 5.8 Assessment tools related to objectives for the double science courses [*Integrated Science: Community Science* (S15) and *Integrated Science: Problem Solving* (SO2)]. The numbers are percentages.

Syll.	Assess Tool	Knowledge objectives						Skills Objectives								Sub total		Total	
		K1		K2		K3		SA		SB		SC		SD					
		S15	SO2	S15	SO2	S15	SO2	S15	SO2	S15	SO2	S15	SO2	S15	SO2	S15	SO2	S15	SO2
	Exam	15	15	0	10	10	0	0	0	0	0	0	0	0	0	25	25		
4th	Prac	0	0	0	0	0	0	5	5	3	3	2	2	0	0	10	10	50	50
	Class	5	5	0	5	5	0	0	0	2	2	3	3	0	0	15	15		
	Exam	15	15	0	10	10	0	0	0	0	0	0	0	0	0	25	25		
5th	Prac	0	0	0	0	0	0	5	5	3	3	2	2	0	0	10	10	50	50
	Class	5	5	0	5	5	0	0	0	2	2	3	3	0	0	15	15		
	Exam	30	30	0	20	20	0	0	0	0	0	0	0	0	0	50	50		
sub-	Prac	0	0	0	0	0	0	10	10	6	6	4	4	0	0	20	20		
total	Class	10	10	0	10	10	0	0	0	4	4	6	6	0	0	30	30		
Total		40	40	0	30	30	0	10	10	10	10	10	10	0	0	10	10	100	100

NB. The submission for examination in 1980 (submitted to the board in September 1978) was a modification of the earlier submission which the school had made (Tom Ackroyd, in fact) for the course which was to be examined in 1978. The earlier submission had a project which was used to assess SD. This is the reason why a non-assessed objective appeared in such a formal way on the summary grid.

Designing and writing the single subject science course for 4th and 5th years

Almost the entire single science course was planned and written in the first instance by one person, Martin, the head of department. This was a contrast to the double science course where there had been what amounted to competition amongst staff to be involved.

Martin produced the course outline (figure 5.9) and presented it to colleagues at a department meeting in December 1977. He had developed it partly from looking at a range of other CSE courses and curriculum projects such as LAMP and partly from his experience of teaching science to the non-examination 5th year group. He emphasised that the course must be socially meaningful and 'not constrained by what's needed later academically'. He reiterated this when talking with me two years later by referring to the single science course as taking its justification from life and the double science course taking its justification from science.

Figure 5.9 Proposed units for the single science course, December 1977

Proposed Units for the Single Science Course

motor vehicles (8 hrs);
photography (8 hrs),
illusions (5 hrs);
electricity (7 hrs) and electronics (8 hrs);
the Earth and her neighbours (19 hrs)-
(covering geology, astronomy and weather);
gardens and plants (12 hrs);
pollution (6 hrs);
personal science (mostly human biology, health & hygiene) (20 hrs);
continuity of life (6 hrs) and early development (8 hrs);
power for man (11 hrs);
man made materials (13 hrs);
metals (9 hrs).

At the meeting in Dec. 1977 Martin invited others to write any sections they wanted. No one was forthcoming at the time, but one of his colleagues pointed out that he must already have planned much of it if he had been able to specify times for each section. Martin insisted that this was not so but did not press for volunteers and the meeting moved on to other business. At the end two people, Helen and Betty, offered to write the unit on gardening. The following January, Geoffrey asked Martin who would write the course if nobody else volunteered. Martin said that he would and that is what happened.

This difference between the development of the single science course and the double science course warrants comment. It could be that the single science course did not challenge subject autonomy in the way that the double science course did. The reason may have lain in the different relationship between Martin as overall head of department and his colleagues.

A small group of staff, Betty, Helen, Kenneth and Marion, did meet Martin in July 1978 and went through a more detailed outline of the proposed course. The group suggested a number of improvements and indicated where they would need help in their teaching. During the summer holidays Martin wrote two thirds of the course in lesson by lesson detail and the first unit on personal science was typed duplicated and distributed to staff. By November 1979 however this course was in the same state as the double science course. Units were ready only a day or two before they were to be taught and this did not allow for full preparation. One cause of the delay was lack of help with typing and reprographics. Eventually Martin typed most of the units himself.

The units consisted of between 15 to 35 pages and each was divided into two sections, one for teachers and one for pupils. The teachers' section contained reasonably detailed notes on each lesson, a summary page listing titles of lessons, and indications of where advanced planning was necessary. The pupils' section contained experimental sheets, information sheets, record sheets and homework sheets.

Martin made it clear that his course was not prescriptive. Each unit carried the preface:-

> This represents a set of resources on which teachers may draw - a selection of material which could be used in this topic. It provides a complete and coherent short course which could be used in its entirety and without addition by an inexperienced teacher or one working in an unfamiliar field. More experienced teachers may wish to select and adapt this material always keeping in mind that the work must be appropriate to the target population.

Quite early in the preparation of the course Martin found that collecting necessary books and pamphlets for resources was difficult because the chosen topics did not fit any particular textbook topics. Models and apparatus were also not conventional science department equipment. The technical department was helpful in supplying sections of induction coils, carburettors, batteries and car engines. Colin Race, who had been in the school since 1955 when it was a secondary modern school said:- 'Since Martin has been doing this course he comes down to me to see if I've got any useful odds and ends. I've kept old junk from when I taught plumbing. If you wait long enough it all comes round full circle!'

The final list of units comprised:-personal science; man-made materials; pollution; gardens and plants; electricity and electronics; continuity of life and early development; earth and her neighbours; when my body goes wrong; motor vehicles; power; first aid; metals.

Martin reported that, although he was short of time, he particularly enjoyed the task of curriculum development. Since he had been at the school he had been involved to a large extent in administration outside his teaching commitments. He did comment that he found it easier to write the course himself than to spend time chasing other people.

Summative assessment of the single science course

A separate, and entirely new, submission had to be made to the examining board for the single science course. The board required clear statement of aims, assessment tools, weightings of different objectives, and grade boundaries. The submission was a 'limited grade' submission, in which it was not envisaged that candidates could score more than grade 3, although the criteria did make allowance for this possibility. Samples of practical tests, end of unit tests to be used for coursework, and the sort of question to be used in examination papers were submitted. Figure 5.10 gives the aims with relative weightings (which of course had to be reflected in the teaching as well as the assessment); figure 5.11 gives the way the different assessment tools were used to assess each objective. Written examinations contributed 50% of the marks, course work 40% and assessed practical work 10%. There were ten end of unit tests for the coursework and five assessed practical tasks. Figure 5.12 gives the specification of grade boundaries.

The difficulty of specifying grade criteria can be seen in the description of grade 5: here a 'pensketch ' of what might be thought of as typical of grade 5 is given, but does not represent positive criteria against which to mark. It could imply that the pupil had to be careless to achieve a grade 5.

Figure 5.10 Assessment objectives for the single science course

Assessment objectives of the single science course

A. An ability to recall the factual content of the syllabus. (40%)

B. An understanding of the factual content of the syllabus and the ability to interpret it. (40%)

C. An awareness of the impact of science on society. (10%)

D. An ability to follow experimental instructions, carry out practical work, link it with course work, report it accurately & draw valid conclusions.(10%)

Figure 5.11 Assessment tools related to objectives for the single science course.

Syll.	Exam Prac Class	Mark distribution in percentages for different objectives				Total %
		A	B	C	D	
4th	E	8	8	4	0	20
	C	0	0	0	4	4
	P	8	8	0	0	16
5th	E	12	12	6	0	30
	C	0	0	0	6	6
	P	12	12	0	0	24
sub-	E	20	20	10	0	40
total	C	0	0	0	10	10
	p	20	20	0	0	50
Total	P	40	40	10	10	100

Figure 5.12 Grade criteria for the single science course

Grade criteria submitted to SEREB for the Single Science course

CRITERIA FOR THE AWARD OF GRADES(Grades 1 & 2 are unlikely to be awarded except in exceptional cases)

GRADE 4
A candidate would have a fair knowledge and understanding of the syllabus content, follow practical instructions well, observe and note the more obvious aspects of the work and be aware of the impact of science on everyday life.

GRADE 1 (As written and used in Duckworth school, the courses would produce a grade 1 pass only in a very exceptional case).
A candidate would have a very sound knowledge and understanding of the syllabus content, understand even the most difficult ideas involved and apply them, take a keen interest in the part which science plays in society and show an exceptional flair for practical wok and its accurate recording.

GRADE 2 (As with grade 1, it would not be envisaged that many students would achieve this standard).
A candidate would have a good knowledge and understanding of the syllabus content, (taken to mean a knowledge of 50% of the syllabus), follow practical instructions well, be accurate in the performance and recording of experimental work and show a personal interest in the impact of science on society.

GRADE 3
A candidate would have a fund of factual knowledge of the syllabus (30%) and an unclear understanding of science and its importance in life, find it difficult to follow practical instructions, be careless with apparatus and report very little accurate experimental work.,

GRADE 5
A candidate would have some factual knowledge of the syllabus and an unclear understanding of science or its importance in life, find it difficult to follow instructions, be careless with apparatus and report very little accurate experimental work.

UNGRADED
A candidate would show a very unsatisfactory knowledge and understanding of the work, perform and record very little accurate experimental work, and be unaware that science has any real part to play in his life.

Organising the teaching of the new courses

The department adopted the policy of involving most people in only one of the new courses at the start. Teachers were paired for the double science course, but not for the single. Pupils came to science in half year blocks and the department banded them into top, middle and bottom bands for both the double and single courses. With many classes being taught at the same time it was important for classes to be at different parts of the syllabus so there was no clash over resources. Tom Ackroyd played an important role here in devising a scheme for the department, as he was the only one who had a complete view of the course because of his previous responsibility for SCISP. He was not officially in charge but filled many gaps in the administration.

Teachers' reactions to the new courses have been summarised under the section on inservice education below. A few teachers mentioned the pupils' reactions. Kenneth had found that one or two pupils had reacted adversely to the title 'gardening' as they did not conceive that to be science. He suggested 'horticulture' as an alternative. Martin found many units divided pupils on interest grounds. In his group some were very interested in gardening while others could not wait to get onto the next unit.

Most staff took the initiative to adapt course guidelines to fit their own styles of teaching. In an interview in June 1978, Marion a part-time teacher commented that some students' sheets did not seem appropriate. Other teachers in the preparation room where we were talking reported that they did not use sheets that did not suit their classes, which surprised her. As a part-time teacher she often missed the informal communication.

Work was not differentiated within the units so that teachers had to adapt their teaching to the different double science sets. Guides indicated to some extent how this could be done; reference to the original SCISP books was a means of indicating suitable activities for the most able.

From internal assessments to examination grades

By early May 1980, marks from internal assessments had to be standardised, collated and assembled for each candidate, mark lists prepared for SEREB and the results of teacher assessments done for AEB. For CSE candidates, staff had to decide on the CSE grades 1 and 4 boundaries. I attended a meeting on 21 April 1980 when staff were engaged in this exercise for assessments on unit T of the double science course. The meeting had been arranged by Peter as a training exercise. It was extremely difficult for anyone who had not taught the unit and staff relied on the judgement of Peter and Alan. When marks and work were eventually scrutinised by the board's moderator in June there were no great discrepancies between the school's marking and his.

The staff met deadlines as far as the board was concerned, but were aware that in future they should make greater use of assessments as feedback to both pupils and teachers. Assessments had been marked by one person for the whole department, hence individual teachers were not receiving feedback on their classes' understanding and on their own teaching. Martin commented that marking was invaluable to him both as a teacher and as a curriculum writer. Because test grades were used for CSE grades nobody could go over a test with their class until all candidates had completed it, by which time pupils had forgotten about it. Alan Hull commented that he wished that they had as many assessments but that only half of them were used for examination grades. Such a step would involve re-specification which was unlikely to be done for some time.

The pressure towards the end had affected writing assessments. Peter found that his later tests were worse at discriminating particularly at the boundaries where this was needed. Alan found, on the other hand, that he became more skilled and efficient at writing tests which were easy to mark and yet retained their other qualities.

Inservice education and communication channels

Teaching staff

New skills and knowledge required

Writing and teaching the new courses made considerable demands on teachers' skills and knowledge. Many teachers, however, commented that they learnt a great deal from the exercise and were aware that the involvement had contributed significantly to their professional development and confidence.

There were several types of difficulty reported. Teachers found it difficult at first to judge the level of detail that was necessary in the guides. It was easy both to overestimate and underestimate the support that colleagues needed. They also frequently had to sort out their own understanding of the science before writing.

Some teachers found difficulty in matching teaching and assessments to course objectives. There was evidence of neglect of process objectives, in particular. In preparation for the use of end of unit tests as part of the CSE assessment, the course team had allocated quite precisely what objectives, with their weightings, had to be assessed in each unit. For instance the practical test on Unit E, molecules, had to test objectives SA, SB, and SC (see figure 5.6) and marks had to be allocated in the ratio of 9:13:14. The course work had to test objectives K1, K2, SB and SC, with marks allocated in the ratio 15:15:6:9. Some teachers had attended courses on assessment but many had undertaken no formal training.

In teaching unfamiliar topics staff discovered that making the relevant practical activities 'work' was the most difficult aspect. Alan (chemistry graduate) summed this up with one example:

> 'The theory of cm radio waves is fairly easy; I can understand that from a book; but making the apparatus work is the problem - what wire to connect where and what to do if the apparatus doesn't work the way that you expect.'

I noted during the few observations of lessons which I made and at staff discussions that unfamiliarity with equipment and techniques, was a major problem. And not only in alien subjects; some of the biology staff had never grown seeds in a seed box nor a garden!

The third area was interpersonal skills and the ability to work as a team. There was no training of any sort to help with this except experience.

Means of improving

Several means of inservice education occurred: the use of formal sessions; the use of informal channels of communication; studying privately; staff seeking help from specialist colleagues on an individual basis; staff learning from teaching.

Only one formal training session took place during the period of this study and significantly it involved complicated apparatus. Sandra demonstrated to all staff the use of the Perrin tube. Previously during the development of the third year course there had been three formal sessions:- one on the teaching of the unit on particles, given by Frank; another on geology given by Tony and a third on the movement unit, given by Kenneth.

Informal communications depended to some extent on where staff taught. Jane, a new member of staff in Sept. 1979, learnt a lot from Peter, not because he was head of her section but because:

> 'He happens to be teaching in the laboratory next to me and if I have forgotten anything I have to go through his laboratory to the preparation room to collect it. I often pause for a second or two and he makes some comment about how the practical is working. This is particularly valuable when we have parallel classes.'

Morning coffee break and tea at the end of the day in one of the department's preparation rooms were important for sharing information. This was noticed by Jane when she was new to the school. At first she went to the staff room for coffee but soon found that she was missing important information. Links at an informal level, with other departments in the school were also essential so the science staff made a practice of going to the main staff room at lunch time. Part time teachers did not benefit as much from this; they were not able to use these channels of communication as effectively.

Private study was a dominant means of learning; not only learning from books. Martin bought electronics kits for the electronics unit in the single science course and teachers took these home to work through the practical activities.

Individuals also sought specialists. Sandra became an important source of information partly because there were so few physics specialists on the staff. Alan helped colleagues with chemistry, and Peter and Kenneth with how to standardise tests.

Teaching provided its own inservice education and was explicitly mentioned by teachers. Alan, discussing his ability to write units, commented that he really did not know whether he was good at it and thought that early comments from colleagues were a particularly poor guide. In the first year of the course he had received complaints about particular practical activities, only to be told the following year that they were good; (magnesium was said not to react with dilute sulphuric acid, whereas in the second year it did! An experiment where potassium chlorate was dissolved in water at a high temperature and solubility products were measured as it cooled down had been deemed difficult in the first year and a good experiment in the second.)

The technical staff and the effect of the change on them

New knowledge and skills needed

The technicians are an essential part of the staffing of a science department; they rarely initiate curriculum change. They are seldom involved at the evolution of new ideas and begin to appreciate the implications of a new course as it is implemented and have to adapt to the change in a short time. In November 1979 and June 1980 I spoke with many of the technicians in an attempt to find out how the new courses had affected them.

Before the new courses started each laboratory was serviced by one technician (or two part time technicians). Chemistry had been taught in the chemistry laboratories and serviced from the chemistry preparation room. Similar arrangements were made for biology and physics. SCISP had had its own laboratory in a hut separated from the other laboratories, its own set of equipment, and its own technician. The third year Integrated Science course was taught in all laboratories. Technicians maintained apparatus and stock in 'their area' and looked after requests from staff in those laboratories. Usually each member of staff taught all her/his lessons in one laboratory so there were reasonably close relationships between individual teachers and respective technicians. This made communication easy. Only two members of staff did not have their own laboratories: these were Helen who was based in the lower school and Martin the head of department. Martin had not taken a laboratory for himself because as head of department he had a section of a small room as a personal base.

When the new courses started technicians continued to maintain apparatus and stock in their laboratories and to service the lessons that were to be taught in their laboratories (see the names of the teaching and technician staff on the plan of the laboratories). Alan however could be teaching unit P (electricity) in the chemistry laboratory and this meant that Shirley had to prepare the apparatus from things located in the physics laboratories and preparation room. To begin with she did not know where they were stored and this usually meant asking another technician. With some apparatus she might find that she did not recognise them when she found them. So inservice education was as important for technicians as for teachers. The changed situation and different tasks for technicians necessitated the head of department preparing a document summarising the technical staff structure for 1979-80, and in particular specifying the role of the senior technician.

Means of acquiring new skills

All technicians reported that they had learnt a lot during the changes. They learnt mostly from each other as the teaching staff 'were too busy with writing'. Shirley had learnt how to make up agar jelly plates for microbiology from Joanne and she had subsequently marked these instructions in her copy of the unit which no one was allowed to take from the preparation room. She shared this copy with Angela the morning technician. Shirley reported that although the change was hard work she was proud to be able to set up a physics trolley and know that it was correct, which she would not have been able to do the previous year. Joanne who had always worked quite closely with Peter rather than with other technicians 'I muddled along with the power lines with Peter' and sorted out how they worked. She attended the meeting when Sandra had explained the use of the vacuum tubes and reported learning a lot of physics from Don. Don said that to some extent he had enjoyed learning new bits of science (he always checked that he knew how things worked when he borrowed apparatus from other people's laboratories) but he found he did not really like chemistry. He also said he was happiest working at the things that he knew he did well.

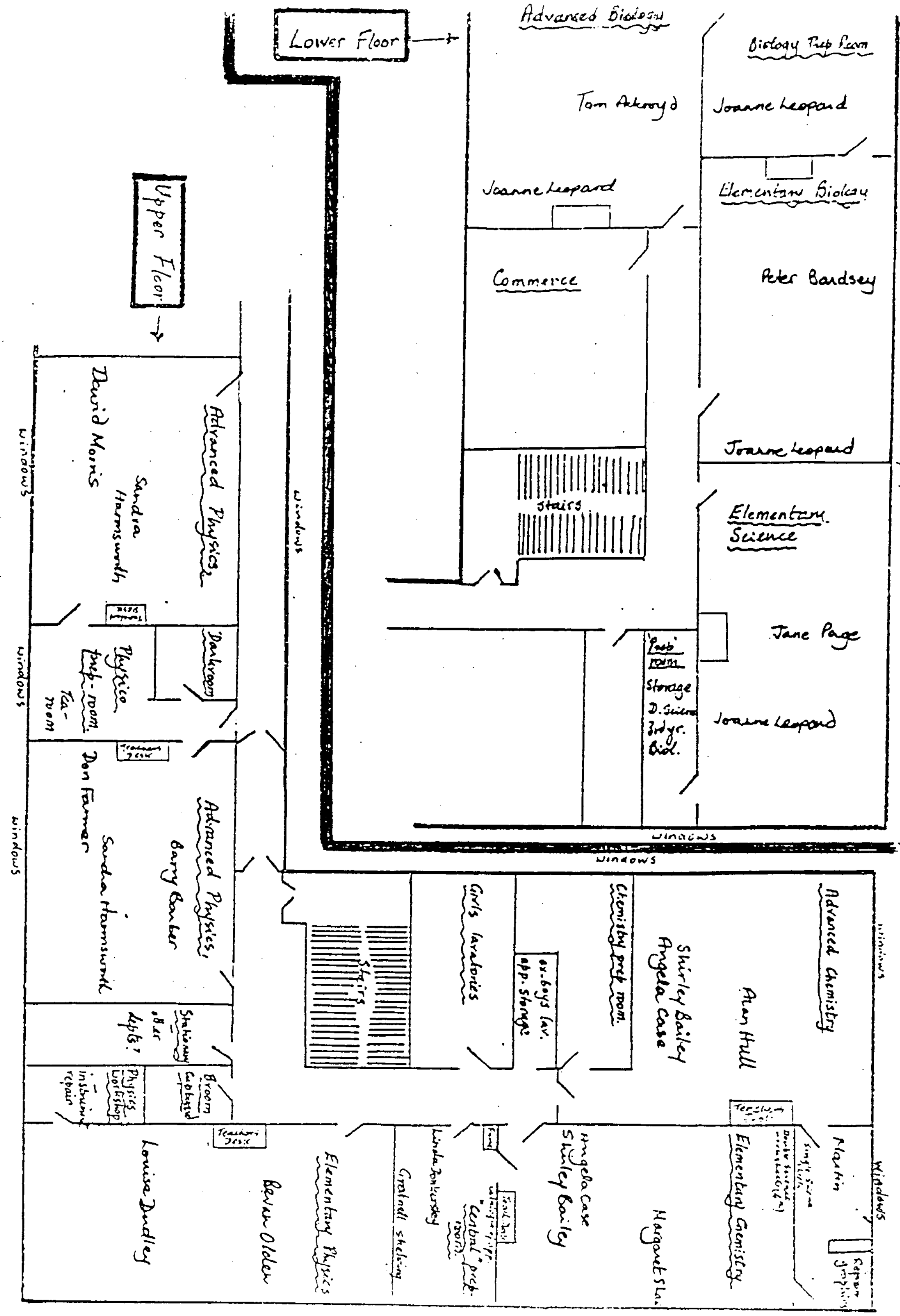
The new arrangements did require technicians to communicate with a larger number of people even though they were still servicing the same laboratories and the same staff. They now had to be aware of what the whole department was doing and Shirley reported communication problems in the first year. Technicians had a peg on which staff hung requests for apparatus etc. but teaching staff had no such place. She did however report that as the course developed problems reduced. New informal channels began to emerge and everybody became aware that there was a wider group of people who had to be told about particular points.

During the first year of the course the technicians found that care of equipment was not as good as previously. Don reported having to repair far more electrical meters and Joanne reported one or two microscope slides being broken; but no other specific examples were given. Peter reported that the Perrin tube had blown during his lesson the day after Sandra had given the inservice talk on the use of all the large tubes; most people were prepared to give him the benefit of the doubt and put the failure down to the age of the tube. The fact that apparatus had to be moved more increased the risk of an accident; of items falling off trolleys and of trolleys being bumped in corridors. Jolting was enough to loosen contacts on some electrical equipment.

The laboratories and equipment

A particular curriculum is built into the physical structure of a school. This is particularly evident in school science laboratories. Duckworth School had been designed for separate science subjects (see figure 5.13), each laboratory with its preparation room and specialised equipment. Chemistry rooms had fume cupboards; physics equipment was stored in the physics area. Visual aids were located in sub-departments with no central co-ordination. Teachers and technicians did not know what resources were held in other parts of the department. Some teachers regarded apparatus as 'theirs' and were not sure other teachers were entitled to use it.

Figure 5.13 Science laboratories in Duckworth Upper School 1978



Change in the curriculum therefore required change in established practices. Apparatus had to be stored so that every one had easy access; servicing of equipment had to be co-ordinated between all technicians. The preparation room between elementary chemistry and elementary physics, and the biology preparation room on the lower floor were modified to become central stores for routine equipment and glassware. For this purpose the department bought £1 800 worth of Gratnell shelving which was put up during the summer holidays of 1978 by teachers and technicians. The new storage system had to be catalogued, not only because apparatus was in new places but because technicians would need to prepare apparatus that they had not previously used. Teachers and technicians initiated the system but one technician, Shirley, prepared the cards during the holidays. Within a year these cards needed modification but without them the technicians would have found their job impossible.

Laboratories were used more than previously because more pupils studied science. This altered daily work loads for technicians and created particular problems when practical skills of pupils were to be assessed. For practical tests pupils had their own apparatus and question sheet, which had to be set out before the class started. For the first lesson of the day this could be done the night before, for the second lesson it could be done during the morning break and for the fourth lesson, during the lunch hour. But for the third and fifth lessons there was no time available between lessons. Staff found ways of surmounting the difficulty. One teacher asked her previous class to put out routine equipment - things like Bunsen burners and glassware, and two technicians came in between classes to put out chemicals. In one test students each had 2 white powders (labelled A and B) so 50 specimen jars had had to be filled and labelled. Apparatus for assessed work had to be kept together until all six classes had completed it. This testing could be spread over a week and sometimes longer. This caused difficulties for other lessons. If, for instance, 24 stop clocks were set aside for practical tests, they were not available for teaching.

Technicians became aware of increased movement of apparatus as a result of the curriculum change. Don had made large trolleys which were a help on any one floor but not between floors. Here apparatus was usually carried because it was easier than using the small lift, which was not large enough to take a person or a trolley. Although teachers taught in a particular laboratory for most of their time, it became necessary to change rooms for some classes to avoid heavy and/or expensive apparatus being moved between floors.

As mentioned before technicians noticed an increase in the need for repair of apparatus during the start of the new course. Teachers unfamiliar with equipment were also less familiar with possible damage that might be done. Subconsciously there was not the pride of ownership that had occurred before. 'My microscopes' can be an inhibiting attitude, unhelpful to colleagues who want to use them, but it also generates a pride in looking after them. This is not deliberate but is a factor in this sort of change.

In 1978/9 the sharing of apparatus became a problem. The course was new and staff had difficulty in anticipating where clashes would occur and in staggering lessons accordingly. Books were also in demand in two places at the same time. If the department had had more money, duplicate sets of books would have been bought.

Another result of change was that ordering of equipment and consumable material needed to be undertaken by a team and not independently by three sub-departments. In the second half of the summer term of 1979 a team of four people, Sandra, Peter, David and Shirley met once a week for an hour and went through each unit of the double science course ordering the apparatus still needed. They had £1 500 to spend on double science including updating of apparatus and consumable material for the third year course and looking ahead to the needs of the fifth year course. The latter was difficult as not all units had been written. Ordering of apparatus for the single science course was undertaken by Martin on his own. There was a need for more consumable material with more pupils studying science but no increase in the budget allowed.

The final phase - June and July 1980

With examinations completed and many of the pupils having left school there was relief amongst the teachers that they had met deadlines. Related tasks that needed to be done and which had been shelved earlier began to be undertaken, often by people who had not been central to the development of the new courses.

This was in marked contrast to the reaction colleagues had to Alfred's suggestions when he joined the staff in April 1980. He suggested alterations that should be made to the third year course and was surprised by the cold reception his ideas received. When he read my report of the changes, coupled with staff shortages, that had occurred since 1977, he recognised why staff could not contemplate more change.

Science courses in the 1st and 2nd year - note added in 1996

The first and second year science course was not discussed much at the time, but for completeness a summary of it is given here. The course was divided into sections (see figure 5.14) which were essentially physics, chemistry and biology and drew on the Nuffield O level materials, Nuffield Combined Science as well as other books. The staff regarded the course as one in which they set a priority on students developing a lot of practical skills and techniques.

Figure 5.14 Science course for the first two years, 1978

First and Second Year Science Course

Year 1 Units

B1 The microscope
B2 Microbes
B3 Reproduction (including human reproduction)
B4 Seed dispersal

C1 Introduction to chemistry (Bunsen, sols/ sep. mixtures/ acids and alkalis)
C2 Effect of heat on chemicals
C3 Extracting chemicals from raw materials

P1 Measurement
P2 Simple circuits
P3 Magnetism
P4 Simple Investigations into light
P5 Temperature
P6 Sound

Year 2 Units

B4 Seed dispersal, germination
B5 Food and testing for nutrients
B6 Environmental science (range of habitats)
B7 Tree studies

C4 Physical and chemical change. Oxidation and the reactivity series
C5 Oxidation

P7 Forces
P8 More light
P9 Heat movement (conduction, convection and radiation)
P10 Expansion

Summary of part a.

Staff at Duckworth School had prepared, organised, taught and examined two integrated science courses for fourth and fifth year students between 1978 and 1980. All other courses had been phased out at the end of the academic year 1977/78. The two courses were different in time allocation, approach and to a large extent content, their development had taken place independently.

The changeover to the new courses was an intensely busy period which put a great demand on a range of teachers' skills. Teachers and technicians were aware of rapid growth in their professional skills and knowledge during this time, but were also aware of a sense of incompetence when dealing with new subject matter for the first time; this was reported most often in terms of whether a practical activity 'worked'. Writing course material rarely occurred much in advance of the teaching and towards the end course material was generated during teaching and recorded in a more systematic way afterwards.

In the early stages, teachers had to stop the double course being framed under chemistry, physics and biology. The processes by which they developed a framework gave teachers an opportunity to understand the principles behind the construction of SCISP and to have some ownership of the framework. Teachers made the assumption that a specialist was needed for parts of the course, and divided the teaching of the new double science courses between two teachers, just as they had done for the third year integrated science and for the SCISP courses earlier. There was more involvement in the double science course than the single science course. Reorganisation of resources, laboratory equipment, visual aids, was an intrinsic part of the curriculum change. Science teaching is heavily resource based. Resources are stored and maintained for easy access for teachers and technicians to fit the demands of the teaching; any change in the courses required a related re-classification of resources.

The change in the curriculum created new responsibilities which had to be distributed between the existing staff. This challenged the existing structure of the science department. Distribution of new responsibilities and changing the structure became significant issues and are described in part b.

b. The effect of changing the pattern of courses on the science department structure, Duckworth 1977-80

The development of the new courses affected the structure of, and hierarchy within, the department. I had not anticipated it, although in retrospect I should have. The structure of any organisation is a mix of rational planning and what happens to have occurred but is related to tasks and responsibilities of that organisation. If these tasks and responsibilities alter then the structure of the organisation has to evolve to adapt. The science department at Duckworth school was no exception.

Concern over people's roles within the department had been raised in 1976 soon after the formation of large faculties within the school. It is useful to quote in full the opening paragraphs of a document written by Frank, head of chemistry, in collaboration with the other two heads of subject departments.

> It is no secret that I have for some time been very concerned about the present role of a head of department in Duckworth School. During the time I have taught at Duckworth school I have never had the framework of such a role defined to me satisfactorily by a senior member of staff. It has always been assumed that a new head of department knew what his responsibilities were. I believe that the head of department's already nebulous role has become even more confusing in the era of the big Faculty. It appears that in the past the role of a head of department was defined solely by the head of the department himself and the limits of tolerance of his colleagues. Put in its simplest terms it meant carving out an empire for himself. I contend that such a course of action was, and still is, the cause of much hostility and disenchantment among the staff of Duckworth school, and must distract and interfere seriously with the main purpose of their professional role, i.e. to teach. I therefore believe such action to be wrong. Further I am totally opposed to it and find the concept distasteful both mentally and professionally. I have therefore given much thought as to the proposed role of the head of department and I accordingly submit these thoughts in writing as the basis of a discussion document. (Then followed a list of 16 aspects the role of head of department.)

At the time Martin invited all members of the science department to write down their roles as they saw them and produced a summary paper. Through discussion staff attempted to rationalise the structure of the department. Figure 5.15 gives a summary of how responsibilities were shared between different people. This structure was the one that existed when the research started in Sept. 1977. Scale points were given for particular tasks and many of these related to curriculum areas of physics, chemistry , biology, environmental science and three of the posts related to integrated science or combined science courses.

As head of faculty Martin had overall responsibility for a 'Science and Mathematics' faculty of about 26 teachers, 8 technicians, 14 laboratories and a budget of £10 000. He was part of the school management team as a member of the academic board and as head of one of the largest faculties in the school. He was responsible for appointing new members of staff. Much of the job entailed ensuring that all tasks were appropriately distributed among the staff.

The heads of the three sub-departments of biology, chemistry and physics were seen as part of the management team of the science department and sometimes Martin met with them separately from a full department meeting. They had considerable autonomy within their own section. They had responsibility for other staff within their sub departments; for recommending them to Martin for promotion, for allocating classes to them when timetables were drawn up, for their general welfare and for their appointment when they first came to the school. They helped decide how the departmental grant should be divided and spent their section's share. They monitored how their subject was incorporated within all courses in the school and the standards set. It should be noted, however, that the three had slightly different jobs. Two of the chemists were senior teachers in other areas of the school and hence would not be looking to Frank for promotion recommendation, whereas Peter had six biologists in his section all on scale 2 or 1. Sandra's department was the smallest of them all, comprising just herself and Barry in summer 1978, and herself alone for the middle term of 1979/80.

Figure 5.15 Science department structure 1976/8

MARTIN (ST)
Head of Faculty (Science and Maths)

PETER(3) Head of Biology — FRANK(3) Head of Chemistry — SANDRA(3) Head of Physics

TOM(2) SCISP — KENNETH(2) I/C Third Year — HELEN(2) I/C Environmental Science — DAVID(2) I/C Lower School

BETTY(1) MARION(1) BRETT(ST) COLIN(ST) TERRY(1) GEOFFREY(1) BARRY(1) PHILIP (1)

nb. Staff on the highest salary have been placed nearer the top except in cases where the 'points' were given for responsibilities held outside the science department.

Figure 5.16 Subject grouping of staff within the science department, January 1978

Physics

Sandra Harmsworth (HoD), Barry Barber, Trevor Donne

Chemistry

Frank Clegg (HoD), Alan Hull, David Grant, Brett Laybrook, Colin Rees

Biology

Peter Bardsey (HoD), Tom Ackroyd, Kenneth Pines, Helen Talbot, Betty Packer, Marion Simmonds, Philip Hilman.

All teachers on a scale 2 post were in charge of a named task within the department's work. Tom, in charge of SCISP, organised the teaching of the course, spent the allocated money, looked after the SCISP laboratory, which was serviced by one technician, submitted a mode 3 CSE syllabus to the appropriate board and wrote the examination. Kenneth, in charge of the third year integrated science course, organised the writing, testing and preparation of the course as well as the day to day running. The course had to have appropriate links with the fourth and fifth year courses and with the lower school science course. The end of unit tests and the end of year examination were used to select students for the science courses in the following year. This involved statistical work in order to standardise the scores in the tests. Helen, in charge of environmental science, had written and submitted a mode 3 CSE syllabus with the help of colleagues in 1975 and had to prepare the CSE examination each year. She had to advise students about the course, spend the money allocated for the course and set work when staff were absent. In preparing the laboratory for environmental science she had painted the room herself.

David, in charge of the lower school science course taught in the lower school , ordered the necessary apparatus and books, helped the head of faculty in timetabling staff and laboratories, supported colleagues as necessary, and was responsible for course evaluation and development. During the period of the research there was little development or evaluation of this course as everybody was more concerned with the new 4th and 5th year courses.

The new 4th and 5th year courses required collaboration of the three sub-departments. Staff were faced with the problem of organising this so that no one head of the three sections had greater authority than the other two. Tom's position and expertise created an additional complication. He had the greatest experience of the O level course which was already a double science course and which was being used for the basis of the new courses. Sandra and Frank had taught sections of SCISP several times but Peter had not. At the time the staff did not articulate the problem quite in this way, but, in the period from Feb. 1978 - June 1978, it is significant that between 8 and 10 meetings took place between Martin, and the heads of the three sub departments, in order to define roles and tasks within the department. For the rest of the year 1977/8, the team responsible for the writing of the double science course comprised the three heads of the sub-departments, with the addition of Tom, who was in charge of SCISP and Kenneth who had responsibility for the third year integrated science course. Nobody was appointed as chairperson.

During this time the head of the school raised the question as to whether the structure of the science department should change. The suggestion was that there should be a 'deputy' appointed on a scale 4, who would be in charge of the double science course and that A level courses would be the responsibility of staff appointed on scale 2. The idea was that the department would evolve slowly into this new structure and new moves would be made as people left the school. It appears that at one stage early in the discussions about the departmental roles, the head of the school offered Tom the post of co-ordinator of the double course but on his existing scale (2), which Tom declined. The responsibilities were eventually shared for the year 1978/9 so that no one was promoted and everyone seemed to have the appropriate authority. The chart for 1978/9 is shown in figure 5.17.

Figure 5.17 Science department structure 1978/9

MARTIN (ST)
Head of Faculty (Science and Maths)
Single science course co-ordinator
Overall discipline

PETER (3)	FRANK (3)	SANDRA (3)
Head of Biology	**Head of Chemistry**	**Head of Physics**
Control biol. syll. (1-7)	Control chem. syll. (1-7)	Control phys. syll (1-7)

Rotating chairmanship of the double science team (one term each)
responsible for discipline for four other members of staff

TOM (2)	KENNETH (2)	HELEN (2)	DAVID (2)
I/C SCISP(yr5)	**I/C Third Year**	**I/C Environmental Sci**	**I/C Lower School**
'involved' in co-ordination of courses in yr. 3-5			

BETTY(1)	MARION (1)	COLIN (ST)	BARRY (1)

Tom was to be involved in the co-ordination of the work in yrs. 3 - 5; in particular the organisation of the new syllabus and teaching order, production of the mock examinations and external SCISP entries (including mode 3). In practice in the early stages of the development he was the one person who had a map of the whole course in his head and all the co-ordinators relied on his experience of SCISP. Kenneth took over the responsibility for all the internal tests for years 3 - 5. He did not write the tests because the writer of each unit did this. He standardised the marking and also ensured that sufficient test papers were available and adequately filed. Barry took over the responsibility for maintaining up to date stocks of worksheets and assessments for the third year course. Helen had taken over the responsibility for lower school science at the beginning of the year when David had left. Slowly as the courses altered everybody was taking on tasks which affected nearly everyone in the department.

The staff planned to do the same exercise a year later but some rethinking had to be done earlier than that as Frank left at Easter to take another scale 3 post in Somerset. There was no replacement for Frank until the start of the next academic year. In accordance with the long term plan Alan, who had been in the school since January 1978, was given a scale 2 post in charge of A level chemistry. Kenneth left in summer 1979 so his responsibilities had to be redistributed. Otherwise there were no changes in departmental structure. Figure 5.18 summarises the structure that emerged for 1979/80

Under 'syllabus Mode III', Tom was responsible for syllabus preparation for years 3, 4 & 5; production of teaching notes; organisation of the teaching order; production of the 5th year mock examination and the CSE mode III double science examination 'in collaboration with the rest of the team'. In other words the same 'hybrid' structure remained in an attempt to retain the status of the existing staff and to use Tom's expertise to the full.

The responsibility that the three scale 3 teachers held for supporting other members of staff over discipline was part of an arrangement for removing the idea that a science department is made up of biology, chemistry and physics departments.

Before the start of the academic year 1979/80 there were several staff changes. When Kenneth left he took with him much of the department's knowledge of examination statistics. The original intention had been that he should train Alan to do this, but Alan took on so much writing of the double science course after Frank left that he did not have time. Some expertise was passed onto Peter, who was also attending inservice courses run by SEREB for markers and moderators.

Figure 5.18 Science department structure 1979/80

MARTIN (ST)
Head of Faculty (Science and Maths)
Single science course co-ordinator
Overall discipline

PETER(3)	SANDRA(3)
Head of Biology (6&7)	Head of Physics (6&7)
Control biology syllabus (1-7)	Control physics syllabus (1-7)
Control of rural studies unit	Examinations secretary (school)

Co-ordination Of Double Science

MAINLY PETER	MAINLY SANDRA
Statistics and records	Money and equipment

Shared Responsibility
Control of CSE
Control of O level
Assessment specification
Marking distribution
Exam control oversight
Examination entry
Trip organisation (3 & 4)

HELEN (2)	ALAN (2)
I/C Lower school science	I/C Chemistry (6&7)
	I/C Chemistry (1 - 7)

Syllabus Mode III	Worksheets	Resources	Tests & Assessments
TOM (2)	JANE	MARGARET	BARRY
	DAVID	MARION	HELEN

At the start of 1979/80 three new members of staff joined the department, Bevan Olden, Margaret Shaw and Jane Page). For the Autumn term 1979 the department was fully staffed but Barry left at Christmas and no replacement was made until Easter. So again the department was short of one member of staff during this time. Alfred was appointed for the summer term but Derek left for promotion at Easter and no replacement was made until Autumn 1980. So for the summer term 1980 there was also a shortage of staff. Alfred's appointment broke the tradition that scale 3 appointments were made for named roles within the department; neither did it fit the new model that was supposed to be evolving. It was justified by 'it would be impossible to attract someone with a physics qualification and some years' teaching experience without offering a scale 3!'

It would be foolish to try to identify clear-cut reasons why people left at this critical phase of the department's work. But perhaps the following reflections are useful. Many of the teachers had been at the school for 5-8 years and this is often when people look for the next step in the career ladder. The staff had been stable for some time and had included teachers who held senior positions within the school. A stable staff with considerable experience can contemplate the sort of development that Duckworth undertook; but teachers who innovate will also be 'go-ahead', enjoy a challenge and look for the next step.

Brett left to take up a deputy headship in a nearby school. He had been one of the people enthusiastic about integrated science and had taught SCISP in the early days. Kenneth left to take up a scale three post in the midlands. The training that he had had at the school by being involved in so many courses had been a valuable 'commodity' when it came to looking for a new job. Kenneth was originally qualified in biology, but the new post involved responsibility for an integrated science course at CSE and O level physics. He soon earned himself the reputation at the new school for hard work but admitted that he was not working as hard in the new school on a scale 3 as he had worked at Duckworth on a scale 2.

David left for a scale 3 post elsewhere, having been at the school for nine years. Barry had been at the school for three years and left for a scale 2 post. There seemed no possibility of his acquiring a scale 2 at the school, although it remained a matter for speculation amongst the science staff as to why the head did not feel able to promote him, especially in view of the work he had undertaken for the double science course. Tom left the school in the summer of 1980 to take up a scale 3 post where he would be responsible for introducing integrated science courses. He had gained a great deal of experience at Duckworth and had a lot to offer another school. It is worth noting that as the new model for the department had only scale 2 and scale 4 posts, teachers would have to leave to acquire the next step in their career.

Reflections on the staffing changes

Situations which provoked discussion of departmental structure and people's jobs were:-

- the creation of a large faculty from already existing smaller units
- cross subject development especially where the expertise for the new development lies with a junior member of staff
- the allocation of scale posts
- departure of a fairly senior member of staff (Frank)
- arrival of a reasonably senior member of staff (Alfred)
- natural development of people, such that they take on different or increased responsibility in the school or maybe outside
- a person's inability to acquire promotion or recognition (Barry)
- reorganisation of resources - encroachment of territory by other members of staff.

Shortages of staff did not raise questions of people's roles; they tended to be temporary everyone and everyone just tool on extra work for that time. It was more permanent changes that were discussed.

Perhaps this staff were particularly sensitive to their role changes, but their sensitivity and willingness to articulate concerns highlighted issues which could well lie dormant in any department undergoing a similar change. The change required a more inter-related team than had existed before. Everybody's task within the department affected most colleagues, whether it was maintaining stocks of worksheets, writing units, ordering apparatus, advising colleagues or marking assessments.

Teachers' status as knowers of particular types of knowledge became less visible and their control over the quality of that knowledge was diminished. For heads of subject departments control had been exercised by selecting syllabuses, writing courses, having small numbers of people teaching those syllabuses and having direct authority over those people. With the change, the syllabus was agreed by a committee, units of courses which contained say chemistry would hopefully be written by specialists in chemistry but taught by a wide group of people. The support necessary was greater and less well defined.

Titles like 'head of chemistry' which represented a guardian of an established body of knowledge, were replaced by titles such as 'course director' or 'in charge of assessments and examinations'. Heads of chemistry etc. had always been in charge of courses, resources, examinations but these were part of the job, not the title of it. People's allegiance to a subject can be deep rooted. People select areas of study for a variety of reasons often related to personality traits and ways of thinking. Selection is made relatively early in life and people are increasingly socialised into a community which talks about and studies a particular subject. They become conditioned by the thought patterns, the objects and areas of study and they continue to adapt to these familiar surroundings. This allegiance to subjects within science as opposed to science as a whole needs to be recognised.

Reflections on the case study at Duckworth School

Some reflection came from the comparison with the other two schools which I visited, Timburn and Sixford. Details of those case studies are in appendix 3. Timburn and Sixford Schools had implemented integrated science courses a few years earlier.

Timburn School, unlike Duckworth had secured the recommended 20% curriculum time for science for all 4th and 5th years, and had devised two double subject courses, one based on SCISP and one submitted as a mode 3 CSE. The courses had common elements at the start to allow pupils to transfer if necessary. The third year integrated science course was an adequate base for both 4th year courses and could be taught to the whole ability range. There was one teacher per science class up to the end of 3rd year. They usually had two teachers per class for 4th and 5th years; variations on this indicated a willingness of teachers to experiment with alternatives, including team teaching, and one teacher teaching the whole of the course.

The organisation and management of the department and the work showed similarities with Duckworth. The department was a complex team with a structure which was in the process of evolving. Heads of separate science sections were becoming less prominent. Coordination of ideas and activities across the department was important. Teaching materials and resources had to be accessible to all members of staff; labelling, storage, renewal mechanisms and ways of preventing timetable and resource clashes were all part of the system. There was an increase in the movement of equipment with the introduction of integrated science courses up to 16.

Teachers worked within constraints of the agreed courses but then had freedom to teach how they wanted. Teacher interest was explicitly built into the optional modules of the CSE course. Attention to assessment objectives was considered both important and useful.

Sixford presented a similar picture to Timburn but the staff had less sense of 'change' because the system had been set up from scratch. All students studied double science. The science department was structured as a team, and at the time it was a relatively small team as the school was still growing. Subject specialists taught within their specialisms in the 4th and 5th years, with teachers rotating on a fairly complicated 'carousel', reducing the continuity teachers had with any one class.

No new meanings of integrated science emerged from the study at Duckworth, nor, for that matter at the other two schools, but the two courses, double and single science did have different 'pedigrees'. The double science course was based on SCISP, with a more modular structure. As the double science course progressed through the year it effectively developed into two courses, one linked to SCISP objectives and the other to CSE objectives. Attitude objectives were no longer assessed at CSE. The open-endedness of investigations in SCISP, was replaced, by and large, by set practical activities which did not involve design. Some element of design was, however, retained through coursework.

The integration of the single science course came from the strong emphasis on everyday objects and activities, such as car maintenance and horticulture and paid more attention to the personal lives of pupils than the double science. Assessment objectives for the practical work focused on a limited number of objectives: could candidates follow instructions, put apparatus together, make some sense of it and report it well.

I turn now to issues raised by Bernstein's thesis, first in the matter of the control which people could exercise. How did introduction of integrated science courses alter the 'framing' for teachers as individuals and as a group? As individuals, they were constrained by the scheme of work. There was little scope for modifying the order in which units were taught, but teachers could vary the order in which they taught material within a unit. First time through, however, people tended to follow the lesson by lesson guidelines. As a group teachers had been free to create the pattern of courses which they wanted provided that they used a specified amount of time and that the courses led to some form of qualification. The senior management team had not interfered, although it had expected to be informed of changes had and ensured parents and local employers understood them.

Teachers exercised greatest freedom in pedagogy and how they built relationships with classes. This freedom was curtailed when teaching a topic for the first time because of lack of experience of explaining the topic. It is not in the least surprising that reports came in of 'experiments not working'. The comment from Alan about the centimetre wave apparatus will be a familiar scenario to many teachers. Practical work is skilfully crafted and requires a prepared mind and hand to 'make it work'. Time and experience is needed to build up practical know-how; the second time round many of the experiments worked.

As a group teachers had more control over the examination process than they would have had say twenty years earlier. They set their own objectives and syllabus, and wrote their own papers, admittedly within the guidelines from the board, but to be in charge of the examination process provided a considerable motivation for school based developments.

What of Bernstein's prediction of the alteration of relationships between staff? The hierarchy within the department altered. Heads of separate subjects no longer had automatic authority over people from their subject discipline, nor over the related equipment. Responsibilities became more diffuse. Responsibility for subject control remained, but exercising it required different techniques when teaching was carried out by a wider range of people.

Addressing the shift in the department structure took time. There is probably a range of reasons. The established career path and the 'pecking' order inherent in different salary scales was disturbed. The status of different people was threatened. Seniority and authority had to be negotiated rather than given. Allegiance to subject was supplemented, or even in competition with, allegiance to a wider enterprise. Just change itself requires time, not for doing the job, but for 'mourning' the old system before engaging with the new one. I will concede, and in fact suspect, that events in this particular case study could be explained by a deeper understanding of the personalities involved. I am sure Kirk (see chapter 4) has a point. I did not, however, explore this so it is out of place to attempt any comment other than to acknowledge its likelihood.

The question of working outside 'specialist' subjects was raised by teachers and technicians. The same mixture was found at Duckworth School as Sally Brown found in Scotland: an enjoyment in teaching new material, in not being confined within one area of science and a pride in learning new skills, coupled with the discomfort, and extra preparation, associated with working in an unfamiliar area of science. The school acknowledged the difficulties by pairing teachers of different subject backgrounds, by providing inservice support and by putting 'specialists' with the top sets.

The study at Duckworth School highlighted the interlocking of courses with internal structures of schools. New courses, especially new patterns of courses, had ramifications for those structures. There was a shift in the autonomy and status of individuals which was uncomfortable. This had been well documented in other contemporary studies of change, so in retrospect was not surprising:

> In viewing this battle, it is important to bear in mind that most innovations have strong implications for the internal politics of the school. The school has a hierarchy of status and power. Curriculum and organisational change disturb that allocation of status. Integration threatens the power base of subject departments. The introduction of new subjects increases the competition for resources and may create new opportunities for promoted posts.
>
> (Stenhouse, 1975, p171)

> A further barrier to innovation in schools is the threat innovation poses to the identity of the teacher and the burdens it imposes on him. I wrote earlier of the teacher as a man of learning skilled in teaching. He identifies strongly with his subject knowledge and his professional skills and often it is upon these that his professional self respect is based. Most innovation changes both subject content and method. As innovators teachers are asked to take on, initially at least, the burden of incompetence.
>
> (Stenhouse, 1975, p169)

Elizabeth Richardson in *The Teacher, the School and the Task of Management*, described how the problem of leadership of a new integrated humanities project was shelved for a long time (Richardson, 1973, p 87). She also recognised that a teacher who raised the question about the status of 'drama' within the integrated project was in fact talking about his own status as the drama teacher. She went on to comment that discussion of an integrated course had within it the idea of a 'disintegrated subject' (Richardson, 1973, p 84).

Despite difficulties and hard work Duckworth School had gone a long way towards implementing a common course in science for all students up to the age of 16. They had a common course in years 1 and 2, and another one in year 3. The double science course catered for about 60 - 70 % of the 4th and 5th year. They coped with the differences in learning rates and styles by 'setting' classes and expecting teachers to adapt teaching accordingly. Choice of examination (GCE and CSE), a choice which teachers generally disliked making, was delayed as long as possible, but the practice of double entry was still used. The existence of the single science course meant decisions still had to be made at the age of 14 years.

The case study is at one level just a snapshot of the tasks and work involved in reshaping the pattern of science courses in schools along lines being advocated (and increasingly accepted). Much of the hard work was sustained by the enthusiasm many teachers showed for school based development in the 1960s and 1970s:

> ...then wherein lies the novelty of school based curriculum development? In one sense such a development is certainly not new! ...it is no more than a re-expression of the prevailing norms. ...but in another sense it is entirely new for it represents a take-over by the schools of the new active rather than passive style of curriculum change. For generations the curriculum developed slowly and imperceptibly. ...it was no teachers' specific task to take hold of it and set out to change it
>
> (Eggleston, ed., 1980, p1)

Summary

It is easy to forget that 1980 was only seven years since the raising of the school leaving age to 16 for all students. This provided the opportunity to develop five year courses for all pupils as part of a long standing agenda to put into practice 'Egalitarian ideals of equality of opportunity, *via* equality of access to *common* schools offering a *common* culture by means of a *common* curriculum' (Schofield and Waring, 1981, p 215). The three schools in the case studies were slowly minimising the divisiveness characteristic of 4th and 5th year science courses by introducing the integrated science courses. Removing most options at 14, delaying choice about the examination to be entered, reducing differences between routes, were all strategies being used.

The shift in the relationships of the staff as a result of the curriculum change was one of the important findings. The role of subject specialists altered from being in charge of a subsection of the department to taking on the role of consultant to the rest of the department. The personal identity of individuals through 'their subject' became less prominent. Working as a team became an intrinsic part of day to day life. The task of management of this large and interconnected web of people, resources and courses was a complex task. The implication for the head of department was becoming more and more evident. It is not surprising that the Schools Council commissioned a study from the ASE on decision making in science departments. The publication (Hull and Adams, 1981) is to my mind an outstanding document that stands the test of time, and addresses ways in which teams of teachers could work together to review and advance its work .

The case study illustrates the complexity of what was to be achieved. The science courses had retained distinct elements of integrated science courses: knowledge and understanding of scientific concepts and information, and the ability to apply this to problem solving; an understanding of science, technology and society issues; skills and understanding linked to experimental work, particularly the interpretation of data and relevant communication skills. Such a complex set of aims required appropriate assessment tools which could differentiate over a wide ability range, not just for formative assessment but for summative assessment moderated against external standards. The case study provides one school's attempt at a 16+ curriculum and examination system in integrated science. The three courses (double science SCISP, double science CSE and single science CSE) all had the elements of integrated science listed above; an attempt at least to pass on a common culture and assess the success of learning to all the students.

The next decade saw the introduction of a common examination (GCSE), a common curriculum and assessment (the national curriculum) which would frame the work of all science departments in the country. The way in which this was achieved is documented in the next chapter.

CHAPTER 6

INTEGRATED SCIENCE: 1980 - 1996

Introduction

Between 1980 and 1996 the term 'integrated science' as the label for courses virtually disappeared. It was replaced by 'balanced science' and then just 'science'. There was continued pressure and exhortation on schools to rationalise science courses, to allow less choice for pupils and to draw all pupils into science education for the whole of compulsory schooling. Differences between courses in different schools and for different groups of pupils were ameliorated first through the national criteria for GCSE and then through the national curriculum to which all schools had to conform. This chapter traces the elements of integrated science courses, the breadth of content, the inclusion of science, technology and society aspects, and the investigations in science, through these various changes.

a. 1980 - 1986 - The Secondary Science Curriculum Review, the publication of *Science 5-16 A Statement of Policy* and the introduction of GCSE.

ASE published its new policy for science education *Education through Science* (ASE, 1981), as a result of the consultation initiated by the publication *Alternatives for Science Education* (ASE, 1979). The 1979 consultation produced a large response and it was regarded as 'no mean task' to have produced the policy document from it. It might however be seen as a 'compromise' document in which the radical proposals of the 1979 document had been lost or severely muted. The authors, however, saw the document as a non-neutral stance. One of its strongest emphases was in the title, *Education through science* not Education in Science, addressing the role of science in contributing to general education.

It offered guidelines for curriculum planning in terms of *Science as an Intellectual Discipline*, *Science as a Cultural Activity* and *Science and its Applications* (ASE, 1981, p 10). The more radical proposals of the 1979 document can be seen in the elaboration of the latter two. The history, philosophy and social implications of scientific activities which 'leads to an understanding of the contribution science and technology make to society and the world of ideas' were included under the cultural aspects. Applications were to contribute to the worlds of *leisure*, *work* and *citizenship*, and to *survival*. *Survival* was in terms of environmental concerns and sustainable technologies 'self-sufficiency, the conservation of resources and the utilisation of alternative technologies'.

Science as an intellectual activity, the pursuit of scientific knowledge as an end in itself, was however, first in the list and continued to be when translated into a list of aims, which contained the concepts and generalisations, the practical skills and the procedures of investigations. It retained familiarity with what had always been in science education in schools and therefore by dint of habit and socialisation if nothing else, retained what many science teachers held as important. The social and cultural elements were less familiar and there was only limited experience of what might be contained within them. The last aim on the list 'The realization that scientific knowledge and experience is of some value in the process of establishing a sense of personal and social identity' was new.

The ASE urged schools to rethink the organisation and teaching in Year 3 let alone in the later years, by requesting them:

> to consider the development of courses taught by one teacher (with team support where possible) which are timetabled to facilitate experimental and field-based work. A system of 2+2+2 periods per week for biology, chemistry and physics taught by three different teachers independently is not necessarily the most appropriate organizational or pedagogic approach to science studies in Year 3 of the secondary schools in England and Wales...
>
> (ASE, 1981, p 17)

Teaching approaches were discussed in recognition of the wider ability range of pupils drawn into science:

> We are also conscious that any attempt to broaden the science curriculum in terms of both content and the range of pupils for whom it is designed will create further significant pedagogic problems in many schools.
>
> Our proposals for broadening the content of the science curriculum imply a far greater flexibility on the part of science teachers in the issue of selecting optimum teaching styles and strategies.
>
> (ASE, 1981, p 26)

Of particular mention was the role of language in learning, the authors finding it necessary to point out that there is a difference in the language needed for *establishing* learning and another for *reporting* learning, and that perhaps time should be devoted to allow pupils to *read* about science as well. The dearth of reading material for pupils in science was in part a result of the emphasis on learning by doing. There was also a need for more individualised learning.

The general move towards a common examining system at 16+, the introduction of criterion referenced assessment and the use of profiling were seen as important in helping to support the changes in the curriculum that ASE was advocating. As the SCISP experience had shown using criterion referenced techniques in science was not familiar to teachers nor was it easy.

The extent of the development that was needed in providing science courses to *all* pupils in the 11-16 range, for the same amount of time and with the same set of aims was recognised throughout the report. The study at Duckworth gave an indication of what might be involved. Amongst the recommendations of the report was that 'the policy statement should act as a focus for national, regional and sectional meetings and conferences in the immediate future.' Within this recommendation was the recognition that ASE did not control the curriculum and that changes, if they were to be successful had to be articulated by the people concerned in the contexts in which they were working.

In order to support the implementation of the ASE's policy, the Secondary Science Curriculum Review (SSCR) was set up under the aegis of the School Curriculum Development Council (SCDC) and ASE. The development work of SSCR ran from 1981 until 1986 with a dissemination phase from 1986-9. Over 200 local working groups of science teachers and advisers were engaged in tackling at a local level the task of implementing science courses which would meet the SSCR's aims for science education (see figure 6.1).

The review made several contributions by :

- involving about 5 - 10% of the science teaching force in debate thus forming a major inservice activity;
- articulating principles and practices about access to the science curriculum for all, irrespective of disability, race or gender;
- developing considerable expertise on issues of implementation;
- paying attention to widening the range of teaching strategies used in science lessons, addressing the issue of the link between primary and secondary science.

Figure 6.1 Aims of science education as seen by SSCR

Aims of the Secondary Science Curriculum Review

The Review has the broad general aims of providing a system of science courses such that all boys and girls - whatever their abilities and career intentions - receive an appropriate science education. Within this overall brief the Review will initiate work that enables schools to provide, at appropriate stages of a five-year programme, adequate opportunities for all students to:

a) Explore the nature of biological and physical environments through observation, experiment and systematic enquiry;

develop the ability to design and carry out experiments, evaluate evidence and solve problems;

study key concepts and principles of science that are essential to an understanding of science as a way of looking at the world;

study those aspects of science that are essential to an understanding of oneself and of one's personal well being;

b) use their knowledge of science to design and develop solutions to technological problems, to test and evaluate those solutions and to cost such as exercise;

study the key areas of science and technology that relate to the world of work and leisure so they are better able to participate in a democratic society;

study key concepts that are essential to an understanding of the part science and technology play in a post-industrial and technological society

c) gain some understanding of the historical development and contemporary cultural significance of scientific principles and theories;

appreciate that technologies are expressions of the desire to understand and control the environment and that technologies change in response to social needs;

appreciate that past scientific explanations were valid in their time and that early technologies are still valid in some cultural contexts;

d) discuss, reflect upon and evaluate their own personal understanding of key scientific concepts, theories and generalisations;

explore topics or themes which exemplify the limitations of scientific knowledge as an explanation of the human condition.

SSCR aims were worded differently from those of the ASE policy. They were more specific (twelve separate statements) and were grouped into four major groups. Three groups were related to science as an intellectual discipline activity, science as application, and science as a cultural activity. The fourth group of aims, d, (figure 6.1) referred to the role of learners evaluating and discussing their own understanding, and of being aware of the limitations of science as an explanatory framework.

Practical work appeared under three headings: the observations, explorations and systematic enquiry to establish understanding; the design of experiments and the evaluation of evidence; and the technological problem solving. The latter spawned several publications with ideas for practical problem solving which could be given to pupils. Apart from the problem solving, a strong technological thread ran through the aims. The link between science and technology was emphasised in understanding how technologies related to work, how they were used and had been used to manage and alter the environment. To a large extent the breadth of ideas of the review was consonant with the breadth of aims of integrated science courses.

Many outcomes of the review cannot be seen in written product. The dissemination phase summarised ideas in a collection of booklets *Better Science*, which addressed management of science departments, access to the science curriculum by everyone, primary and secondary links and questions related to assessment. More intangible products came from support given to people making changes, and from the exchange of ideas which took place during discussions.

Implications for science departments were addressed. *Better Science Making it Happen* presented a simulated case study of a school with responses from governors to proposed changes to the science curriculum. It raised issues that were evident during the study at Duckworth and in the aftercare system of SCISP. Jeff Thompson, Chairman of the SSCR Steering Committee wrote in the foreword:

> The second purpose in the production of this book arises from an acceptance that the process of change in any part of the secondary school curriculum is certain to be a very complex activity, involving a range of agents and agencies. Science education is no exception to this, and it is acknowledged that among those agents will be many without first-hand knowledge of science itself...The characters portrayed there are fictitious, but the issues raised within the governors' meetings, consequent on a review of the school science department, are real.
>
> (SSCR, *Better Science: Making it Happen*, Foreword, 1987)

Practical considerations of organisation of time, of timetabling, of resources, and of inservice needs for teachers and technicians were described in *Better Science: How to Plan and Manage the Curriculum, Curriculum Guide 5*, along with the need for consultation:

> Students
> (They are) the group with the biggest stake in education...They are entitled to consultation and a clear rationale for the curriculum. The consultation is by its very nature usually informal but students are less likely than they were to accept unquestioningly the curriculum set before them by their teachers. Disaffection with the curriculum is a spur for change and a negotiated curriculum will increase the sense of purpose shown by the students. We should welcome and respect the increasing sophistication and independence of mind of our young people.
>
> Parents
> Consultation and negotiation...are crucial, not only because they (the parents) have a right to be informed but also because they have a vital supportive role to play in their children's education. They cannot expect to negotiate effectively unless they understand and believe in the school's educational policy, its aims and methods.
>
> (Heaney, for SSCR, 1987, p 3)

Consultative approaches in education were, however, giving way to increased central control of the curriculum by government. This manifested itself very obviously in science in the publication of *Science 5 - 16: a Statement of policy*, published in 1985. This was the first *policy* statement from DES on a curriculum subject. Many of the SSCR's themes, (breadth, balance, progression, continuity, differentiation, equal opportunities in a reshaped curriculum for all throughout compulsory schooling, including in primary education), were echoed in it (figure 6.2). The policy was claimed as belonging to the Secretaries of State, but was in fact written by HMI who had worked from responses to *Science Education in Schools: a Consultation Document* (DES, 1982), and from their own close involvement in science education at the time. Norman Booth and Vic Green, two successive chief science HMIs, played a crucial part.

Guidelines on time allocation in secondary schools and content were given, along with an insistence that science become part of the curriculum of all primary schools. In secondary schools 10% of timetable time was to be devoted to science in years 1 and 2, 15% in year 3 and 20% in years 4 and 5. No more time was to be given even for those pupils going on to study A level sciences. Control was being exercised by organisational features: specified time, science was to be compulsory, all strands of science were to be linked and included.

The scope of the curriculum (far wider than just chemistry, physics and biology) was described as:

> 39. Science for all pupils up to the age of 16 should include coverage at an appropriate level of the basic concepts of biology, chemistry and physics. Astronomy and the earth sciences can provide a suitable context for

important concepts to be developed. Teaching should also be closely related to everyday and industrial applications of science: science and technology are intimately linked, and understanding of scientific concepts can and should be greatly enhanced by the study of their technological applications. The social and economic implications of scientific method and technological activity also have a place, always provided that the teaching is essentially concerned to foster the education in science itself.

(DES/WO 1985, p 12)

Figure 6.2 Ten Principles of the *Science 5-16* Policy Document (DES/WO, 1985)

(a) *Breadth:* all pupils should be introduced to the main concepts from the whole range of science; to the technological application and social consequences of science; and to a range of scientific skills and processes;

(b) *Balance* all pupils should be able to continue their study of each of the main areas of science throughout the compulsory age range; and all science courses should achieve a balance between the acquisition of scientific knowledge and the practice of scientific method;

(c) *Relevance*: science education should draw extensively on the everyday experience of pupils, and should be aimed at preparing pupils as effectively as possible for adult and working life;

(d) *Differentiation*: the intellectual and practical demands made by science education should be suited to the abilities of the pupils, in ways which will allow the highest existing standards to be maintained for the most able while catering fully for pupils unable to reach those standards and providing for all pupils the essential experience of broad balanced science;

(e) *Equal Opportunities:* science education should give genuinely equal curricular opportunities to boys and to girls and should in particular actively seek ways of exciting the interest of girls in those aspects of science which some girls at present find unappealing or intimidating;

(f) *Continuity*: as science education develops in primary and middle schools, it is increasingly important for the schools to which pupils subsequently transfer to give attention to building on the foundations already laid; and links between secondary schools and further and higher education institutions should be fostered so that those institutions are better equipped to build on newly developed courses in the schools;

(g) *Progression:* courses should be designed to give progressively deeper understanding and greater competence, not only within individual schools but also over the compulsory period as a whole, whatever the age of transfer between schools may be;

(h) *Links across the curriculum*: in primary schools teachers should link work in science with the development of the language an mathematical competence of their pupils, and with the practical component of the curriculum more generally; in secondary schools science teachers should work closely with their colleagues, not only in mathematics, CDT and home economics departments but also more widely, to ensure that the generally applicable aspect of science, not least its investigative approaches, are firmly established in the curriculum, and that the contribution which other subjects can make to the teaching of science and vice versa is fully exploited;

(i) *Teaching methods and approaches*: science is a practical subject, and should be taught at all stages in a way which emphasises practical, investigative and problem solving activity;

(j) *Assessment*: progress in science should be assessed, both within school and in public examinations, in ways which recognise the importance of the skills and processes of science as well as rewarding the ability to reproduce and apply scientific knowledge; and which allow all pupils to show what they can do rather than what they cannot do.

The implications for departments of physics, chemistry and biology which operated independently within one school were described in:

> 81. But the aims of this paper imply more radical changes for pupils of all abilities than simply pruning the content of existing physics, chemistry and biology courses to provide more room for investigative, applied and problem solving aspects and then continuing to teach those subjects in isolation from each other. Those schools which do continue to teach separate subjects will need to arrange much closer collaboration between the teachers of these subjects than is commonly found at present, to secure more orderly progression in the acquisition of knowledge and skills across the spectrum of science and to avoid unnecessary repetition or gaps. The reforms now needed require science departments to be united in philosophy and method. (DES/WO 1985, p 22)

Examination boards responded rapidly to the likelihood of 20% timetable time for science in years 4 and 5, and all had some form of 'double science' syllabus available by 1986 (ASE, Education Research Committee, 1987).

While the policy document looks fairly unremarkable now, it is likely (in time) to be seen as critical in the development of science education in UK. This was effectively saying: no opting out of science during compulsory schooling, no studying one corner of science; no leaving out investigations and problem solving or the context of science; and remember to liaise with the primary school as they will be teaching science seriously before long. In addition to all this it 'set a clear framework by excluding any model which gives separate certification to the three sciences and by specifying that, within double subject framework, a variety of curriculum solutions, including combined courses, integrated courses, and modular courses should be approached' (Black, 1986, pp 669-681).

In his presidential address *Integrated or co-ordinated science?* to ASE in January 1986 Paul Black explored the ways forward from the policy. It is in many ways an extraordinary piece of public relations, in that he conceded most of the arguments that people put forward for integrated science, but pointed out that there might be other solutions to the problems. He had a clear principle that the 'combative stances' in debates about how to organise the curriculum were at their best, unhelpful and at their worst an 'insult to rationality'.

Black conceded the weak boundaries between the sciences and the existence of boundary subjects such as biophysics and molecular biology. He argued, however, that there were real differences in the science areas, both in content of study and the type of theory which is used and that science had advanced by isolating small areas, focusing intensely on them and controlling other variables to minimise the interference from other aspects of the system.

Black could find few major concepts which acted as the bridge or link between separate areas. Energy, which was frequently quoted, was exceptionally difficult to understand and only when a lot of other ground work had been done, do people begin to grasp it as an integrating concept. It was unlikely to be accessible to many pupils.

He conceded that one science draws on understanding from other areas, but argued that did not mean that they had to be taught together. It was an argument for not allowing students to drop areas of science before they had a minimum understanding of important concepts from other areas.

The courses which focused only on the 'processes of science' (e.g. Screen, 1986) were not providing a possible framework because processes were in practice specific to content. Someone good at solving biological problems was not necessarily good at sorting out defunct electrical circuits.

Black conceded that new learning must be meaningful and this would mean some link with existing knowledge. There were dangers in assuming that this automatically meant linking with the pupils' everyday life, although it may do in many cases. This linking was, however, not a preserve of integrated courses. He saw the need to prevent the existence of *two cultures* (sciences and arts) (Snow, 1959) as an argument for not allowing people to specialise in one area or another and that it was a whole curriculum decision not a science decision.

Black conceded that the curriculum for future scientists (very much the minority), influenced the curriculum for everyone else and that this needed to be addressed and moderated, but argued that the training for future scientists would continue to be specialised; and 'must necessarily be so'. He conceded that education *for citizenship should be included*, but pointed out that this was a reason for ensuring that science courses included the consideration of science related issues, such as the ethics of genetic engineering etc. He recognised the value in not allowing premature choice of study so that later life choices were not lost, but this was not necessarily an argument for integrated science. Co-ordinated science courses could just as easily fulfil this need. He also drew attention to the problem of there being a limit to the extent to which teachers, can teach outside their main areas of expertise.

In the matter of title he claimed that:

> if there were to be a variety in titles then problems of status would inhibit the freedom of teachers to explore alternative solutions. So we must make a strong plea that there be a single subject with a single title - Science, or Sciences, with double weight but without two separately identifiable parts.
> (Black, 1986, p 679)

It was arrogant to assume there is only one way of organising courses.

> For the structure of science as a whole, we owe it to pupils to give them some feel for the range, of types of problems, of levels of complexity of systems, and of methods, that characterize the work of scientists. We owe it to them to show how the methods and concepts have both unifying threads and intriguing diversity as we range over the sciences. We owe it to them to show some of the delights of those who have worked on narrowly controlled problems, but equally to help them to see the complexity of real and human problems. For this latter aspect we share a broader responsibility with colleagues in other curriculum areas and we cannot serve pupils well by working in isolation from them any more than we can serve them by working in isolated compartments within science.
> (Black, 1986, p677)

> Successful programmes will present a patchwork of separate and combined activities, informed by a strong and shared spirit of critical enquiry. Whatever the final pattern, I hope it will be one in which specialists will still need to contribute their separate skills but in which they will have lost all their concerns to protect their special interests save one - the concern for the development of our pupils.
> (Black, 1986, p677)

Over the next few years a range of co-ordinated science courses came onto the market, each with the chemistry, physics and biology in separate books. (Nuffield Co-ordinated Science, 1987, 1991; Suffolk Co-ordinated science, 1987; Nelson Balanced Science, 1991).

Developments in science education were, of course, taking place within the context of the widening debate about the school curriculum as a whole. The need for a 'core' or national curriculum was shared by a large number of people. DES attempted to draw threads of the debate together and in 1980 published *Framework for the Curriculum*, which was received critically by the education world. In March 1981 *The School Curriculum* (DES, 1981) was published, setting out the government's wish **not** to specify subjects in the school curriculum, other than RE, but to provide a framework within which schools could plan. This document gave priority (although not clearly defined) to mathematics, English, science and modern foreign languages. It similarly received considerable criticism (although less than the previous document) not least in the publication *No, Minister. A critique of the DES paper 'The*

School Curriculum'. (White, J. et al 1981). John White's introduction 'Enigmatic Guidelines' contained a warning that the minister's statement that 'every school should analyse its aims, set these out in writing, and regularly assess how far the curriculum within the school as a whole and for individual pupils measures up to its aims' could lead to a narrow interpretation where aims were set within the limits of what could be learned and tested easily, resulting in disastrous consequences for the quality of education.

The much delayed implementation of proposals for replacing GCE O Level and CSE by a Common Examining System at 16+ (Waddell, 1978), were at the last minute introduced in a hurry. In 1984 Sir Keith Joseph, the then Secretary of State for Education and Science, announced that GCSE courses would start in September 1986 to be examined in 1988. Assessment was to be criterion referenced (as opposed to norm referenced), and involve a component of teacher assessment in most subjects. It was hoped that it would enable a higher number of students to achieve qualifications. National criteria for all subjects were set up (DES, 1985c). There was some uncertainty about the starting date, but September 1986 was confirmed in February 1986. Between February and June 1986, the examining boards had to have their syllabuses published and schools had to select a syllabus, be ready to start teaching it in September 1986, and be prepared for a higher role in the assessment of students than had been the case for many. The speed of implementation produced pressure on examination boards and teachers alike (Kingdon & Stobart, 1988).

The national criteria for science provided guidelines for all science syllabuses (DES, 1985b) and focused assessment on three main areas: knowledge and understanding; investigatory work; science technology and society. Subsequently the draft grade criteria for subjects were drawn up (DES/WO 1986) as the next step in setting up guidelines for criterion referenced assessment. All science courses were to have experimental work assessed which would draw all science teachers into some form of teacher assessment. This was a massive undertaking from the point of view of establishing good practice and the appropriate moderation procedures.

Just before the implementation of GCSE, Sir Keith Joseph was replaced by Kenneth Baker as Secretary of State for Education in July 1986 . This fact on its own is not important, but for once all teachers knew who was the Secretary of State for Education and changes in who filled the post seemed significant.

b. 1987- 1996 The development of National Curriculum Science

The nine years from 1987 until 1996, saw the introduction of the national curriculum, with science designated as one of the 'core' subjects along with mathematics and English. Year groups were renamed from Year 1 (5 year olds) to Year 11 (16 year olds), and divided into four Key Stages (Ys 1&2; Ys 3-6; Ys 6-9; Ys 10 & 11). National Curriculum science was implemented with Y1 and Y7 in 1989 and was examined first for GCSE in 1994. By that time it had undergone a major revision in 1991. A third revision of the national curriculum took place in 1994/5, to be examined at GCSE in 1998. External assessment via Standard Assessment Tasks - later Tests (SATs) were introduced at the end of key stages 1, 2 and 3. These were reduced to just key stage 2 & 3 in science after 1994.

In January 1987, Kenneth Baker set up working parties to advise on the form and content of the national curriculum in two subjects, science and mathematics. I have selected six documents to review subsequent developments of the national curriculum in science, namely:

- the interim report from the working party published in November 1987,
- the 1988 *Proposals from the Secretaries of State for Education*, incorporating the final report from the working party and reply from the secretaries of state;
- the three versions of the national curriculum in science: 1989, 1991 and 1995;
- the consultation document published in May 1991.

Figure 6.3 summarises four of these; it excludes the first interim report (1987), because its format was different from subsequent documents and cannot be incorporated in the same chart. The further consultation document which was sent to schools in August 1991 is also excluded.

Interim Report of the Science Working Party, set up in July 1987. Report published November 1987.

The science working party, set up in January 1987, was given the remit to produce guidelines for the national curriculum in science, based on the *Science 5-16* proposals. Members of the working party were well known in science education, with Jeff Thompson, Professor of Education at the University of Bath, as the chairman. The interim report, published on 30 November 1987, was available for wide consultation, and provoked response from many groups. The report gave a high profile to attitudinal aims of science by designating them as one of the three broad groupings for the curriculum ('Knowledge and Understanding', 'Skills' and 'Attitudes'). 'Knowledge and understanding' was divided into four themes: Living things and their interaction with the environment; Materials and their characteristics; Energy and Matter; Forces and Effects. 'Skills' contained a broad mixture of: practical skills; general thinking skills or processes; skills to produce evidence of understanding; skills in using scientific models and theories; skills to show understanding of the place of science in society; and skills of communication.

Attitudes within science included such things as:

> curiosity and sense of wonder and excitement...appreciation of excitement of discovery...respect for the environment...responsible attitude to ...readiness to search...appreciation of investigational methods and tentative nature of science: willingness to appraise and use scientific evidence.... appreciation that science can make important contributions to other areas of learning... of relevance of science in everyday life...of contributions the application of science can make to quality of life; awareness that application of science may cause difficult moral dilemmas.
>
> (DES/WO, 1987, pp 56/7)

The next stage of the national curriculum in science was influenced by both responses to the consultation, and the publication of the report from the Task Group on Assessment and Testing (TGAT) in the National Curriculum. TGAT had been set up in July 1987, under the chairmanship of Professor Paul Black, (Professor of Science Education at King's College, London and joint project leader of APU Science) to prepare a report on how assessment and testing could be achieved throughout the whole of compulsory education. Its report, published in January 1988, (TGAT, 1988), emphasised the importance of assessment to support learning and teaching, focusing on formative and diagnostic assessment. It incorporated possible mechanisms for reporting of progress at key points in children's education. A model of progression with ten levels was proposed. It acknowledged that this model would need elaboration for each subject and that it would be breaking new ground in England. The reporting of the progress of children would be based on the ten level scale. The science working group was the first to use the model, and its interpretation influenced subsequent developments in all subjects.

1988 final report to the Secretaries of State, published August 1988, with their responses

The final report of the science working party, with the responses from the Secretary of State for Education and Science in England and the Secretary of State for Wales, under the title of the *Proposals from the Secretaries of State* was published in August

1988 as a consultative document (DES/WO, 1989). The science working party had developed its original ideas into a format which was entirely new to the teaching profession, with its terminology of 'profile components', 'attainment targets', and 'statements of attainment'. The science curriculum was structured under four headings called 'profile components' with sub-sets of attainment targets (ATs):

Knowledge and Understanding (16 ATs)
Exploration and Investigation (2 ATs)
Communicating in science (2 ATs)
Science in Action (2 ATs)

The structure was an attempt to provide a framework which emphasised the different facets of science education and into which detail could be slotted. It was supported by related 'Programmes of Study' which indicated in broad terms experiences pupils would have in science lessons.

The combination of profile components, attainment targets and programmes of study, defined science broadly. The attainment targets included: personal social education in the health education sections; ethical issues in the section on human influences on the earth; earth sciences; a consideration of information science; technology in the component titled 'science in action'; interpersonal skills in 'working in groups'; development of practical and investigational skills; an appreciation of the nature of science alongside a more traditional selection of content from physics, chemistry and biology (but without these labels). In addition to science, the working party had developed the technology curriculum for the primary years, making proposals for four attainment targets.

The working party attempted to use the ten level model, and succeeded in writing statements of attainment for all ten levels for the ATs within the knowledge and understanding profile component (and in fact for technology in the primary years). They had a variety of resources to inform this process, the work of the APU in the early 1980s (DES, 1989), the ongoing work of constructivists who were charting the understanding of a range of scientific concepts for an ever increasing age range (see Driver et al, 1994 for a summary of research for secondary students), and of course the accumulated experience of teachers at both primary and secondary level, and of the examination boards

Figure 6.3 Four versions of the national curriculum.

NC Science changes 1988-1996

	August 1988 Proposals			**NC Science 1989**	started Sept 1991
	Profile Component: Exploration and Investigation			***Profile component 1: Exploration of Science***	
AT 17	Exploration and Investigation	Doing	AT 1	Exploration of science	plan, hypothesise and predict
AT 18		Working in groups			design and carry out investigations
					interpret results and findings
					draw inferences
					communicate exploratory tasks and experiments
	Profile component: Knowledge and Understanding			***Profile component 2: Knowledge and Understanding***	
AT 1	Variety of life		AT 2	Variety of life	
AT 2	Processes of life		AT 3	Processes of life	
AT 3	Genetics and evolution		AT 4	Genetics and evolution	
AT 4	Human influences on the earth		AT 5	Human Influences on the earth	
AT 5	Types and uses of materials		AT 6	Types and uses of materials	
AT 6	Explaining how materials behave		AT 7	Making new materials	
			AT 8	Explaining how materials behave	
AT 7	Earth and atmosphere		AT 9	Earth and atmosphere	
AT 8	Forces		AT 10	Forces	
AT 9	Electricity and magnetism		AT 11	Electricity and magnetism	
AT 10	Information transfer		AT 12	Scientific aspects of IT + microelectr.	
AT 11	Energy transfer		AT 13	Energy	
AT 12	Energy resources				
AT 13	Sound and Music		AT 14	Sound and Music	
AT 14	Using light		AT 15	Using light & electromagnetic radiat'n	
AT 15	The Earth In Space		AT 16	The Earth in Space	
	Profile component: Communication				
AT 19	Communication	Reporting and responding			
AT 20		Using secondary sources			
	Profile component: Science In Action				
AT 21	Science In Action	Technological and social			
AT 22		The nature of science	AT 17	The nature of science	
	Profile Component: Technology 5-11			**Layout**	
AT 1	Technology In Context			Strongly Influenced by TGAT report	
AT 2	Designing and making			Attainment targets and Statements of Attainment were at the front of the document	
AT 3	Using ideas of forces and energy			Programmes of study were at the back	
AT 4	Communicating technology			Non- statutory guidance	

NC Science changes 1988-1996

	NC Science 1991	**started Sept 1992**		**NC Science 1995**	started Sept 1995
	Attainment Target 1			***Programme of study. Pupils should be taught:***	
1	Scientific investigation	Ask questions, predict and hypothesise	1	Experimental & Investigative Sc.	Planning experimental procedures
		Observe, measure and manipulate variables			Obtaining evidence
		Interpret their results and evaluate scientific evidence			Analysing evidence and drawing conclusions
					Evaluating evidence
	Attainment target 2				
2	Life & living processes	Life processes & organisation of living things	2	Life processes and living things	Life processes
		Variation & the mechanism of inheritance & evolution			Humans as organisms
		Populations and human incluences			Green plants as organisms
		Energy flows and cycles of matter within ecosystems			Variation, inheritance and evolution
					Living things in their environment
	Attainment Target 3				
3	Materials & their props	The properties classification & structure of materials	3	Materials and their properties	Grouping materials
		Explanations of the properties of materials			Changing materials (includes some geology)
		Chemical change			Patterns of behaviour
		the earth and its atmosphere			
	Attainment target 4				
4	Physical processes	Electricity and magnetism	4	Physical processes	Electricity and magnetism
		Energy resources and energy transfer			Forces and motion
		Forces and their effects			Waves
		Light and sound			The Earth and beyond
		The Earth's place in the Universe			Energy resources and energy transfer
					Radioactivity
	Over-arching themes in Programmes of Study			***Over-arching themes ('Sc0' - not 'levelled' in attainment targets)***	
	Communication		0	Systematic enquiry	
	The application and economic, social and technological implications of science			Application of science	
	The nature of scientific ideas			The nature of scientific ideas	
				Communication	
				Health and safety	
	Layout			**Layout**	
	Programmes of Study ran alongside SoAs and examples			Programmes of Study preceded attainment targets but looked like SoAs	
	Chart sumaarising ATs and SoAs produced				
	Notes			**Notes**	
	Some parts of PoS were not in SoAs and therefore not assessed externally			SoAs had gone to be replaced by broad level descriptions	
	First version to be assessed at GCSE in 1994			Idea of 'best fit' for determining levels makes room for professional judgement	
	Reporting by AT and not by profile components			Levels apply up to key stage 3	
	Profile components effectively gone			Over-arching themes not assessed	

The group was less successful in specifying statements for all levels for the other profile components and, instead, produced broad bands of descriptors for each key stage; so exploration and investigation, communicating science and science in action were denoted by statements for the key stage. The difficulty of being more precise was explained for the exploration and investigation by:

> The interrelationship between skills and knowledge and understanding has meant that we have not been able to define ten progressive statements of attainment for skills which stand independently of the statements of attainment and supporting programmes of study for knowledge and understanding. (DES/WO, 1988, p13)

The response of the Secretaries of State was that some of these statements lacked the 'precision needed if they are to form a clear basis for assessment, particularly those relating to personal qualities' and suggested combining them with other statements. They also considered the number of profile components was too large.

The value the working party put on different components is shown in the relative weightings in figure 6.4. The response of the Secretaries of State was that the weighting for knowledge and understanding was insufficient and should be increased.

Figure 6. 4 Weightings given by science working group to the 4 profile components in the national curriculum

Profile component	Reporting Age			
	7	11	14	16
	%	%	%	%
Knowledge and Understanding	35	35	40	40
Exploration and investigation	50	50	30	25
Communication	15	15	15	15
Science in Action	-	-	15	20

(DES/WO, 1988, p 88)

The working party indicated the time needed must not be 'less that one sixth of overall curriculum time in secondary years 1-5, and that the time allocated in years 4 and 5 of secondary school should not exceed 20 per cent of total curriculum time'. The response was to doubt whether this was realistic and a request was made to develop a course which could be delivered in 12.5% of the time, and would lead to a single certification in science at GCSE (DES/WO, p iv)

Technological aspects of science featured quite strongly in the science curriculum, in specific SoAs such as 'know about the implications of information and control technology for everyday life' 'understand the relationships between population growth and decline and environmental resources, including the control of human populations', 'know about the basic principles of genetic engineering in relation to drug and hormone production'.

The layout of the document was important. Programmes of study on the left page with relevant SoAs on the right, emphasising they had equal importance.

The first version of the National Curriculum in Science (May 1989)

The revision, which became the first orders for the National Curriculum in science, had incorporated all requests of the Secretaries of State, which paved the way for the dominance of assessment and accountability over curriculum. It went through Parliament in March 1989, and by May 1989 copies had been delivered to schools. Schools had to prepare new schemes of work ready to be taught to Y1 and Y7 in September 1989.

Organisation of content - Two profile components with 17 Attainment Targets

The first order (DES/WO, 1989) retained only two profile components: *Knowledge and Understanding,* and *Exploration*. Material from other profile components was put elsewhere, or omitted (all statements referring to students working in groups were omitted). 'Science in action' was incorporated into one attainment target, AT17, 'the nature of science', and put into the knowledge and understanding profile component. The communication profile component was distributed throughout the document. One of the consequences of this was that the 'doing' part of investigations became combined with the ability to report, and particularly to report *in writing*. (e.g. 'level 3 - describe activities carried out by sequencing the major features'; 'level 8 - prepare and deliver a report matched to audience which incorporates background material from a variety of sources').

The layout of the document also altered. Programmes of study no longer lay next to statements of attainment, but were relegated to the back of the file. As a consequence a substantial proportion of teachers planned from the SoAs and virtually ignored the programmes of study as having equal statutory significance. This was particularly the case in primary schools. Many teachers in secondary schools, however, carried on as before because they already had a broad science curriculum and with minor modification could incorporate the extra material.

The ten levels

All attainment targets had the ten levels separately described, as had been requested by the Secretaries of State, despite the lack of evidence on which to base descriptions. Somebody (or maybe, some people) had managed to create statements to put at each of the ten levels. Differences were difficult to detect as shown in the level 8 and level 10 statements from AT17, the nature of science:

> Level 8 • be able to explain how a scientific explanation from a different culture or a different time contributes to our present understanding
> • understand the uses of evidence and the tentative nature of proof
>
> level 10 • be able to demonstrate an understanding of the differences in scientific opinion on some topic, whether from the past or present, drawn from studying different literature
> • be able to relate difference of scientific opinion to the uncertain nature of scientific evidence.
>
> (DES/WO, 1988, pp 36/7)

Given the tentative evidence on which statements of attainment in general had been based, it was not surprising that people referred to SoAs as hypotheses or as 'sign posts' which gave an indication of 'things to be met on the route'. This did not prevent the SoAs from being taken to be unproblematic when it came to matters of assessment.

Teacher assessment

The TGAT report had stressed the importance of teacher assessment as an intrinsic part of teaching. With absence of guidance on teacher assessment many people linked teacher assessment closely to SoAs. Elaborate schemes were devised across the country, often by LEA personnel, which required teachers to record both coverage of curriculum and achievement with reference to a checklist of SoAs (thus automatically defining the curriculum by SoAs and not by PoS). As the first order had nearly 300 SoAs for secondary students (from level 4 onwards) this was, to say the least, unwieldy.

AT1 The Exploration of Science,

The exploration attainment target (AT1) turned out to be difficult to use; students were to investigate their own questions, design the means of investigation and interpret the data collected. While teachers had involved students in many problem solving tasks, there was less attention at GCSE, and certainly at KS3 to whole investigations, which were generated and designed by students. Schools that had been involved in SCISP had some experience, as well as those involved in graded assessments of practical work (e.g. GASP, Davis, B. C., 1989). The development of non-statutory guidance (NCC, June 1989, section D, ppD_{1-12}) was of some help, but it was yet more paper which had to be read. Phrases which caused particular difficulty were those concerned with variables and hypotheses. 'Independent', 'dependent', 'discrete', and 'continuous' variables were mentioned along with 'control' of variables. 'Hypotheses' had to be formulated by pupils in both primary and secondary school and they had to convert these into testable hypotheses and simple questions which could be investigated.

For the highest levels students had to be able to work on extended investigations with two continuous variables and the SoAs read rather like those that might go with an A level project. Possibly the practical implications of this (large GCSE classes leaving experimental work out in laboratories that have to be used by other classes) had been overlooked.

The context of investigations was also to provide evidence of pupils' communication skills and their ability to apply knowledge and understanding. It was in fact a very complex mix of skills, processes and understandings.

AT17 The Nature of Science

The attainment target concerned with the nature of science (AT17) provoked debate and attempts to develop ideas about how to incorporate it systematically into teaching at all ages in secondary schools began (it was not a component of the primary curriculum). The summary of what was to be attained was described as:

> Pupils should develop their knowledge and understanding of the ways in which scientific ideas change through time and how the nature of these ideas and the uses to which they are put are affected by the social, moral, spiritual and cultural contexts in which they are developed; in so doing, they should begin to recognise that while science is an important way of thinking about experience, it is not the only way. (DES/WO, 1988, p 36)

Examples given to explain how this might be achieved comprised ones which had often appeared in school science: Pasteur's work on air-borne organisms; Pascal's work on the evidence for atmospheric pressure; ecological balance and concern for the environment; Galileo's dispute with the Church; the discovery of the structure of DNA and the different approaches of various scientists; competition between theories such as plate tectonics and the shrinking earth, and 'living things reproduce their own kind' as opposed to 'spontaneous generation of species'. The examples of questions such as 'What is the cause of 'cot deaths'?' and 'what is responsible for the death of trees in European forests?' were suggested to show how the uncertain nature of scientific evidence can lead to differences in scientific opinion. (DES/WO, 1988, p 36-7).

Models A & B - double and single science at KS4

The science working party had recommended 20% curriculum time for science for all students at KS4, to have a reasonable balance of subjects across the curriculum for those who might want to specialise in science and to raise the profile of science for others. This recommendation was not upheld by the Secretaries of State who feared it might prohibit some students from studying a second modern foreign language. A course which would take only 12.5% of the timetable at KS4 was therefore incorporated in the first order. The ATs removed to enable this to happen were those focused less on pure science, namely: AT5 human influences on the earth, AT7 Making new materials; AT12, the scientific aspects of information technology including microelectronics; AT15 using light and electromagnetic radiation: AT16 The earth in Space and AT17 the nature of science. AT2 (the variety of life) was also removed; again scrutiny of higher levels shows that they referred to environmental issues to do with the protection of ecosystems, and to relationships between living things in managed ecosystems. This selection could be viewed in two ways. Was it a shrewd decision to leave in parts which were conceptually difficult and which probably needed mathematical treatment, to make sure that it became genuinely a course which was taken only by the most able? Or was it a move to stick to pure science and to remove the parts which could be controversial and which necessitated science teachers dealing with material which looked more like the province of the social studies teacher? The move had not been popular with the ASE (ASE, 1989).

The removal of technology from the science curriculum

The working party for technology was set up between the publication of the first draft and the emergence of the first version of National Curriculum Science. Primary technology was therefore taken from the science working group, rather than science and technology being developed together.

Just before the implementation of the national curriculum in September 1989, the Secretary for State, Kenneth Baker, was replaced by John McGregor who lasted until 2 November 1990, when he was replaced by Kenneth Clarke, just before the end of the Thatcher government in late November 1990.

The consultation for, and preparation of, the second version of NC Science

In January 1991, Kenneth Clarke, who had by then been in post about two months, chose the occasion of a talk at the Association for Science Education's annual meeting to announce that he was going to make the curriculum and assessment in science and mathematics simpler and charge the National Curriculum Council (NCC) to undertake the task. (It happened that, in a room nearby, Mike Coles, the then head of the Science Section of NCC, was giving another talk and knew nothing about the Secretary of State's announcement until colleagues spoke to him afterwards).

The change was occasioned by concern expressed by examination boards that they could not match GCSE grades to the NC levels. AT1 in particular was causing problems. If anything was to be done about it, it had to be done quickly so that when the first NC cohort (Y7 in 1989), reached the start of their two year lead up to GCSE, an appropriate syllabus would be available. Several members of the original science team were part of the revising team under the chairmanship of Mike Coles. The guidance from the Secretaries of State was that they wanted fewer attainment targets, and fewer statements of attainment.

The organisation of content - no profile components and 4 ATs

The team simplified the presentation of content by bringing linked ATs together. In the consultation, respondents were asked about the possibility of five attainment targets (life processes, materials, physical processes, earth sciences and investigations) or four (life processes, materials, physical processes, investigation). The number responding that they would prefer five far exceeded those who said they wanted four. Other revisions included some rearrangement of statements of attainment which had proved to be in completely the wrong place. The number of SoAs was also reduced which meant that each one carried more hidden science.

The second version of NC Science (1991)

Despite the preference for five attainment targets as opposed to four, the final version of the revised NC in science had four attainment targets. Profile components had disappeared and the main headings resembled biology, chemistry and physics with investigations added. In practice, much of the original material was retained. Meteorology and geology were retained in 'materials' and astronomy in 'physical processes'. The NCC team emphasised there was little alteration; if schools had recently re-organised schemes of work then major adjustments were unnecessary.

The removal of the profile components was considered by some as a step towards removal of the importance of process alongside knowledge

> This may well have been a decision taken only to reduce the burden on teachers without thought for its implied curriculum message; alternatively it could be a deliberate move to confine science to conceptually based content. (Harlen, 1992)

This may seem like quibbling over a small point, given that the main body of content was still present, but it opened the way to describing science as biology, chemistry and physics. It drew attention away from the need for an overarching description of science, leaving it to be defined by the sum of its parts. Overarching themes (*Communication*; *The application, and economic, social and technological implications of science; The nature of scientific ideas;*) were found as single pages at the introduction to each programme of study (eg. see DES, 1991, p 22), but they were quickly and easily glossed over as teachers focused attention on the statements of attainment, which focused increasingly on pure science.

Layout

Programmes of study were brought forward in the file so that they were printed alongside statements of attainment. Examples were added to give an indication of the interpretation which was expected in SoAs. This had the effect of valuing PoS as much as SoAs, thus giving a greater emphasis on curriculum and appropriate activities. The large reminder chart which set out the SoAs for quick reference and which could be put on the laboratory wall, however, again made planning from the SoAs an inevitable feature of subsequent development work. The overarching themes were not included in the assessment levels and this effectively removed them from the curriculum, for all but a minority of schools.

'Exploration and investigation' changes to 'Scientific Investigation'

Despite NCC's reassurance that little had been changed the investigation (AT1) had changed. In the 1991 version it became more narrowly defined and became labelled 'Scientific Investigations'. There was no doubt that the first version had been ill defined and cumbersome. In the new version progression in investigations was specified by the number and type of independent variables based on the research from Durham (Foulds, Gott and Feasey, 1992). Two independent variables were found to be more difficult to handle than one, and continuous variables were more difficult than categoric or discrete variables. There was also emphasis on the ability to control variables. This provided examination boards with more clearly defined criteria for assessment purposes. If candidates could show that they had devised an investigation which involved two independent continuous variables, and seen it through from the planning to the evaluation stage, they had a chance of scoring the top marks. Nevertheless the link between procedural knowledge, concepts of evidence and conceptual understanding posed difficulties for the use of AT1 (Gott and Duggan, pp 127-138).

Implementation

Before this version of the national curriculum was implemented there had been another change of Secretary of State for education; John Patten was appointed to the post in April 1992.

Implementation of the revised curriculum began in August 1992. This was the date at which the 1989 version of the national curriculum in science should have reached Y10 (start of KS4). In practice, therefore, the first version of the national curriculum was only ever used in KS3 in secondary schools, (Y7 in 1989/90, in Y7 & 8 in 1990/91 and in Y7, 8 & 9 in 1991/2). The Y7 group which had started in 1989/90 reached Y10 in 1992/3 when they started on the second version and became the first cohort to take GCSE based on the National Curriculum in Science. Their examination papers, and teacher assessment, were based on the <u>second</u> version, NC 1991. No one had therefore attempted the task of examining some of the more controversial aspects such as AT17, the nature of science, before they were removed from the SoAs.

The effect of the change

One effect of tying GCSE syllabuses to the national curriculum assessment meant that all schools (both maintained and independent) were subject to the national curriculum, whereas the national curriculum was originally for maintained schools only. Other effects came from people's responses to continuous change. Some argued that it was too early to change the curriculum after it had run for such a short time; that it was better to allow it to evolve and then take stock of the changes which had developed in practice. Others had made little change to their practice and now felt justified in their delaying tactics. Some of the broader, and more novel, aspects of the curriculum had been removed or at least had less prominence, so it was possible to return to what had always been done.

Running alongside the national curriculum implementation was the development of the related standard assessment tasks (SATs) which had been recommended by TGAT as a means of sampling national performance at the ends of key stages. These tasks were developed for English, mathematics and science. Administration and marking fell on teachers. This was a particularly heavy burden for primary teachers who had to administer and record tasks in all three subjects. The 1991 science SATs, like the 1990 pilot, assessed Exploration and Investigation as well as the Knowledge and Understanding Profile Component.

The demands became impossible because:

> SEAC had made the unfortunate decision that primary teachers had to record the SAT results not at the global levels but by giving a result for each statement of attainment in mathematics, English and science
>
> (Lawton, 1996, p85)

From the following year, however, knowledge and understanding was tested by 'pencil and paper tests' only and investigations were left for teachers to assess as an ongoing part of their work. While the pencil and paper tests became less cumbersome, they seemed less valid than the many interesting classroom tasks which had been developed for the pilots.

Teachers were becoming weary, and wary, of a consultation process where they were no longer sure that anyone took any notice. The authorship of the documents became increasingly anonymous and it was no longer clear to whom one was writing. The confusion which developed over which course teachers had to teach to which year groups was increasing and the legal jargon of much of the material was unhelpful.

An angry confrontation between teachers and the government was growing over the assessments which were being implemented alongside the national curriculum, the impossibility of implementing a subject based curriculum which was so overloaded, the increasing lack of consultation on the part of government, the imposition of particular points of view, especially with regard to the English and history curricula, and the marginalisation of the professional voice of teachers and education specialists. It culminated in a boycott of the national curriculum tests in the summer of 1993 by the teachers' unions, one of the few occasions when all the unions had acted together (Barber, 1996).

The Dearing review of the whole curriculum

Soon after the second national curriculum in science began to be implemented in September 1992, there was an announcement that the operation of the whole of the NC and assessment was to be reviewed by a committee chaired by Sir Ron Dearing, who was also appointed as chair of Schools Curriculum and Assessment Authority (SCAA). He was known as a negotiator and was brought in to mediate.

The Dearing committee was convened in April 1993, and its interim report was published in July. This gave rise to considerable consultation and the final report was published in December 1993. The committee had been charged with four key issues to examine:

- the scope for slimming down the curriculum;
- the future of the ten-level scale;
- how to simplify the testing arrangements;
- how to improve the administration of the National Curriculum and tests.

In outline the report recommended that:

- all subject orders should be reduced;
- that external testing through SATs at the end of KS3 should take place only in the core subjects of English, mathematics and science;
- that the ten level scale should be replaced by an eight level scale, and that it should apply to the end of KS3 only;
- that KS4 should be examined through a wider variety of means, such as GCSE and vocational qualifications;
- that what remained essential at KS4 was reduced (geography, history, art and music were designated as 'optional').

These proposals made a distinct break in the continuity from 5-16, with the end of KS3 as a significant stopping point in several respects.

The third version of NC Science - after Dearing (NCScience 1995)

The draft proposals of the national curriculum in science following the Dearing review were produced by May 1994 and sent out for consultation. The final document was published in January 1995.

Organisation of content - four attainment targets are retained

The overall content was similar to that of the 1992 version, except that meteorology had been moved to the geography orders. Overlap between one key stage and the next had also been removed. The biggest changes were: the specification of the programme of study for investigations; the inclusion of a new introductory section for each key stage which became termed colloquially 'Sc0'; and the layout of the document. The single science option remained.

Layout

Programmes of study were put at the *start* of the document, under five sections: the un-named section (designated by teachers as 'Sc0') was to apply across the other four sections of the programme of study; Investigations and Explorations; Life Processes and Living Things; Materials and their Properties; and Physical Processes.

Apart from 'Sc0', each PoS started with 'Pupils should be taught:' followed by a list of content, so that it looked like a syllabus made up of statements similar to a much reduced set of statements of attainment. Programmes of study in the earlier versions which indicated the sorts of experiences students should have no longer existed. Attainment targets were denoted by more general *level descriptors* not by statements of attainment. In determining levels teachers were expected to arrive at a 'best fit', not expecting a pupil to gain success on all statements in order to be deemed to be working at that level. This was requiring a much higher level of teachers' professional judgement in assigning marks.

'Sc0' started with 'Pupils should be given opportunity ...' for 'Systematic enquiry', 'science in everyday life' and 'the nature of scientific ideas', but 'Pupils should be taught...' in the case of 'communication' and 'health and safety'. There was no attainment target corresponding to Sc0 reducing the likelihood of its being represented in schemes of work and assessment. The sections within 'Sc0' were similar to the profile components suggested in the final report of the original working party.

'Scientific Investigations' becomes 'Experimental and Investigative Science'

The rubric for Experimental and Investigative Science was the key to the change. A range of contexts should be used 'to teach pupils about experimental and investigative methods'. 'Methods,' not 'method', was used. In addition the statement 'On some occasions, the whole process of investigating an idea should be carried out by pupils themselves.' was significant. It removed the need to undertake whole investigations in order to build up investigative skills. The danger was that skills might be assessed out of context and it was possible that the testing of separate practical skills would emerge at GCSE level. The major change, however, was the focus on evidence and on the understanding of how to plan experimental procedures, and how to obtain, interpret and evaluate evidence.

The eight level scale, with a starred level extra

One of the features of the third version of the national curriculum was the application of levels to KS1, 2 & 3 only, and the dissociation of assessment at KS4 from national assessment, other than GCSE. This removed the need to articulate the connection between GCSE grades and the 10 level scale, and also freed the 14 - 16 curriculum, from the 5-14 curriculum, to fit the discussion about the 14-19 curriculum. A curious element of the level scale was the * starred grade for 'exceptional performance' beyond level 8. Level 8, which was the equivalent of grade B at GCSE is a good grade for a 14 year old; the significance of the starred grade remained unexplained.

Implementation

The third version of the national curriculum in science began to be implemented in the year starting September 1995 for key stages 1, 2 & 3 and in September 1996 for Y10 (Y11 were finishing GCSEs based on the 1992 version). The third version of the national curriculum was examined at GCSE level for the first time in 1998.

What was in place was not, essentially, at odds with what many people had attempted to achieve under integrated science courses. A fair content across the sciences, attention to scientific procedures in investigations and understanding of evidence, combined with science, technology and science and the nature of science, were the essential ingredients. The organisation of the content into the three sections identified as biology, chemistry and physics would predispose schools to organise their schemes of work along the same lines.

Summary

During the 1980s there were five factors which forced a different pattern for science education in secondary schools. The first was making science compulsory for everyone to the end of schooling. The second was insisting (in the first place at least) that everyone should spend the same amount of time on it and that this should be the equivalent of two subjects in the 4th and 5th years (Y10 and Y11). The third was to demand that the science studied spanned elements of all the sciences, included investigatory work and an understanding of the science, technology and society interface. The fourth was to have a common examination for all pupils at 16 and the fifth was not to allow 'double science' to be certificated as chemistry, physics and biology.

Of the characteristics associated with integrated science courses, the majority could be found in the national curriculum and in associated GCSE syllabuses. Their status varied, however, from those supported by external written examinations (the areas of understanding and knowledge of physics, chemistry and biology), those supported by teacher assessment, with external moderation (exploration and investigation) and those that were not examined and which were only 'over-arching' themes. The interface between science, technology and society, came somewhere in between the two. Sections of the programmes of study had relevant topics (e.g. energy resources, the influence of humans on the environment, the control over genetic make-up), and such topics were also included in GCSE syllabuses. Its inclusion, however, also in 'Sc0', the non-assessed part of the national curriculum, might slightly reduce the priority given to it, particularly below key stage 4.

By the 1990s ideas which had been associated originally with integrated science courses had become part of the pool of ideas which were incorporated more widely into science education. The ideas can in fact be traced back long before the integrated science courses were developed; but their eventual incorporation into a national curriculum, a common examining system and a range of published courses, made them more generally accessible and accepted.

Chapter 7 documents a return to both Duckworth and Timburn Schools in 1996, in order to gauge the extent to which the integrated science courses of 1980 resembled the science courses of 1996. To what extent were teachers finding the prescription of the national curriculum, GCSE and SATs, modifying what they were teaching? Having had a pattern of integrated science courses which provided a broad, balanced science for all in 1980, had the subsequent transition to national curriculum science been straightforward?

CHAPTER 7

INTEGRATED SCIENCE IN DUCKWORTH AND TIMBURN SCHOOLS: 1996

Introduction

I returned to Duckworth and Timburn in 1996 in order to find out the extent to which teachers had had to modify science courses, given that both schools had balanced science courses for all students up to 16 by 1978. There were four overriding impressions from those visits: both schools were smaller, Duckworth especially; both heads of science reported they and their staff had only just kept their heads above water over the preceding years; both departments had more explicit, and documented, policies about their work, than had been the case in 1980, which leant a air of being business like and professional; both were conscious of the effect of the league tables on the school population and on the way they were affecting the priorities in the science teaching.

a. Duckworth School 1996

Duckworth school's population had fallen to 600; about a third the size it had been in 1980. Staff pointed to the effect of the school being one of only six 'all-ability' schools in a county which retained the 11+ examination, and had a comparatively large number of selective grammar and independent schools. Schools were in competition for the dwindling school population. More prestigious schools tended to win, and some grammar schools were known to be taking a wider ability range than hitherto. With 'no value added' component to the 'league tables' Duckworth was near the bottom in the county. About 60% of the school population was designated as needing Special Educational Needs (some only at level 1). Duckworth school still drew from the town and surrounding areas. About 40% of students were still bussed in each day from rural areas. The school had slightly more girls than boys, which staff explained as parents fighting harder for boys to go to more prestigious schools than for girls. One casualty of the change in size was the house-block system which had been built into the design of the school. The house blocks were now just general accommodation.

The lower school site had been sold for housing, with one part retained as a playing field. The staff was much smaller and on the first day I visited, teachers were to hear about a revised staffing structure. The school was still carrying too many senior posts appropriate to a larger school; reductions in salaries and forced redundancies were predicted. The era of the large faculty had ceased; teaching staff was divided into departments. Information technology, learning support and the unit for children with educational behavioural difficulties were new departments.

Subject choices for students in years 10 and 11 (the old 4th and 5th years) had been reduced because of the increased compulsory core of the national curriculum: French, technology, information technology, personal and social education, had been added to the 1980 'core'. Optional subjects focused mainly on visual and performing arts, subjects where students were gaining considerable success (for 1996, the list comprised: art; child care; dance; drama; music; ceramics; business and information technology; photography; textiles; vocational and community studies).

The school sustained a post sixteen programme through a consortium with Sixford (school roll down to 640). The Y12 and 13 courses comprised a one year course; a range of GNVQ courses and A levels, including A level courses in chemistry, physics and biology.

The science department had a staffing of 3.75 full time equivalent teachers, made up from five different people. Iola Mason (chemistry), the head of science, whom I had met previously through SCISP work, had joined the staff in 1983. His deputy, Peter Bardsey (biology), who had been there in 1980, was only half-time in science, because of responsibility for the IT network and for teaching information technology. The other science teachers comprised, Rupert Leo, (a chemistry graduate who replaced a physics graduate in September 1996, leaving the department without a physicist); Heather Norman (biology) and Darren Roberts (mathematics and science).

The technical team had similarly shrunk to the equivalent of 2.4 full-time posts, made up essentially of four people, one of whom had been there in 1980. Despite the work which Martin Jameson had done in the late 1970s to reduce territorial demarcation of the technical team, Iola had inherited a system where territories and duties of technicians had been separate. One of his first tasks had been to re-organise the technicians as a team.

The pattern of science courses for the 11- 16 age range (key stages 3 & 4) was similar to that in 1980; a 'science' course for years Y7, 8 & 9, and a choice between 'double science' and 'single science' for Y10 & 11. The school had abandoned 'two teachers per class' for Y9, but retained it for the double science in Y10 & 11. The policy that the more experienced teachers taught the top and bottom bands in Y10 & 11, had been retained as far as possible given the small staff.

Y7 were taught in mixed ability tutor groups; thereafter students came to science in year groups which were split into broad, overlapping, bands in Y8, with finer setting in Y9. For KS3 SATs, entries were made to only two tiers (not the higher) giving a possible range of grades 3-6. All students were entered (i.e. none was dis-applied) although a number was given help with reading questions and writing answers. Groups were resetted in Y10, based on SATs' results, which staff found were not good predictors of GCSE success. They subsequently modified their procedures. Sets in year 11 reflected tiers that students would be entered for GCSE - the top set for higher/intermediate tiers, the next two sets for intermediate/foundation tiers and the lower set for foundation. Results of ongoing tests, teachers' own assessments, results of Y11 mock GCSE examinations, and students' own judgements were used to determine tier of entry.

The KS3 course came much more into our discussions than it had in 1977-80, because the rate of changes had increased immeasurably with the introduction of the national curriculum. The Y7 & 8 course had developed 'organically' between 1983 and 1987, with the Y9 course remaining as the SCISP-type course from the 1970s. When the national curriculum was first introduced in 1989 for Y7 students (the '8995 cohort', so called because they arrived in 1989 and could leave in 1995) minor modifications rather than a complete rewrite sufficed. At the time the department was rewriting the Y7 & 8 course in order to incorporate a new science text book, *Understanding Science* (a differentiated text, with the first volume for Y7 published in 1989). Staff called the modified course 'Explorations' and units were labelled E1; E2 etc.

In 1991 KS3 courses were changed in light of the second version of the national curriculum. The 24 units of the course were based still based on *Understanding Science* (1991) (figure 7.1). This course was taught initially to the (9297) cohort. The significant shift, with this development, was conceiving the KS3 programme as a continuous one, not an introductory Y7 & 8, followed by a Y 9 programme. By 1996 this course was referred to as 'OLD KS3', because in Summer 1994 the department re-structured the course in light of recommendations from the draft Dearing report (May 1994). The new set of units were referred to as 'NEW KS3' (see figure 7.2). Titles of NEW units were influenced by the third version of National Curriculum

Science. For instance 'Electricity' was subdivided into 'static charge' and 'electric circuits'; and 'Electromagnetism' into 'magnetic fields' and 'electromagnets' in the national curriculum. The subdivisions became the headings of the units.

Comparison of old and new units is interesting. The increase in the number of units (31 from 24) allowed for clearer identification of topics to be included (magnetism, classifying substances, electrostatics, photosynthesis are drawn out as separate units). Titles became more specific - 'Substances' in Y8 became 'Acids and alkalis' and 'Where do substances come from?'. Electronics had disappeared as it had been moved to NC technology. Sections had been moved; for instance, electric circuits had moved to Y8 from Y7, in order to teach it all at once and include some of the more difficult work. What is not so evident from unit headings is the way in which AT1 was made more explicit in course materials from Y7 onwards in 'NEW' science.

'Revision' became clearly identified in preparation for KS3 SATS for the 9298 cohort. Problem solving was increasingly squeezed out by the more restrictive specification for investigations. It was incorporated in 'after SAT' time, at first, but then vanished from the programme. This did not preclude the use of problem solving in teaching, but reduced its likelihood. A perception of lack of time occasioned the introduction of the KS4 programme at the end of Y9.

The period of the development of OLD and NEW units was reported as confusing. The account from the head of science ran like this: *First the framework for units was developed and agreed when the 1992 version of the National Curriculum was published in 1991. In 92/3 the Y7 units had been developed, often as teachers were teaching them. In 93/4 Y8 units were developed, again alongside teaching. In the latter part of the year, the framework for the NEW KS3 course to start in September 1995 was developed from the draft national curriculum proposals. In 1994/5 the OLD Y9 units were developed while they were being taught, while at the same time the NEW course was developed ready to be taught to Y7&8 in September 1995 and to Y7, 8 & 9 in September 1998. The OLD Y9 course was taught in 1995/6 because the classes had already been taught some of the material from the NEW Y9 units in the previous year. As a consequence the OLD Y7 units were taught three times, the OLD year 8 & 9 units twice. Teachers became muddled trying to remember which units to teach to whom.*

Staff hoped the NEW course could remain in place for 5 years, giving time for evaluation and fine tuning. When I visited in July 1996, the department had just completed its evaluation of the Y7 course, and had some confidence that the evaluation would pay off over a longer period than they had seen in recent years.

Figure 7.1 OLD science course units for KS3, to fit 1991 (second) version of National Curriculum (to be taught first to the 9297 cohort and subsequently to the 9398, 9499).

	Autumn Term	Spring term	Summer Term
Y7	7.0 Basic Skills 7.1 Water 7.2 Energy 1 7.3 Materials 1	7.4 Circuits/electronics 7.5 Reproduction	7.6 Environments 7.7 Energy 2
Y8	8.1 Energy 3 8.2 Substances (Materials 2) 8.3 Forces 1 8.4 Health	8.5 Kinetic Theory 8.6 Electricity and Magnetism	8.7 Environments and ecology 8.8 Electronics 8.9 Geology
Y9	9.1 Back to Earth 9.2 Forces 2 9.3 Energy 9.4 Sound & Light	9.5 Reactions (Materials 3) 9.6 Reproduction & Variation	9.7 Revision SATs 9.8 Problem Solving

Figure 7.2 NEW KS3 course units to fit the 1995 (third) version of the National Curriculum (taught from September 1995 to cohorts:9400, Y8, and 9501, Y7.).

	Autumn Term	Spring term	Summer Term
Y7	1 Basic Skills M 2 Solutions M 3 Living Things B 4 Energy B	5 Cells N 6 Separations M 7 Forces W 8 Reproduction N	9 Magnetism W 10 Classifying substances M 11 Electrostatics W 12 Environment N
Y8	13 Energy & Life B 14 Acids and Alkalis M 15 Current Electricity W 16 Light & Sound; Seeing & Hearing B	17 Movement & Life N 18 Where do substances come from? M 19 Kinetic Theory N 20 Heat W	21 Reactions M 22 Photosynthesis B 23 Earth & Soils N 24 Environments & Classifying B
Y9	25 Electromagnetism W 26 Energy resources M 27 Good Health N 28 Forces Again W	29 Periodicity M 30 Survival B 31 Reproduction N Revision	SATs KS4 Biology KS4 Chemistry KS4 Physics

Staff had become increasingly aware, however, of the demand for increased recall in SATs; i.e. recall of specific pieces of information. This necessitated careful trawling of the national curriculum to make sure necessary facts were included. Courses were to be put on a regular two year cycle of evaluation.

The only variation to the 1980 pattern of courses for KS4 had been for the Y10 cohort in 1994 (examined summer 1996), when only double science was available. The senior management team (SMT) had interpreted National Curriculum requirements as requiring double science for everyone and with an impending OFSTED inspection in 1995, had changed policy. SMT re-introduced the single science option in 1996. The proportion taking double science rapidly diminished (51:49% in 1996 and 40:60% in 1997). The attractiveness of the option scheme for Y10 & 11 was seen by science teachers as a positive draw away from double science. There was a belief that colleagues, even members of the SMT, might be discouraging students on the grounds that 'science is hard, especially double science' (and hence higher grades were more difficult to achieve).

Despite the same pattern of courses, there had been changes. The Integrated Science: single certification course offered by the examination board for the first GCSEs (1988) was different in character from the original CSE mode 3 single science course. This necessitated a revision of the course in summer 1986 ready to start in September 1986. After that modifications were those imposed by the board. From September 1996 the department had decided to change to the *Science at Work* course in the belief that it would suit students better.

The double science course offered by SEG in 1986, was 'Integrated Science: Principles' and 'Integrated Science: Applications'; the course referred to as 'son of SCISP'. This was similar to their own double science courses, but nevertheless rapid revision of material and cross checking had been essential. The school had felt the pressure which all schools did of having to react rapidly. Syllabuses from the examination board evolved in this period, to bring them in line, first with the national criteria for science (DES, 1985b) and then, with the national curriculum. This had required constant review of school syllabuses; sometimes requiring quite considerable modification. Figure 7.3 gives the changing titles of the courses. The biggest change came with the syllabus examined in 1994 the first national curriculum. Again planning time was short. SEG published its new syllabus in May 1992 leaving only two school months to prepare for teaching in September 1992.

Figure 7.3 16+ syllabuses and examining boards used at Duckworth, 1978 - 1996.

Group	yearly cohorts start course	Cohort examined	Course	Examining board/group	Supporting materials
O level	1977-1985	1982 - 1987	SCISP	Associated Examining Board	Patterns Books (but used own SoW)
CSE	1977-1985	1982 - 1987	Integrated science :Problem Solving Integrated Science: Community Science	South East Region Examining Board Mode 3	Patterns Books (but used own SoW)
CSE	1977 - 1985	1977 - 1985	Science (Single award - IS) (Grade restricted)	South East Region Examining Board Mode 3	Used own scheme of work
GCSE	1986 - 1988	1988 - 1990	Integrated Science - Applications Integrated Science - Principles General/Extended	Southern Examining Group	Bought Patterns (Lyth) - not used
GCSE	1989 - 1991	1991 - 1993	The Sciences: Double Award General/Extended	Southern Examining Group	
GCSE	1986- 1991	1988 - 1993	Integrated Science: Single Certification General/Extended	Southern Examining Group	
GCSE*	1992-1995	1994 - 1997	Science: Double Award Found/Gen/Higher	Southern Examining Group	
GCSE	1996 -	1998 -	Science: Double Award *Found/Inter/Higher*	Southern Examining Group	
GCSE	1996 -	1998 -	Science: Single Award (modular) *Found/Higher*	Southern Examining Group	Science at Work

The double and single courses had during this period been linked in a way they had not been in 1980. The department had structured its courses into a set of over 40 units, 26 of which were referred to as 'core' units and the rest referred to as 'options' units. The effective model adopted when the single science course was changed was the 'core and options' model (Waring and Schofield, 1981).

In summer 1994, in preparation for the new syllabus for 1998 examinations, the department reduced the number of units because students had found it difficult to see how they fitted together. The double science course was reduced to 21 units and the single science reverted to being a different course based on *Science at Work* .

Science Investigations - Sc1 for KS3 and KS4

Like many schools, Duckworth had found students did not readily adapt to the demands of Sc1, particularly in the second version of the national curriculum, and that support was necessary. Understanding what was meant by a variable was a major problem. Activities from the *Thinking Science* Project (Adey and Shayer, 1989) had been a help and were incorporated in the Y7 course.

Thinking of investigations which could be done in school laboratories and which involved two independent variables was another reported difficulty. Three investigations were used, one from chemistry, one from physics and one from biology, but teachers considered they were becoming routine. The three were:

- how is the rate of reaction of chemicals affected by concentration and temperature?
- how is the strength of an electromagnet affected by the size of the electric current and the number of turns of wire on the coil?
- how is the rate of production of starch in photosynthesis affected by wavelength of light and exposure to light?

To ensure investigations were developed on a systematic basis, inclusion of at least one was expected in each unit.

The GCSE syllabus examined in 1994 was a trigger for fairly major development of Sc1. Up to that point the SEG syllabus had edged towards Sc1 but still had a wider interpretation of 'problem' and skills which were being tested did not have to be assessed within the context of whole investigations. Marking schemes became highly prescriptive. Above all, evidence had to come from students' <u>written</u> accounts; not from the teacher's account of the students' performance. A premium was put on written communication skills as well as on investigation skills. It was not surprising that Duckworth, like most schools, focused attention on supporting the writing of clear reports. (The departmental handbook contained four different support documents).

Tracking of students' progress through KS3 and KS4

The assessment, reporting and tracking system throughout KS3 and KS4 had undergone several changes. In the late 1980s, the science staff had been deemed to be over-assessing students at both KS3 and KS4 through formal tests (one every tenth lesson) (a judgement by an HMI undertaking a survey on assessment strategies). The department's response had been to drop formal testing, except for the end of year examinations. Teachers relied on formative assessments made as they taught. In retrospect Iola regarded this as possibly unwise because it had been difficult to monitor students' progress against others in the year group.

At the introduction of the National Curriculum and assessment in 1989, the county had suggested recording achievement on a grid, made up of the statements of attainment. (The first version required a grid of 377 statements, if levels 1-3 were included, or a grid of 207 statements if those appertaining to levels 1-3 were omitted.). Duckworth had not adopted this and before long its unwieldy nature was apparent and county abandoned the scheme.

In 1996 the department was in the process of building a new system to track progress of students through the year; the assessment comprised four elements:

- end of unit tests using multiple choice questions
- end of term tests of more extended short answer questions
- assessment of Sc1 in each unit
- teachers' marking of homeworks/classwork

Marks from tests were standardised to the same mean and standard deviation. As unit tests were subject specific it was possible to track performance on physics, chemistry and biology separately if needed. Criteria for marking Sc1 were the SEG's criteria for KS4 and essentially the national curriculum statements for KS3.

The system of recording comprised four elements:

- KS3 record sheet summarising performance in Sc1 on an on-going basis, and giving a 'level' mark for Sc1, 2, 3 & 4 at the end of KS3 as judged by the teacher and as shown by the test score. A similar sheet was used for KS4, using the 2nd version of the national curriculum.
- record of performance in an individual unit on Sc1 and the end of unit test
- records of end of term tests, which were held in the computer
- teachers' own mark books.

The system of reporting comprised one internal report to students and one external report to parents. The internal report indicated attendance (taken from the computerised registration system), attainment, effort and group skills, and was discussed between student and group tutor with the purpose of generating targets.

Careful scrutiny of results in GCSE was done by the department for its own use and for annual reports to governors. Critical incidents in both 1994 and 1995 give an indication of analysis and subsequent action. In 1994, students in one group who had been entered for the intermediate level and predicted to get a reasonable grade, were awarded 'U's and students in a lower group, who had been entered for the foundation level, had achieved better grades. The school had followed this up with the board but without effecting any change. As a result the department had made a careful check on discrepancies between predicted grades and actual grades from the four teachers concerned, to try and monitor their own ability to predict accurately.

In 1995 grades had again been disappointing as only one person scored an A grade. The next grades were C. Comparisons with grades in Mathematics and English, however, had indicated that science was not fairing any worse. The department routinely checked performance of boys and girls separately. There was an indication that boys were overall scoring higher grades than girls.

The 'bottom end' of the single science groups were not originally entered for examinations. In 1993 this altered with all candidates who had shown reasonable attendance being entered.

Overall there were three aspects of the science curriculum which Iola highlighted as having changed: the increased emphasis on recall of specific facts; reduction in problem solving and its replacement by investigations; and the emphasis placed on written communication skills to give evidence of students' skill in science, and on the ability to read well.

Iola regarded the moratorium on change with the Dearing review as an important window when teachers could get back to focusing intently on the business of 'teaching and helping youngsters to learn'. There was a feeling that everyone had had to race to make sure that what they were doing fitted external criteria and that they had accounted for themselves in writing. With systems in place teachers could stand back and take stock of where they were, and what they, as teachers, felt needed doing. Heather, who joined the conversation at one point, commented that they had never really had time to evaluate their courses over the last few years, before they had to change them. Cross curricular links had become increasingly difficult with the subject based national curriculum. The 'activities week or off timetable week' at the end of the summer term was becoming a window of opportunity for imaginative projects. The science department had run a cross curricular course on SPACE with several other departments including drama.

The organisation of the science department

In the case study of 1980, I reported how the organisation of the department had altered in the light of curriculum change. The question of hierarchy and status had been fairly dominant. The situation was so different in 1996 that it was difficult to make simple comparisons. The different layers of hierarchy had been removed when the Main Professional Grade was introduced subsuming the old scales 1 and 2. In 1996 the department had been left with seven points for science, four allocated in the Head of Department post, two to the second in department and one for someone else.

The smaller group brought its own management problems. Three teachers were routinely out of the department with on-going other commitments; Heather Mason for her pastoral role in Y 7 & 8, Peter Bardsey, who was co-ordinator of IT and network and office manager; and Darren Roberts who taught also in the mathematics department. Iola found that he could not rely on informal channels of communication, because these teachers could easily be called away elsewhere; that Peter could be called away from lessons if the network broke down; and Heather could be late for lessons because of intractable pastoral issues; and that all could be involved in meetings and developments in other areas, restricting their capacity to be strongly involved in science developments.

With a small team the work fell on a few people. Much of the work of a science department is not reduced directly in proportion to the number of students to be taught. If a course needs altering then alterations have to be made whether the course is for three classes or eight; the same applies to development of class tests and assessments. The major areas of responsibility (other than HoD), which carried the overall responsibility for the whole of the department's work had been divided into three areas:

- KS3/4 Co-ordinator
- Assessment Co-ordinator
- Resources Co-ordinator

Iola carried the KS3/4 co-ordinator job himself, so effectively he was not only managing the department, he was the one with oversight of the whole of the curriculum. As the one permanent feature in the system, this was perhaps almost inevitable. Peter Bardsey carried responsibility for assessment and Heather Norman for resources.

Science Department Handbook

The science department handbook was essentially a new phenomenon, not just here but in all schools. The 1980 booklet on 'guidance to the Department for New Teachers' had been a short informative booklet. The Departmental Handbook at Duckworth was different. It was a collection of papers which had been written, not just for the new teacher, but for all science teachers, for the senior management team and for Ofsted. Policies on almost every aspect of the department's work were now explicit. There was a mix of:

- audits and reviews
- planning documents (often arising out of reviews)
- summaries of policies
- information about tasks which had been determined and needed recording (for instance the times at which there was technical support available).

Computers, the desire for uniformity of practice, accountability, and monitoring of everything possible seemed to have promoted the use of a large number of pro-formas. There were pro-formas for:

- Staff record of homework set for each class
- Tracking performance on Sc1 in KS3
- Tracking performance in Sc1 in KS4
- Recording performance and effort at the end of every unit
- Permission to leave the class
- Report from a subject teacher to a Group Tutor
- Letter to take when child is sent to the Duty Room
- Letter to parent re forthcoming detention
- Slip to go to form tutor about a child who has not turned up for detention
- Certificate of achievement forms
- Laboratory maintenance sheet
- Audit of resources and resource management
- Lesson requisition slip
- Analysis sheet for lesson preparation (who uses this? what is it for?)
- Duplicating requisition
- Weekly planners for science teachers
- Form for health and safety report

Summary of Duckworth School, 1996

The organisation of courses and resources was similar to 1980. KS3 courses were, however, planned more as a continuum. Schemes of work and teaching material had been updated to accommodate a steady stream of changes imposed from outside leaving teachers yearning for time to drive their own evaluations, and focus more intently on the needs of their particular students.

Assessment practices had changed considerably - both formative and summative, and had just begun to settle into a stable pattern. Teachers were no longer constructing their own external examinations as they had been doing at CSE in 1980, but they were still of course involved in teacher assessment at GCSE. Explicit written support of science investigations had been developed to help raise marks as far as possible.

There was increased documentation about decisions and policies. There was an explicit and written commitment to the improvement of standards through a range of actions. There was a wider range of external constraints against which to monitor and review the work of the department. There was an increase in the proportion of children in the school with special educational needs.

The management of the department's activities was fitted into an explicit (and recorded) cycle of review and planning. The end of the school year was the time when revision of course material was most likely to take place. There was a sense of business-like conformity.

The structure of the science department had been overtaken by events. The group of teachers was so small that the structural issues of the large department in 1980 were irrelevant. Co-ordination across courses, which had been established in 1980, was an essential feature still and an area of major responsibility.

The changes which were evident were attention to management, accountability, the support of slower learners, the drive to make the results better, and the co-ordinated monitoring of progress. There was, also, the acceptance of the changes by the teachers. There was no sense that they had any option but to conform and although it had been hard work, they had done just that.

The sense of freedom which had come from involvement in the examination process of the mode 3 had gone, even though teachers retained responsibility for assessing investigations.

b. Timburn Community College - 1996

The story at Timburn was not dissimilar from Duckworth, particularly in the factors which occupied teachers' attention, namely: the reorganisation of the school; a reduced roll and competition with other schools; a 'creamed' population; the need to maximise scores in the league tables; meticulous attention to developing systems of assessing, recording and reporting; explicit and co-ordinated support for SC1; support for SEN pupils; monitoring and responding to changes in syllabuses and external tests; accountability to the senior management team and governors; preparation of documentation for Ofsted and the follow up from Ofsted reports; the lack of money for refurbishment of the laboratories; the relief of 'off timetable' weeks when there was an opportunity to experiment. Two additional features mentioned were the liaison necessary with the middle schools who taught Y7 and the changes which had had to be made to the sex education programme in the light of government legislation.

The school had been redesignated as a 'community college' (as had all secondary schools in the county) and had been re-organised by the senior management into two smaller schools with their own management teams, although still within one overall organisation. One 'mini school' was in the original lower school building and the other in the upper. There had been various reasons for the change:

- to provide greater continuity of staffing, including a tutor taking students right through the school;
- to provide a sense of community within the smaller units without a sudden break after two years;
- to strengthen the role of the pastoral system, with reduction in power of subject departments.

There was a hope that pupils would be taught all their lessons in the one building, but for subjects with specialist facilities like science, this was not entirely possible.

The school population had dropped by about 300 to 1200. Twenty percent were classified as having Special Educational Needs, and a further two and a half percent were statemented.

The pattern of courses was the same as in 1980: a combined science course for Y8 & 9 and double science courses for Y10 & 11, with one teacher per class for Y 8 & 9, and two teachers per class for Y10 & 11. In Y12 there was a mixture of GCSE science courses; a science component of a GNVQ in Health and Social Care, and a number of one term short courses which were not examined, of which photography was one. Three A level courses (physics, chemistry and biology) were run also for Y12 & 13. In outline the main changes since 1980 were the examination boards used for GCSE in Y10 & 11, the GCSE subjects offered in Y12 and the introduction of the science component of GNVQ. The introduction of the national curriculum in science and the increased focus on assessment had, of course, meant that *within* the courses there had been change.

The teachers reported similar changes to those at Duckworth. When GCSE was introduced the school moved to MEG's double science course rather than stay with SEG, because the board seemed more organised. Results dropped, which the staff put down to too much 'teaching to the middle', and forgetting to differentiate sufficiently. The department therefore switched to NEAB double science course for the top group and Suffolk co-ordinated science for the rest. From 1996 they were to move to using only NEAB, because of the quality of administration and guidance from the board. Support for revision was a major element of the work.

Closer liaison had occurred between Timburn and middle schools over KS3. When the National Curriculum in science was introduced for Y7 in 1989, agreement had to be reached about what would be taught in the middle schools and what left for Y8 & 9. *Science Horizon* (later called *New Horizons*, when modified for the National Curriculum), had a 'map' which showed how a science programme could be incorporated into a series of topics (most lasting half a term), appropriately allocated to the three different years. The staff at Timburn, in collaboration with middle schools, had agreed to use this for organising the KS3 programme between them. The coverage and success of the Y7 programme mattered a lot to Timburn, as mistakes might not be easily remedied in the following two years. Again I was aware of the sensitivity of teachers to the results of external tests, even though personally they would prefer not to be dominated by them. Staff had rewritten schemes of work for KS3 substantially from September 91; and subsequently reviewed and modified them in light of the second and third versions of the national curriculum..

Support for SC1 was again explicit and co-ordinated across the department for both KS3 and KS4. Departmental documents included: *NC Sc1 in 'pupil speak'*; the *science investigation help sheet*; the *investigations planning sheet*, and the *student checklist and self assessment for scientific explorations*. The 'pupil speak' document was subsequently updated for KS3 to fit the 1995 version of NC science, with the NEAB version being used for KS4. Teachers found this collection of material had been useful in teaching students about the elements of an investigation. *Teaching* about investigations as well as assessing them was highlighted in the science handbook.

Teaching staff

The science staff had reduced since 1980. There were still 14 people, (see appendix 3) but several were part time or taught a reduced science timetable because of commitments elsewhere in the school. On average full time teachers taught 26 out of 30 periods per week. Paul Hopkins, however, who had responsibilities for organising the school timetable, managing resources for the whole school (the typing and reprographics unit run for all departments, and management of SIMS), and organising computing, taught only 18. Sian Wirrell, a member of the senior management team (SMT), taught only 12 periods for science (designated to rise to 15 periods in 1996/7, because all members of the SMT would have to teach 15 to make the timetable work). Susan Scott, who managed science in Cookleigh, and was the college's careers co-ordinator, taught 23 periods. The head of science, Dai Cotton, who was also the school professional tutor for PGCE students, taught 22 periods. The PE specialist taught only 4 periods of science a week.

Assessment in KS3

Assessment had been a major area for development at KS3 in 1993/4 and 1994/5. The assessment system for KS3 in operation in 1996 comprised several elements:

- self assessment of Sc1 (formative)
- teacher assessment of Sc1 (formative and summative)
- joint profiling of performance in Sc1-4 mid year, and at the end of the year (February and July)
- end of unit tests for each module (written by the teachers) (formative and summative)
- routine marking of classwork and homework (formative)
- end of year exam (summative)
- observations that teachers made of pupils as they worked in class (held 'in the head', and sometimes also, noted in record books)

At the start of the national curriculum (1989 version) the science teachers had tried a scheme whereby students used self assessments for Sc2-4 as well as teachers recording performance on all SoAs. They had also tried joint profiling on a frequent and regular basis, but this had become unworkable because there had not been enough time in the lessons to do it and it had become counter productive. The half yearly joint profiling was a whole school policy, not just science. The department handbook contained guidelines for profiling.

From 1993 until 1996, the science department held evidence of performance in SC1 for students at KS3 in individual portfolios. In practice these had rarely been referred to. When teachers wrote reports they used their mark books for scores in Sc1 investigations, end of topic tests and homeworks and classwork throughout the year; they had not gone back to the original pieces of work. The portfolios had, however, been kept as staff had been uncertain about evidence that might have been called for from outside bodies. At the time of my interviews in July 1996, the college had been told by the county assessment co-ordinator that it was unnecessary to keep work and staff were about to abandon the system to release storage space. In future the school would hold the end of module tests results with scores for each investigation done.

The department had, however, built up a departmental portfolio of exemplars of different levels for Sc1 and this was used, and would continue to be used, as a reference when marking students' work. Obviously with the changes in Sc1 this portfolio would need some adjusting, and in any case would need annual reviews. The plan was to extend this portfolio to work related to SC2-4 in 1996/7.

The assessment programme, especially the end of unit tests, was supported by a set of revision booklets that the staff had written. Revision, in class time, had become an increasingly prominent part of the programme, giving students plenty of practice in the sort of demands that would be made in KS3 SATs. The evidence was that the revision programme was paying dividends in terms of improvement of scores in both end of unit tests and in SATs, but it was taking a substantial amount of time from the teaching programme. Typically there was a week of revision before the end of unit tests and the second half of the Spring term in Y9 was devoted to revision of the work that had been done not only in Y8 & 9 but with a particular emphasis on the work that had been done in middle schools in Y7.

Organising the groups and the teaching of the courses

After Y9 examinations and SATs, teachers met to allocate students to different courses based on:

student achievement (module tests/investigations/SATs)
teacher assessment of ability/potential
mathematics test

CAT scores, if available from the computer

The two upper band groups studied for the NEAB course and the rest for Suffolk. It was possible for students to change groups during the year, but most changes were left to the end of Y10. For both courses, teachers were paired for the teaching so as to increase the range of expertise available to a class; they decided between themselves who taught which topic.

The organisation of the science department

The departmental structure was in some ways 'flatter' than in 1980. There was a head of department, Dai Cotton, and a second in department, Janice Osborn (who had been there in 1980) and four people who had an additional point for science. Part of the 'flatness' was a result of the introduction of the much longer main professional spine which incorporated the old scales 1 and 2.

The responsibilities distributed were associated with the tasks that needed to be done; overall responsibility for KS3 and KS4, management of the laboratories in the two buildings, non-A level Y12 courses and Information Technology; A level courses. Something of the old subject divisions (physics, chemistry and biology) still existed in the A level responsibilities and in practice this subject responsibility went further to the vetting of the biology and physics units at KS4. As in 1980, this mixed responsibility was described as 'a bit of a grey area'. The areas of responsibilities were similar to those in 1980, except that the co-ordination of KS3 had a higher profile and Information Technology was more established.

Meetings and other channels of communication

Communication between members of the department, given the physical distribution of the laboratories, would always present a challenge to the department and particularly to whoever is head of science. New Science still formed a social base in Slinfield to a large extent, but there were some people who rarely went there, so informal channels of communication could not be relied on as a mechanism. Written memos were a routine in the department; urgent messages had to be telephoned around with the hope that everyone who needed to know did hear.

One night a week was set aside for departmental meetings. The agenda were set in outline at the beginning of the year, to anticipate known tasks (e.g. examination entries). The more immediate agenda was set by the head of science in collaboration with the second in the department. There were nearly always urgent administration points that had to be added. Meetings were chaired by different people depending on the nature of the main agenda item.

Tracking students' performance through the school and the use of formative assessment

Mechanisms for tracking students, noting performance and making sure that no-one 'slips through the net' was embedded in departmental policies and practice. The school was focusing on trying to demonstrate the 'added value' that attending full time education at Timburn provided.

The marking policy for the department showed a focus on formative assessment. Clear guidelines about what was acceptable and what was not, with a reminder about the importance of constructive feedback to learners. The homework policy was similarly informative - why homework was given, how often it had to be given, how long it was to last, the sorts of tasks which should be set, and what to do about students who failed to give in homework.

Concerns/ current priorities

Completing units and finding time to evaluate them were seen as high priority tasks. Communication in a rapidly changing educational environment would continue as a major challenge. The rapidity with which new directives hit the department, or some minor change occurred that if not spotted, could have significant implications had left the feeling that 'we are just keeping our head above water'. The moratorium on change in the national curriculum under the Dearing review had been welcome because it allowed time to focus on aspects staff knew needed to be done. There was concern about students who were not good at reading and writing and who were missing out because there was less practical work being done.

Financial constraints were also a concern - outdated apparatus, inability to refurbish laboratories (a sense that 'make do and mend was beginning to have outlived its usefulness), inability to renew apparatus for A level work particularly; inability to send people on courses for their own professional development; inability to supply textbooks for Y8 & 9.

Given the dependence of schools on image as seen by outsiders, OFSTED reports and publication of results, formed major ingredients of this image. Timburn, like other schools, low in the 'league tables' needed other parameters to show that it gave a worthwhile education. The school was looking seriously at describing 'value added' which it gave to its students' education. This involved careful tracking of the entry scores of students and noting the difference that Timburn had made.

With time at a premium monitoring the implementation of policies and improving on practice remained a challenge.

Summary of Timburn Community College 1996

The science staff had addressed a long list of changes in the previous ten years: planning the Y10 and 11 GCSE courses (1986/8 and again for 1993/5); writing the course material (ongoing, still not complete 1996); rewriting the KS3 programmes to match the national curriculum (first in 1989; then again in 1992 and again in 1995); liaison with the middle schools at a detailed level; science investigations - support for teaching and assessment; preparing revision schedules; tracking attainment, from entry through to GCSE, from a regular agreed set of strategies ; preparing for OFSTED inspection and being inspected; preparing of a science department handbook about policies and practice; ensuring that the department met legal safety requirements; implementing the national sex education policy (ERA); annual reviews and development planning; recording policies and practices in a manner which makes them accessible to an outside audience

These were similar to the activities at Duckworth, as was the general rapid and business like approach, and the willingness and ability to account for the department and its work. Like Duckworth teachers, the Timburn staff had concerns as to whether the curriculum was serving the slowest children well.

Summary

Both the heads of the science departments had reacted when they read the original case studies by saying how different everything was now. At one level it was; the monitoring, assessment and reporting systems were new; departmental policies and practices were documented in handbooks; accountability to the senior management team and governors was formalised; action plans were in place; support to maximise SAT and GCSE results had a high profile; freedom in the science curriculum in the lower part of secondary school was curtailed because of SATs; schemes of work possibly had fewer integrated units in terms of the different sciences and physics, chemistry and biology were more easily identifiable.

The basic framework for the science courses had stayed the same, and much of the content was similar. The courses from Y7 - Y10 comprised a series of discrete units which covered the syllabus, a format similar to 1980. Investigations played a larger role than they had done in 1980, because all students were involved not just those in the top groups. In addition the importance of the written record of the investigation for summative assessment purposes was putting the written communication skills as more important. The students were perhaps gaining proportionately less credit for their practical skills. The need for more recall of specific information, especially in the KS3 SATs was also affecting the teaching.

Integrated science was still in place. It was called science; it had been moulded by the demands of the assessments, and modified by the shifts in content, but much of the science which had been in place in 1980 was still there.

CHAPTER 8

OUTCOME OF THE RESEARCH

a. What was Integrated Science?

Integrated science was not a single entity. It was an umbrella term which emerged in the 1960s and remained in use until the early 1990s. It referred essentially to titles of courses especially in schools. It signalled that in some way course planners were attempting to do something that was new, and usually that they were structuring the study of science in a way which either did not automatically involve the 'traditional' organisation into chemistry, physics and biology, or which had an outcome of learning which was different from a traditional one, or both. At its minimum, therefore, integrated science can be viewed as a collection of attempts to structure science courses in schools in a way which did not start with pre-existing assumptions about what should be included, how it should be structured, what approaches should be used and what purposes the courses should serve. Although the rhetoric of 'pioneers' in integrated science often referred to the essential unity of science and unifying themes, these were difficult to identify. It was easier to identify different features of courses which were linked to different aims of science education and to recognise that integrated science courses attempted to incorporate many of them.

Breadth of science in some form occurred in nearly all projects. The 'scope' of the breadth varied from those which encompassed physics, chemistry and biology to those that also included geology, meteorology and astronomy, or to those that went further into psychology and the social sciences. Breadth of science was a consistent element of integrated science; not because it was essential, but it was treated as if it were essential. The need for breadth followed easily from the argument that science in school must help pupils make sense of contexts they will meet outside, because those contexts can be so diverse. It also followed from a more academic subject-based perspective; science comprises a set of interrelated studies, each with its own distinctive as well as overlapping features so one cannot be said to have a general education in science without having an insight into the different components and be familiar with the concepts and language of each. A similar argument would be given by those arguing from a 'passing on the culture' viewpoint.

The second feature was 'science in context' or the 'science, technology and society' interface. The link between science and technology, in the understanding of how gadgets work, how the environment is managed, was included, alongside how decisions are made in technological situations. Environmental and ethical issues were often included. These were a strong thread of SCISP. For courses like Nuffield Secondary Science the bridge between school science and 'out of school' science was important. 'Personal science' in studies such as sports science, health, hygiene and diet were common topics.

The third strand was connected with exploration and practical experience. There was a mixture of learning skills to explore phenomena as in Nuffield Combined Science, engaging in practical experiences to be able to make generalisations as in Nuffield Secondary Science, undertaking practical projects and investigations also in NSS. SCISP had moved more to the inclusion of science investigations with formal assessment of ability to design experiments and evaluate data.

A fourth feature of the courses was the use of one teacher per class, or at least the belief that this should be the case. In practice, the SCISP team had recommended two in order to cope with the breadth of science to the level needed. It is hard to be sure with NSS as the material was a resource rather than a course and teachers could use it for a range of courses, taught by one or more than one teacher. However if it was being used for the equivalent of one subject timetable slot then only one teacher would be used.

b. What happened to integrated science and why?

To track what happened can be treated at several levels: there are the events which happened in the UK (and particularly in England and Wales) which helped to mould the schools and the educational contexts in which the courses were implemented; these changes in turn moulded the courses. Within these it is possible to identify many of the dynamics which shaped and reshaped integrated science.

The major events were: curriculum renewal through the projects in the first place; the establishment of the certificate of secondary education examination (CSE) and particularly CSE mode 3; the comprehensivisation of secondary education; the raising of the school leaving age to 16 in 1973; the debate about the reduction of choice for students post 14 in all subjects not just science; falling rolls in secondary schools in the late 1970s; increased consensus that everyone should study science;

the introduction of a common examining system, GCSE, which was criterion referenced and which had a relatively high proportion of teacher assessment; the introduction of the national curriculum and assessment.

Like the term 'general science', 'integrated science' became a term to which people had an emotional response, partly because it was a banner behind which people gathered as though it was the answer to the issues in science education, and partly because there was no clear definition as to what this miracle cure was. This response built up very early in the life of the projects, perhaps because, as Haggis and Adey pointed out (1979), many of the writers of integrated science schemes were on the defensive and were having to challenge the secure position of those in the separate pure sciences. In defence of the euphoria of say, *Nuffield Secondary Science*, it signalled an insistence that science did *not* have to be an elitist subject and that it *was* accessible to a wide variety of people.

CSE mode 3 provided a forum in which teachers could develop a range of science courses, and considerable experience of examining integrated science was developed through this route. The comprehensivisation of secondary schools provided the opportunity for cross-fertilisation of ideas between courses for different target groups. The same teachers were teaching the different courses and good ideas from one filtered into others. This reduced the differences between courses. Schools also attempted to delay choice between courses, and it seems that the automatic reaction was to make the scope of the courses as wide as possible, at least up to the end of the third year.

The raising of the school leaving age brought the need to make science accessible for more pupils, particularly the less able. The debate about the reduction of choice for students after 14 in all subjects not just science and the falling rolls in secondary schools in the late 1970s brought the pressure for rationalisation of science courses and a wish for greater uniformity. The 'umbrella' of 'broad, balanced' science contained the ingredients of integrated science courses, and yet was able to accommodate both integrationists and those who wanted 'separate sciences'. The introduction of national criteria for all science in preparation for the common examining system, GCSE, reduced the diversity between courses and the teacher assessed component brought in formal testing of skills related to practical work. Government policy on science 5-16 and later the national curriculum in science further shaped what counted as science in schools.

What happened to breadth in content in science courses?

The implementation of breadth of science in school education started long before the integrated science courses of the 1960s were developed. Tracking its progress from the turn of the century to the present day gives one perspective on the integrated science story and on the dynamics which operated in encouraging breadth and those that halted it. Breadth of science is interpreted in this section merely in terms of physics, chemistry, biology, geology and astronomy.

In the late nineteenth century, science was represented by courses in about twenty different branches of science. Physics and chemistry courses dominated in grammar schools; of these two physics was particularly fragmented. Boys preparatory schools taught no science. Where science was taught in the public schools, it was, on the whole, reserved for those who were not so successful at studying the classical languages. Science in elementary schools comprised nature study and object lessons for the lower standards; these allowed considerable choice of what was studied depending on the objects used. A more structured programme of science was available through the syllabuses for the higher standards, especially for pupils who stayed on beyond the statutory leaving age. These syllabuses drew on nature study, elementary physics, elementary chemistry, physiology, and incorporated domestic science for girls. There were no associated examinations. When the syllabuses of the 1890s were replaced in 1905 by the suggestions for teachers from HMI, the control on what was taught was reduced and the specification for science much vaguer.

The turn of the century saw the start of science masters in public schools arguing for the incorporation of science into the general education of all boys, especially in light of the criticism the schools had received for largely ignoring science. They advocated a freedom of choice in subject matter, so long as interest was aroused and something of the excitement of science was imparted. Science study was not to be bound by what was seen as the narrow vocational training in formal science which dominated science being taught for matriculation purposes. Syllabuses were to some extent idiosyncratic and indicate the predilections of individual masters, but there was a wide range of subject matter and of contexts in them.

The more widespread establishment of secondary education as opposed to elementary education following the 1902 education act, brought the potential for more pupils to benefit from science education in the modern grammar schools. Chemistry and branches of physics continued to dominate, although nature study was often taught in the lower forms. Botany was more widely studied than zoology and this was particularly so in girls schools. Zoology was often restricted to the upper forms for those who wished to study medicine at university. But the proportion of pupils who had access to these secondary schools was still small. The majority of pupils stayed at the elementary schools, where science provision was limited. Despite the developments of science in the schools, evidence to the Thomson committee between 1916 and 1918 revealed a patchy and narrow provision, which caused concern.

Co-ordination of examinations through the school certificate and the higher school certificate in 1918 was a major factor in rationalising science provision, and providing a mechanism for new developments becoming more widely known. General science became an examination subject, which meant that it had a defined syllabus. Its incorporation into schools was slow, although surveys in the 1930s revealed considerable use of general science courses for the first two years of secondary school.

The development of biology, in place of separate botany and zoology courses, and of physics courses in place of about five or six separate branches of physics was another rationalisation which contributed to the development of breadth and the move away from narrow specialisation. The rapid rise in the popularity of biology as a school subject in the 1930s soon brought the number of entries in examination similar to those in physics and chemistry. The fact, however, that school certificate was a group certificate and that choice had to be made across subjects, meant that it was difficult to study all three sciences at school certificate level. General science was one compromise but it was treated as a single subject and allocated less time. Introduction of syllabuses in physics with chemistry was another compromise. There were pupils who went on to study physics and chemistry as separate subjects at higher school certificate level from such a course.

The expansion of secondary education after the first world war increased the number of pupils who had access to the more formal study of science. The concept of secondary education as *consecutive* to primary education as opposed to *parallel* to elementary education became more widespread post Hadow (1926), but it tended to be only in the large conurbations like London, that there was substantial secondary provision outside the selective grammar schools. There was therefore still a large proportion of the population who had only limited access to science through school education.

The introduction of free secondary education for all through the 1944 Education Act and the raising of the school leaving age to 15 in 1947 brought a wider section of the community into the study of science. The introduction of GCE O and A level as single subject certificates in 1953 had important outcomes. First it became possible for some of the non-grammar schools to present candidates for single subject O level examinations without having to undertake all subjects; entries in sciences showed that a number of secondary modern schools took advantage of this. Second it allowed pupils who enjoyed science to spend considerable time on study of all branches without having choice restricted as it had been in the school certificate. This of course could have the effect of overloading the timetable or of biasing the curriculum of an individual heavily towards science at the expense of other subjects.

The 1950s' enthusiasm for science and concern for its enhancement in general education provided the context for the 'audits' of science in grammar and secondary modern schools undertaken by the SMA and AWST, and the impetus for curriculum renewal. That renewal via the large scale curriculum projects took place within the existing groupings: the able, or those who would sit for examinations at O level; the less able, or those who would not sit for examinations. A major focus of the O level projects, which started in 1962, was to up-date syllabuses, and provide greater conceptual coherence for each subject. With a perceived need for more specialists, the developments which took place were within the separate sciences, continuing what had become the dominant pattern of science education in grammar schools. The curriculum renewal for the rest of the population started three years later in 1965 with Nuffield Secondary Science. Overall NSS covered aspects of physics, chemistry, biology, geology and astronomy; it derived its rationale from those aspects of science which would be relevant to contexts which pupils met in their everyday lives and might meet as adults. In one sense, therefore, both the Nuffield O level and NSS initiatives went for breadth across the sciences - the former via separate developments each with its own team of people, the latter through a co-ordinated development by one team of people.

In the year before the Nuffield Secondary Science project started, the certificate of secondary education was introduced, providing another examination forum. CSE examinations in chemistry, physics and biology were rapidly established in all boards, alongside subjects such as rural science, environmental science, applied science and natural science, reflecting the diversity of foci which courses in secondary modern schools had had. Diversity was increased by the introduction of mode 3 syllabuses and many of the natural science and integrated syllabuses were developed through this route. The willingness and enthusiasm of teachers to develop and use examinations was not surprising: the lack of qualification for many students had been a major concern for teachers and parents. Teachers were keen to be involved in the process, as it gave them a role in curriculum development which was quite unlike the role they played as trials teachers of other people's ideas. Inevitably the diversity of courses in science increased, and the programme available to different pupils was dependent on the choices provided in their schools. Breadth in science was dependent now on the choices which were made both by the school and the pupils.

Circular 10/65 gave an increased impetus to the removal of selective secondary schooling. There was a strong ideological stance to avoid the pernicious effects of labelling pupils too early, and of giving different children very different educational experiences. 'Opening doors' for pupils rather than closing them was important. Common courses for all and delays in selection, avoided early labelling. A common science course for all at the start of secondary schooling was an obvious solution. There was also concern about the disorientation experienced by many pupils on the transition from one teacher in primary school to many teachers in secondary school (Plowden, 1967). Any reduction in the numbers of new teachers was welcome, so one science teacher was better than three. Combining these two pressures with the 'tradition' of general science in the lower part of many secondary grammar schools, favoured a combined science course taught by one teacher, and accounted for the popularity of courses such as Nuffield Combined Science. Breadth across the sciences had to be maintained because this course had to be the basis for all the sciences in the third year.

Given this climate it is perhaps not surprising there was pressure to extend the breadth of science to the most able pupils, and to commission a project like SCISP. Inevitably its brief had to include all the sciences as it had to be the basis for the three science A levels. Nuffield Secondary Science had drawn in geology, and so did SCISP. Geology was becoming an increasingly popular subject with exploitation of oil fields and with the piecing together of the theory of plate tectonics. It was moving out of its image of 'rock and fossil collecting' to be seen as a subject which had its own scientific theories underpinned by theories from biology, chemistry and physics.

1973 was the year when the school leaving age was raised to 16, extending the discussion about the appropriate science education for the 14-16 age group to the whole of the school population. Here was the group of pupils who had not sat examinations, staying in school to the age when external testing took place. They had previously had a minimal science course in schools after the age of 15, or had none at all. If they had left school at the Easter of their 4th year, then their courses would have extended to just two terms. Now they would be in school for five or six terms beyond the end of the third year. This was a substantial amount of time and required careful planning. Here was another group to be catered for. They could be drawn into the existing CSE courses (and possibly GCE), or they could have a special course written for them, or they could drop science altogether. All three routes occurred in different schools. LAMP was produced at this time, particularly because schools were finding the overarching themes of NSS too abstract to provide coherence for these pupils.

The examination boards now played an important role in being initiators and gatekeepers of the science syllabuses which existed for the 15-16 year olds. Schools were restricted to use the local CSE boards, so regional variations could exist between what was possible, and this local autonomy was one of the problems encountered for SCISP-related CSEs in a few isolated incidents. There does not seem to be any evidence that breadth of science syllabuses were discouraged, but particular formulations of breadth could be.

The imbalances in science provision and take up became apparent in the surveys of the 1970s. While many of the pressures for the way forward towards some sort of common curriculum for all pupils had ideological roots, the reduction in the school population made the rationalisation of too wide a range of options essential.

Breadth across the sciences became an acceptable 'principle'. From a Bernstein perspective it did not apparently undermine any teacher's territory; they were all allowed a place in the new developments. The specification of time on science was however a larger challenge. The two combined represented a bigger challenge than had perhaps been recognised, and above all it required science teachers in schools to work as a team to implement the changes. Interdisciplinary teams were being formed to deal with these organisational changes, and support was necessary (SSCR, 1987, Hull and Adams, 1981).

Breadth in science was extending to the full age range of compulsory schooling and the policy document of 1985 began to set the seal on this. It effectively removed some of the options, and the phrase 'three into two' (ASE, 1987) showed the organisational interpretation of this - three subjects were now to be taught in the time which traditionally had been given for two subjects. The newly formed examination boards dealing with the common examining system at 16+ (GCSE) quickly had appropriate syllabuses and examinations in place. The breadth guidelines, in terms of chemistry, physics, biology, geology and astronomy, of the 1985 DES policy were retained in the formulation of the 1988 national curriculum proposals. The 1991 and

1995 versions retained the breadth of study, except that meteorology was lost to geography. External tests at both KS3 and KS4 of the knowledge and understanding of this breadth of content was one mechanism for ensuring that it was retained in the teaching. Breadth even held its ground when the single science award at GCSE was allowed. It is retained in the directive that pupils who take separate subjects must take all three sciences. Specialisation in science, where a pupil can select one area of science for study, now occurs only post 16.

Breadth was extended backwards to the primary schools, with the introduction of the national curriculum. Whereas the early projects for primary science (*Nuffield Junior Science*, 1967, *Science 5-13*, 1974) focused on the children's explorations without any great concern for the range of knowledge which was being established, the content side steadily became more explicit and more important throughout the 1980s.

What happened to the integration of science, technology and society in the science curriculum?

The interface between science, society and technology was a strand in the integrated science projects for the 13-16 age range. It is important to distinguish studying science in the local environment, as in the exploratory work of the primary school or the early years of secondary school from the science, technology and society issues which might form the focus of study with older pupils. It is the latter that I want to track.

Applications of science in the chemical industry, in medical and agricultural fields, and in the design of machines and electrical equipment had been a feature of many science courses in the 1930s. The General Science textbooks had lots of examples as did many of the school certificate books in separate sciences and the later O level text books. To a large extent applications were omitted in the O level projects, which focused on giving greater insight into the conceptual framework of the subject and into how the concepts had been developed. This provided one aspect of the human face of science. Science was not depicted as knowledge that was there just for the finding, but as knowledge which required creativity and intuition for its generation.

The Nuffield Secondary Science team took the line that this approach would not and could not engage the interest of most pupils and in any case missed the point of why science was important to young people. The conceptual framework was not an end in itself and whatever concepts and facts were understood they had to be subsumed to the purpose of pupils making sense of themselves and the society in which they lived.

To some extent it mirrored work on applications in secondary modern school syllabuses, but treated the pupils as more adult and more worldly wise than perhaps the pre-war and immediately post war schemes did. The conceptual side was not by any means neglected; the themes such as continuity of life and interdependence of living things, were science stories to be understood in order to make sense of science and society issues. There was, however, limited emphasis on how the ideas were developed in the first place.

The ensuing years in curriculum development saw an uneasy tension between the various emphases. There was fear that too much attention to the science, technology and society issues would diminish the conceptual understanding, and too much attention to conceptual understanding would neglect the other areas and alienate a great number of students. The development of curriculum material to support the science, technology and society issues (e.g. ASE, 1987) was an important contribution.

Science, technology and society aspects have perhaps an ambiguous place in the national curriculum. They lie in the overarching themes at the start of each programme of study, but certain topics have remained in the main body of the programmes: energy resources; the effect of humans on the environment such as in the greenhouse effect, the depletion of the ozone layer; genetic engineering.

Integration of investigations into the science curriculum

The use of individual practical work in schools as opposed to just demonstration done by the teacher goes back to the end of the last century and was associated with Armstrong's advocacy of heurism whereby science concepts were learned through practical work. This fell out of favour for a number of reasons not least of which was the impossibility of gaining a large amount of scientific knowledge in this way. Practical work subsequently took on the role of confirming or illustrating theory and was often associated with set 'cook book' activities reported as 'aim, method, result and conclusion'. The discovery role for practical work was returned to in the Nuffield O level projects and while pupils appeared to be investigating, the apparatus was sufficiently contrived that right answers were ensured. The work took on more the role of illustration with the teacher guiding pupils to the necessary conceptual understanding (Jenkins, 1979). The same approach was used in Nuffield Combined Science and prompted Shayer's critique of the unrealistic conceptual demands this was making on the wide range of ability of pupils for which it was used (Shayer, 1978)

Nuffield Secondary Science did not use the same approach. Practical work, in the NSS circuses, was designed to give pupils a range of contexts which would illustrate phenomena, so that they could, with the help of the teacher, make generalisations and recognise that they were relevant to a range of situations. A lot of the work was illustrative in nature; clear instructions were given as to what to do and what to look for. In addition more of the equipment taken into lessons were objects from everyday life rather than specialised laboratory equipment, than was the case for the O level projects.

SCISP had a strong element of incorporating 'processes of science' in its pattern finding and in the involvement of pupils in investigations. (The influence of the American project (SAPA) Science A Process Approach was detectable). What was distinctive was that the processes of science were seen as an end in themselves, not just as a means of acquiring information. SCISP became one of the pioneers of attempting to design summative assessment tools to 'measure' pupils' abilities in this area, below the age of 16. (The Nuffield A level projects already had open-ended investigatory projects as part of the assessment).

The role of assessment, and particularly summative assessment was important. It served to single out from all the many roles that practical work played in the learning of science those which could be assessed. Duckworth illustrated some of the practices which could be used to provide evidence of appropriate learning. The set practical tasks were used for the more routine skills of setting up equipment properly and taking measurements, and relieved the teachers of trying to make too many assessments 'on the hoof' as they were teaching. Tasks that were more open-ended had to be part of class work because this provided a looser time frame. Higher levels of teachers' professional judgement were required for the assessment.

A whole range of approaches to practical assessment were developed, including what became to be seen as excessively atomistic schemes for both the so-called processes of science and of the practical skills. The successes and the pitfalls of these are discussed at some length in the collection of papers put together under the editorship of Wellington (Wellington, 1989).

The use of investigations which allow pupils to use and apply both concepts and cognitive processes owes much to the work of APU, the Assessment of Performance Unit (DES, 1989). Investigations have been progressively incorporated into the national curriculum. The passage has not been an easy or comfortable one, and some of the unease was certainly evident in the conversations at both Duckworth and Timburn. Some of the early unease came from the incorporation of both AT1, exploration and investigation, and AT17, the nature of science, into one attainment target and then to overload it with the communication skills. The tighter and more specific specification of the second version ameliorated some of the difficulties but by no means all and it was not easy to use (Donnelly et al, 1994, Gott and Duggan, 1994). The last version, with its focus on the procedures to gain, interpret and evaluate evidence, has yet to run for longer in order to gain more experience of it in operation.

I do not want to imply by this very brief account, that the investigations in the national curriculum were a direct descendent of SCISP, nor that they are non-problematic. Ideas about what of the investigatory aspects of science to incorporate in school science and in the assessment procedures have been discussed widely in science education. They were not the preserve of one group.

What happened to the idea of one teacher per class for integrated science?

One teacher per class seemed to be the expectation for integrated science courses, although it was never the recommendation for a course like SCISP. The expectation of one teacher for the whole of science was not new in secondary modern schools as can be seen from a section on the teaching of science from the 1947 *Handbook of Suggestions for Teachers*:

> If the conception of treating Science as a single whole is accepted, it follows that all the work of a class, whatever branch of Science a particular lesson may deal with, should be in the hands of one teacher. This may sometimes mean that the teacher will himself have to study branches of science with which his training has not made him familiar. In most large centres of population there are now facilities for further study, but where such opportunities are not available, there is no reason why class and teacher should not explore the new field of knowledge side by side. A teacher's work is not likely to be alive and stimulating unless he is constantly adding to his own stock of knowledge.
>
> (Board of Education, 1947 p 487)

There was evidence from the Scottish studies (see chapter 4) that many teachers welcomed the opportunity to teach outside their main specialism, to develop a broader knowledge of science and to experience learning alongside the pupils. Tensions arose the further up the school this practice was taken and the higher the ability of the pupils and there was evidence of this concern back in the days of general science. The question of the relation of specialist knowledge to competence in writing units and teaching were raised by teachers at Duckworth School as they began the change to the double science courses. It was not surprising that as double science gained ground co-ordinated science courses began to be written and a pattern of shared teaching, developed. Timburn and Duckworth teachers taught outside their specialism beyond KS3 but had borne the consequences of initial lack of confidence in the classroom and the need for investment of time and effort on inservice work. This had to be balanced with the increased awareness they gained of a range of science and their professional pride in wider knowledge and skills. Sixford had to bear the brunt of a more complex staffing organisation to manage the changes between teachers in an orderly fashion. Similar arguments to the ones raised by the teachers could be found elsewhere:

> Case study - School A
> Now all students study Nf Co-ordinated Science (chosen because of the simplicity of the student assessment scheme) which is taught from year 9 as separate sciences on a rota system. An experiment to get teachers to teach areas of science other than their own had been found to be inefficient in terms of the quality of teaching and science teacher confidence and, by popular request of the staff, had been abandoned.
> (Woolnough, 1991, p 84)

Questions of teacher expertise are complex. They are traditionally looked at in terms of knowledge of chemistry, physics and biology and to some extent this is a feature. There comes a point when teachers feel uncomfortable about teaching outside their specialist areas and according to Hacker and Rowe (1985) teach it badly. But there are other aspects of teacher expertise which are problematic. Many of the comments at Duckworth referred to technical know-how in laboratory equipment (Alan and the centimetre wave equipment; the person for whom the experiment did not work the first year, but it did the second). Others referred to a different sort of technical know-how which came from scientific or technical activities outside - the biologist who had never grown seeds; and how many of the teachers had expertise in car mechanics? The single science course may well have been a greater challenge to teachers' knowledge than the double science course because it was located so much in this technical know-how. Only if a teacher has a feel for these activities will he or she be able to make them come alive in the classroom, and use them to be meaningful to the learners. To use this outside knowledge in the way Bollen claimed that he did in his secondary modern teaching is to require an expertise which is not necessarily the province of the science teacher.

Any arrangement of the teaching is some form of compromise and as double science is currently the dominant pattern of courses, with about ten times the entry for double science as for triple science (QCA, 1998) this continues to be the case. Teaching within a specialism is traded off against the better relationships that can be built with a class when taught for a longer period (Childs, 1998).

What did the early case studies contribute to the story?

Three features of the first Duckworth case study are particularly significant: first, the complexity of the task of reshaping the pattern of science courses in a large secondary school and of setting up organisational strategies to co-ordinate the work of many different teachers; second, the impact of the change in the courses on the structure of the staffing, including the career patterns open to teachers; and third, the realisation that discussions about integrated science and the focus of the science curriculum had drifted into discussion of organisational matters.

The decision to have integrated science courses for all students in the 13-16 age range in order to rationalise the curriculum offering, implied that this would simplify the work for the staff. In the long run it may have done, but in the short term, this decision required co-ordination of resources and teaching over a larger group of people, occasioning a large amount of work. In all three schools the teachers were more tightly framed in terms of pace at which they taught and the order in which they taught the course units, than they would have been in timetabling for single subject courses. The management task of effecting the change and of maintaining the necessary organisation was large. It is impossible to generalise too far from just three schools, but they probably provided an insight into the sort of reorganisation which occurred in many schools in the country as balanced science came on stream.

Relationships were affected by the change in the courses. There was a sort of permanency involved in titles such as 'Head of Chemistry'; that permanency went. Co-ordination jobs emerged and authority relationships were more fluid. Membership of co-operative planning teams was an important role to play for all teachers. Responsibility for subject matter was now more diffuse, but none the less important.

Duckworth provided an example of the tension which existed between the different foci for courses. One of the courses had a conceptual framework inherited from SCISP, the other had a framework derived from applications of science. The overlap was minimal and transfer between courses was not a possibility. It was also evident that unless a clear articulation of the principles on which courses are planned is undertaken at the start, matters of organisation are so time consuming that it is not possible to go back to the drawing board for some time.

What did the later case studies contribute to the story?

The pattern of courses which were taught at the two schools was the same as they had been in 1980, and yet the situation was described as distinctly different by both heads of science. The change in the school population was of course one of the features they had to accommodate. Another was the heightened importance of accountability to senior management, to Ofsted, to parents and to the children. This was evident in the documentation of the work of the department. League tables of results, and open competition with other schools, meant that both schools were hunting for ways of improving the scores on the tests, irrespective of whether teachers thought it was educationally valuable. Teachers at both the schools reported having been busy over the preceding years accommodating changes, but they like me were aware that much had not changed, as echoed in the quotation below.

> In short, teachers' experience over the past ten or fifteen years is of a curriculum which is ever changing. But observers and evaluators of the curriculum scene, over the same period, in different educational systems where curriculum reform has been actively pursued, offer judgements that are difficult to square with the everyday experience of teachers....We are left with the paradoxical impression of stability and yet change, of diversity and yet sameness.
>
> (Rudduck, 1986, p 5).

The fate of the early integrated science projects in secondary schools

It is worth returning to some of the individual integrated science projects to comment on what happened to them specifically and why. I will consider SCISP first, which despite considerable support failed to gain more than one per cent of the O level candidates. Woolnough has suggested several reasons for this, many of which refer to poor public relations on the part of the project team and the Schools Council (Woolnough, 1988, p.113). He lists: the lack of charisma and commitment of the organisers; the political naiveté of the organisers in not getting the important people on their side from the start coupled with the arrogance of the Schools Council in trying to use only teachers and not involve 'the establishment'; the use of an obscure psychologist's theories on which to base the work; and finally the inability of teachers to cope with the spread of science. He may well have identified significant influences. None of these are points which I can challenge from the perspective of the research, other than the competence of teachers and this is addressed above.

I would add other factors. The 'third year problem' was very specific to the time SCISP came onto the market. Schools required a third year science course which could be used for all pupils and there were almost none. SCISP did not solve that problem. They also needed parallel CSE courses to allow transfer between GCE and CSE. To implement SCISP or SCISP type courses for everyone, a mode 3 CSE had to be written. The evidence from the aftercare system was that there were schools prepared to do this, but these were the ones already committed to SCISP. There is little doubt that the rather public resignation of the chief examiner in 1978 did not enhance people's confidence in the course. I suspect also there was a failure on the project's part to recognise the importance that employers and parents place on familiar qualifications. Much of the work of the aftercare system involved public relations exercises over these matters. The unusual timetable slot required was probably also a contributory factor. Nuffield Combined Science did not experience the same problems as it was fitting an accepted timetable slot. I wonder also whether the use of the AEB for the examining body was another contributing factor, because the AEB was the board which had been set up to help devise syllabuses more appropriate to the secondary modern school. Was there again a matter of status? The supposed problems of it not being suitable as a base for A level were not borne out by the small number of studies which were undertaken.

Nuffield Secondary Science is more difficult to track. First it was not such an easily identified course in examination terms. Schools could easily be using the material but without any evidence of it at the examination level. Apart from the evaluation undertaken by Alexander soon after the material was available there was little research done on the extent of the use of NSS. Woolnough suggests that the fact that many of the teachers were poorly qualified (in science terms) secondary modern teachers might have had something to do with the lack of take up. There were parts of the syllabus which might have been better done in extended times and this did not fit well with the inflexibility of school timetables. Nuffield 13-16 modules sold well for a while suggesting that the tighter off-the shelf modules were what busy teachers and technicians welcomed.

Brown has suggested other factors. Resource reorganisation was one. She commented from her research in Scotland that schools where there was not a split site fared better in the implementation of integrated science. The resource reorganisation was a major task for Duckworth and although not a split site, having science on different levels added to the work to be done.

Lack of explicit frameworks which were easy to assimilate was another factor, which made integrated science difficult. The problematic nature of the framework of SCISP has been alluded to earlier and particularly the concept of patterns applicable across the whole of the sciences.

The answer then to whether integrated science has vanished, is both yes and no. The name has gone but the ideas have resurfaced and now there is a far wider range of resources on which to draw.

Summary: What dynamics have been brought into play in the story of integrated science?

By way of summary I have drawn together the dynamics which have been brought into play in the shaping of integrated science. The dynamics which have probably militated against integrated science have been:

- the tradition of 'pure' science with the divorce between technical and scientific education, particularly for the most able;
- the tradition of separate sciences;
- the practice of allowing choice between subjects in schools;
- the socialisation of teachers into the separate 'pure' sciences, through their own training and through the organisation of career paths within schools;
- epistemological differences between the sciences, such that each area has its own objects of study, its own methods and its own language;
- the tradition of science in schools as the early steps of training for specialised university science, dominating the way people thought about what was appropriate for everyone;
- the belief (mistaken) that integrated science meant mixing the separate sciences together all the time;
- the expertise of teachers did not allow them to feel comfortable (or competent) teaching the whole of the science curriculum, and this was exacerbated the further up the school they went;
- the organisational inertia which comes from the way a particular curriculum is built into the practices of the way a school and a department is run;
- the need for good management skills in a science department because of the need to co-ordinate a wider and more diverse group of people;
- the need for new assessment tools to cope with the changed remit of the science curriculum;

- the stability and relative certainty of scientific knowledge compared with contexts provides a good reason for retaining it as a way of defining a syllabus;
- the elusiveness of a clear definition of an integrating concept or theme.

The dynamics which have contributed to retaining many of the ideas which were in the early integrated science courses are:

- a recognition that science has a well established set of ideas about the way the universe works which should be shared with the next generation. They are taken for granted in discussions in the media, in the metaphors by which we live and in the contexts in which we meet science; this at a minimum argues for breadth;
- a more widespread willingness to recognise that science education contributes to people making sense of themselves and of the society in which they live; this means that people must be able to understand science in context;
- a focus on the learner as much as on the subject;
- the mixing of teachers from different traditions in comprehensive schools;
- a recognition that the problems resulting from pupil choice of subjects might outweigh the advantages;
- wider acceptance of balanced science by organisations concerned with the products of school science;
- organisational features in schools can be changed to accommodate a new curriculum;
- creation of new assessment tools to accommodate more facets of science;
- finding ways of organising teaching which allow the use of expertise within a team;
- finding ways of organising syllabuses which retain some of the conceptual coherence of the separate sciences, while enhancing the links between relevant parts;
- a climate where science has a much higher profile on the media than thirty years ago;
- the acceptance on the part of science teachers joining the profession that they teach outside their specialism at least at key stage 3;
- the dropping of the term 'integrated science'.

This is not to imply that the science curriculum in secondary schools is non-problematic. In the 'lull' following the Dearing moratorium on change, rethinking and 'taking stock' has taken place. One product of this is the publication *Beyond 2000, science education for the future* which resulted from a series of seminars funded by the Nuffield Foundation (Millar and Osborne, 1998). While acknowledging recent achievements it highlights some of the tasks still to be tackled. These have echoes of the concerns raised at Duckworth i.e. the attention paid to small factual detail may be at the cost of a more general understanding of science, there is insufficient time to get everything done and scientific investigations have displaced more technological problem solving activities. The overall pattern of science education which it paints, however, has its antecedents in what has gone before. Different dynamics and events will mould what will happen in the future, but many of the ones identified in this study will continue to operate.

CHAPTER 9

EVALUATION

a. The Value of the Study

The study gives an account of Integrated Science in secondary schools in the UK in the late 1960s and early 1970s through to the 1990s, which I believe does not exist elsewhere. The study identifies how discussions about integrated science, and the relative merits of integrated science and separate sciences, drifted into discussions about 'balanced science'. To many people integrated science and balanced science were the same; in the way they were realised in schemes of work in schools they probably were in many instances. Eventually all qualifying labels were dropped and 'Science' became the umbrella term.

The study identifies how science as a body of knowledge has survived as the most prominent way of describing the science curriculum. Nevertheless the incorporation of science investigations is a significant modification, as is a wider acceptance of the need to articulate pure science with science in context. However inadequate this framework of the science curriculum is, it applies to all pupils not only in the 11-16 but also in the 5-11 as well.

The study has identified the dynamics which influenced the path that science education took in UK. Those dynamics include the shift from a selective to a non-selective secondary school pattern; the welding together of two different traditions in science education; the desire to have a common framework for science education for all pupils up to the age of 16; the reduction in the secondary school population; the suggestion from HMI in the late 1970s for a specified amount of time for science in each year of secondary school; the directive of government over curriculum and time through the national curriculum; the position of science as a 'core' subject; the changing examination system; the increased accountability of schools and the publication of results.

The study has focused on many of the events and tasks which have kept the science education and science teaching community busy over the last thirty years. It is easy to forget the work that has gone into the preparation of courses for different groups, and into the attempts to revitalise the science curriculum through large curriculum projects and through school based developments. The change from selective to non-selective schools and the raising of the school leaving age have been major contextual changes which brought with them tasks to be addressed. The expansion and co-ordination of the examining process was another large undertaking along with a new raft of assessment tools.

The case studies were important in maintaining the focus of the day to day events and tasks to be addressed in a science department. They allowed the study to be sensitive to the impact of changes on the schools and to recognise how wider changes played themselves out in the lives of busy science teachers. Whilst no attempt was made to test Bernstein's theories against the case studies the theory illuminated much of my work and the case studies serve to provide examples which supported Bernstein's thesis in some respects. An important outcome of the research, at school level, was the link between curriculum organisation and departmental organisation such that change in one necessitates change in the other. Both the adoption of integrated science courses and the need to rationalise science provision to allow no more than 20% of curriculum time to be allocated to science for 15 and 16 year olds were factors in achieving this change in organisation. Such changes in the relationships between teachers were predicted by Bernstein as a necessary consequence of some degree of integration (see Chapter 5, pp 143-4). In order to evaluate further specific aspects of the story of integrated science I shall return to Bernstein's thesis on classification and framing in curricula operating under collection and integrated codes.

b. Analysis of the integrated science story through Bernstein's concepts of integrated and collection codes

Strength of Integration

Bernstein recognised that a curriculum operating entirely under an integrated code was an imagined entity rather than anything that was institutionalised at the time of his writing (see Chapter 3, p 68). He therefore devised his *strength of integration* 'measure' of actual curricula using four parameters: the existence of integrating themes; the number of subjects co-ordinated (the more, the greater the strength of integration); the number of teachers coordinated (again the more, the stronger the integration); the integration of 'everyday knowledge' with academic knowledge.

Integrating themes

Bernstein regarded the existence of a single integrating idea (or set of ideas) which subsumed pre-existing subjects as a defining characteristic of a curriculum operating under an integrated code. The use of ideas from one subject within another, such as the use of the principles of chemistry and physics within geology, did not, for him, constitute integration. Contexts as integrating devices, where different subjects were focused on a common problem were also excluded from his definition of integrated, these being regarded as a *focused* curriculum (Bernstein, 1971, p 60).

Here then is one of the drawbacks in placing the science curriculum at the limit of the integrated end of the integrated/collection continuum. A unifying theme for science did not emerge (see Chapter 4, pp 87-92) despite considerable attempts to identify one. At a very general level this might not be true because science is seen as being concerned with linking cause and effect, and creating theoretical models to explain natural phenomena, but this does not make for a driving principle for determining a course of study.

Nevertheless ideas did emerge, which went some way to linking pre-existing subjects, however problematic and limited. I have selected four: the processes of science; procedural knowledge; concepts which bridged previously discrete topics; and the emergence of boundary subjects such as biochemistry.

Processes of science, loosely defined as the thinking processes which scientists engage in (observing, hypothesising, predicting, interpreting, pattern finding, evaluating) seemed to offer themes to bridge the sciences. They were, however, regarded as problematic because success in these were dependent on context (see Chapter 6, p156); they were not things which could be taught as they were an intrinsic part of what the human brain does (Millar and Driver, 1987); and they were not specific to science. The discussion around them did, nevertheless, contribute to the debate about shifting attention towards the science curriculum contributing to an understanding of how science was built up and not just to an understanding of established scientific knowledge.

Processes were replaced by the concept of procedural knowledge i.e. knowledge of how to proceed in investigations in order to collect, interpret and evaluate evidence, (see Chapter 6, p 156) and this was made reasonably explicit in the third version of the national curriculum (see Chapter 6, p 175). The context and concept dependency, however, of procedural knowledge weakened its function as an integrating idea. Nevertheless the language of investigations goes across the sciences: assessment statements are common (in, for instance, the levels of the national curriculum and in the criteria for marks for GCSE) and provided science teachers with a common agenda.

Concepts which bridged previously discrete topics contributed to coherence of science courses, for instance the concept of 'cell' as a linking mechanism in biology, 'fields' in physics, and 'energy' across the sciences, but their scope was limited and their accessibility for all pupils was problematic (see Chapter 6, p 156). Boundary subjects such as biochemistry and biophysics, a facet of the increased specialisation characteristic of science today, also provide boundary topics linking one piece of information to another but this did not mean that there were not real differences between one area of science an another (see Chapter 6, p 155).

Additional coordination came in science courses, however, from the assumption that knowledge from one topic was a pre-requisite for studying another and that coherence in the language used for teaching related topics was important to aid learning. These two aspects of coordination were particularly important in the construction of courses such as the Nuffield Coordinated Science Scheme, which was written so that the elements of it could be taught by different specialist teachers, and in the national curriculum, particularly with respect to the language associated with the teaching of energy.

While the integrating idea remained illusive, it is possible to identify a wider purpose emerging for the teaching of science: i.e. a wish to leave an image of science which more nearly reflects the nature of the subject. Pupils are to be able to stand back from the detail of the particular facts and principles they are learning (what Bernstein refers to as 'states of knowledge') to appreciate how knowledge in science is built up (Bernstein's 'ways of knowing') and the limits of that knowledge. To Bernstein this was letting the learner into the permeability of knowledge earlier in educational life and was more likely to occur in a curriculum operating under an integrated code. Of the attempts at curriculum change reported in the thesis many have been driven by this wider purpose: breadth of science contributing to an understanding of the scope of science; investigations to the understanding of the ways of acquiring information in science; history and philosophy of science to the many ways in which scientific knowledge has been generated; science and technology to both the way in which science is used, and its limitations in real life settings where many decisions are not based on science alone (see quotation from Black, Chapter 6, p 157).

Before leaving the section on an integrating theme, mention needs to be made of the use of a uniform *approach to learning* science being used in some curricula as a means of integration. This was not a mechanism recognised by Bernstein. The discovery learning which was supposed to permeate the Scottish Integrated Science scheme and the pattern finding of SCISP were two examples. They have, however, represented an ambivalent area for science education because the same words *discovery* and *pattern finding* are also used in descriptions of scientists. The evidence from research, however, (see Chapter 4, p 91) was that teachers did not view these as integrating themes.

The number of subjects coordinated

Bernstein's second factor in judging the extent of integration was by the number of subjects coordinated. Rationalisation of the multitude of subjects at the turn of the century, into only three - physics, chemistry and finally biology - gives an indication of the extent of coordination which had occurred prior to the main period studied in this thesis. Geology, astronomy have also been incorporated into the study of science at school level.

This discussion begs the question, of course, as to what is a subject. Bernstein did not address this, his concern being focused on the sociological aspects of the power related to subjects. Certain areas of science designated as subjects in school certificate (light, electricity and magnetism) now have, at most, the status of topics within science curricula, examined possibly by an end-of-module test in school. Subjects such as agricultural science, became parts of syllabuses (for instance the modules in the single science course at Duckworth), or were used as illustrations of contexts in which certain scientific principles were applied (Continuity of life, NSS Chapter 4, p 77) or as examples of scientific enterprises which had economic as well as scientific dimensions (SCISP, Chapter 4, p 80). In the schools studied in the thesis and in the national curriculum, the former non-contextualised topics have been retained for syllabus description in the 1990s; the contextualised topics familiar in the 1978 single science course at Duckworth, in the double science course at Timburn and in the published syllabuses for the so-called less able, have become less prominent in syllabus descriptions in the 1990s.

The number of teachers coordinated

Bernstein regarded the number of teachers coordinated as an indication of strength of integration. One teacher per class in a primary school would for him represent weaker integration than several teachers working together. At the time Bernstein was writing there were experiments with teams of teachers teaching collaboratively, for instance, the integrated humanities curriculum in the first year of secondary school. In my study there was only one instance of team teaching reported from the schools (Appendix 3, p 278). To consider the strength of integration from the number of teachers coordinated requires attention, therefore, to what happened at the planning level. This has to be interpreted as the number of teachers from different areas of science, not just the literal numbers of teachers. In the case of the double science course at Duckworth the number of teachers of different subjects was four, if we include the geology teacher, along with teachers of chemistry, physics and biology. The fifth 'expertise' which was part of the team was that of how the subjects could be coordinated, from the experience which Tom had had in SCISP teaching. The strength of the integration attributed to this factor in the single science at Duckworth was less, as there was no insistence that all the sciences would be represented in the personnel involved in the writing.

At the teaching level the number of teachers coordinated varied. In the lower part of secondary schools, where, in most cases, one teacher teaches all the science the degree of integration depends on the teacher's perspective and on the way he/she is constrained by the way the scheme of work is written. At the upper secondary level at Duckworth and Timburn two teachers were coordinated for the teaching of the double science. This was particularly true for O level, and later GCSE, classes as teachers had to collaborate over the summative assessments of the teacher assessment component. At Sixford four teachers were coordinated, with pupils attending classes in a carousel. Duckworth and Timburn teachers would, however, regard themselves as the more integrated schools, because individual teachers were coping with a wider range of science. This is consistent with the findings of the research in Scotland where 'Integrated science became equated with "all science is taught by one teacher"' (see Chapter 4, p 91).

The three schools in the study had to plan carefully how time and resources were distributed between teachers to meet the demands of the courses. This would be the case for all schools teaching double science. This did not necessarily coordinate teachers in the sense in which Bernstein intended, but it did contribute to providing conditions in which coordination of subjects is more likely to occur.

The inclusion of everyday knowledge

Bernstein indicated that at school level the inclusion of 'everyday' knowledge 'the everyday community-based knowledge of teacher and taught' (Bernstein, 1971, p 64) was characteristic of curricula operating under integrated rather than collection codes. This knowledge was in some way local, and did not have the generalisability of academic knowledge. Bollen's course (see Chapter 3, p.62) organised around the maintenance of a motor bike rather than around the principles of physics (even though the latter were taught through the former) would be one example; it was the practical know-how versus the de-contextualised knowledge applicable to a wider range of contexts. Everyday knowledge was included quite explicitly in most of the schemes of work for lower ability pupils: the single science course at Duckworth (see Chapter 5, pp 119-120); the attempts at 'relevance' in Nuffield Secondary Science (see Chapter 4, pp 76-78); Science at Work (see Chapter 4, p 84); LAMP material (see Chapter 4, p 83); the optional modules focused on teacher interest at Timburn (see Appendix 3, p 276).

Bernstein's interest in the inclusion of everyday knowledge lay primarily in his concern about how the selection, organisation and evaluation of knowledge was a reflection of the power and control in a society. To include everyday knowledge was to break the control of the universities in being gatekeepers of what was worthwhile, and to allow interests of learners to influence what is to be studied. He noted the dilemma that this posed if taken to extremes: it could exclude some learners from access to the more generalisable aspects of science. He commented that there was relatively weak framing between academic and everyday knowledge in England compared with the rest of Europe, and that there was a weaker frame for less able than more able pupils. Overall with the introduction of examinations for everyone, the increase in assessment points and the wish to retain GCSE as a pre-requisite of A level, there has been a reduction in the explicit inclusion of everyday knowledge in the science curriculum. An overall disposition to believe that it is a 'good thing' (c.f. TTA standards for teaching, TTA, 1997) does, however, remain but the extent to which this is realised would be apparent from studying individual teachers and this was not done in the study.

The persistence of a curriculum operating under a collection code

What this analysis reveals, so far, is that there is a range of strengths of integration, determined by a range of factors from the design of the curriculum to the organisation of the teaching. Strong elements of science curricula operating under the collection code do, however, still persist. Curricula operating under a collection code have closed relations between the subjects with the boundaries between the subjects strongly maintained. In school science education in UK there has been a shift overall from what Bernstein called the specialised collection type near the turn of the century to an increasingly broad collection code (Bernstein, 71, p 55). This has been achieved, first, by subsuming the large number of small subjects together under only three headings, and second, by applying pressure for everyone to study across the sciences.

The three subject classification has been left effectively intact in the organisation of the three programmes of study of the science national curriculum. This is reinforced by there being three separate examination papers set at GCSE (with marks combined to give tandem rather than dual certification). In schools where triple science is studied, the distinction between the subjects is emphasised by the separate science certification i.e. the assessment is profiled on traditional subject lines.

The thesis covers essentially the years of compulsory secondary education, but it is worth noting a shift in the post-16 science. Specialisation was, and still is, a characteristic of the post-16 phase for GCE A level. In the 1950s choices made by pupils tended to be either within the sciences or the arts, what Bernstein referred to as a 'pure' specialised collection code. The pattern in the 1990s for post-16 has shifted considerably towards the 'impure' specialised collection code where students frequently take a selection of subjects from different fields of knowledge.

This persistence of a collection code, indicates, according to Bernstein, the resilience of boundary maintaining mechanisms between subjects (see Chapter 3, p 64). The shift of code indicates weakening of the mechanisms. The boundary maintaining mechanisms, along with their weakening and their resilience are discussed below.

Boundary maintaining mechanisms

Strong classification implies, by Bernstein's definition, strong boundary maintenance between subjects. The boundaries between the science subjects were maintained, say in grammar schools, by:

- areas of science being designated as subjects in the curriculum;
- separate subjects having departmental status in a school;
- allocation of separate timetable slots for separate subjects;
- having different 'specialist' science teachers to teach the different subjects;
- allowing choice between the subjects at the examination stage, such that each subject would, potentially, have a different cohort of pupils although inevitably there would be some overlap;
- having separate assessment instruments with no overlap between them;
- having laboratories set up differently for the different subjects;
- specialised curricula having higher status than integrated curricula.

Bernstein suggested that the existence of specialised teachers was one of the strong boundary maintaining mechanisms: people who had been socialised into the subject through a long apprenticeship comprising A level and university courses in the subject, and had developed considerable subject loyalty and personal identity through this process. They had jumped the necessary official assessment hurdles to gain this identity. The socialisation process was reinforced in returning to the organisation of a school and to the school examination system. Bernstein commented that this socialisation occurred fairly early in England compared with Europe because of the highly specialised (and hence narrow) selection of A level subjects. Until compulsory science was brought in the socialisation into different sciences began earlier. It is important to recognise that these boundary maintaining mechanisms did not exist to the same degree in many secondary modern schools where teachers were often not trained through the specialist degree route, where there were limited laboratory facilities, and those that there were would be of a more general all-purpose nature. Many pupils did not sit examinations and so were not subject to the socialisation which occurred through them. Testing was internal to schools so it was possible for teachers to set tests on what had been studied, until GCE and the CSE examinations became available to pupils in secondary modern schools (see Chapter 3, pp 57-62).

Reducing the boundary maintaining mechanisms

The thesis has documented a number of challenges to the boundary maintaining mechanisms, which have consequently encouraged more open relationships between subjects. These have been associated mainly, but not exclusively, with the introduction of integrated science courses.

Areas of science having subject status

The removal of subject status for the so-called 'separate sciences', evident in all the integrated science schemes, has continued into the national curriculum where science is all contained in one syllabus, contained within the covers of one book. Treating science as 'the subject' means the areas of science are linked together more officially (if not more explicitly); they are seen to go together; what is seen to apply for one applies for all areas. This has affected the way the content of syllabuses have been written; the long list of patterns for SCISP, and the use of 'Investigation', 'Life processes and living things', 'Materials and their properties and 'Physical processes' in the national curriculum show the necessary shift to describing the contents instead of taking the contents as a collection of subjects.

In many contexts described in the thesis, sciences were in fact seen to go together, pre-dating the development of integrated science. In the lobbying and arguments for science to be included in the curriculum from the turn of the century to the present day, science teachers worked together arguing for science generally.

Separate subjects having departmental status in a school

'Difference from rather than communality with' is maintained by the designation of subject status, because of the associated features i.e. designated staff, staff hierarchies, autonomy from the other subjects and timetable slots. The studies of Duckworth school, in particular, revealed the gradual dismantling of these consequences of subject status, replacing specific subject loyalty by a loyalty to science education as a whole, replacing heads of separate subject departments by subject consultants, and designating one person in charge of courses across the sciences. Timburn lived with the tension of subject heads and subject consultants, describing it on both occasions, nearly 20 years, apart as 'a bit of a grey area' (see Appendix 3, pp 272 - 275, and Chapter 7, p 195). Sixford had set up a committee form of staffing from the start recognising such a collaborative organisation would be needed for the teaching of a course like SCISP.

Allocation of combined timetable slots and reduction in time

Sciences began to be treated as one subject in the allocation of combined timetable slots, which implied a single subject rather than separate subjects. This practice goes back to at least the 1950s for the lower forms of some grammar schools and became increasingly widespread in comprehensive schools. In the upper secondary years it became more common by about the mid eighties at the time that 20% timetable time was seen to become recommended practice (see Chapter 6, p 155). At a minimum it forced teachers to work together to decide how time would be allocated to different parts of the syllabuses, with the potential of having greater flexibility over the organisation of the material.

Weakening the concept of the specialist teacher

The practice of having one teacher per class, which became common for the first two years of secondary school from about the early 1960s and slowly extended to the 13-16 age group from the late 1960s onwards, challenged the need for a long socialisation into the subject. It permitted teachers to enter the community which 'owned' the subject without going through the normal hurdles and socialisation process. It was to some extent a continuation of a practice which had occurred in secondary modern schools, into the comprehensive schools.

The imbalance in the supply of teachers of the different science subjects, contributed to a weakening of 'ownership' of knowledge, because if the curriculum is to be taught then teachers have to teach outside their subject. This again challenges the long socialisation into the subject as the only entry route. Teachers are not jumping the assessment hurdles of A levels and degrees before they take on teaching other subjects. Their socialisation into unfamiliar areas of science comes from private study, inservice support from colleagues and the process of teaching itself. It is a different socialisation route. This route is however influenced and controlled quite strongly by the more traditional socialising route. If teachers have to prepare pupils for the examination system, then the teachers themselves must be fully aware of those requirements. This has little to do with integration, but is a contemporary feature. The shortage has been exacerbated by raising of the school leaving age in 1973 and by the requirement that everyone learn science to the end of compulsory schooling.

The enjoyment which some teachers experience from teaching across the sciences is a factor which is easy to neglect. Involvement in an integrated course prevents the feeling that certain areas are out of bounds because of lack of the appropriate socialisation into the subject. The technicians at Duckworth, for example, expressed pride in their new expertise (see Chapter 5, p 227) and some teachers in the studies in Scotland, enjoyed the wider remit of their jobs when teaching integrated science (Chapter 4, p 87).

The emergence of synthesising theories such as plate tectonics has contributed to disturbance of the separation of subjects, as by its nature, it draws together a vast range of disparate information about the earth and uses material from physics, chemistry, and biology. To include plate tectonics in a curriculum is to take for granted access to the other areas by both teachers and pupils.

The removal of choice from the science curriculum

The removal of choice for pupils about what science they learned has had a subtle effect on increasing the collaboration of teachers and reducing the visibility of subject boundaries. It removes, at least for students up to the age of 16, the need for teachers to compete for students. Teachers no longer have to display their subject to pupils at the end of the third year (Y9) nor to explain the characteristics of physics say so that pupils know what they are choosing. This helps to prevent establishing the educational identity with the subject so early, and so weakens the socialisation into the subject, which Bernstein saw as a feature of strong classification.

Overlapping assessment procedures

Bernstein argued that curricula operating under integrated codes would automatically require new assessment tools to evaluate the new overarching ideas. This in fact applies to any new curriculum: the Nuffield O level teams made sure that they altered the assessment as well as the curriculum when they embarked on syllabus renewal (see Chapter 4, p 73). SCISP continued with this practice and one of the principles of its design was that all aims should be assessed (see Chapter 4, p 82). New tools were designed which required teacher assessment as opposed to written tests which could be set externally. What was assessed was more intrusive of individuals as it attempted to penetrate attitudes and working relationships as well as practical skills and understanding (see Chapter 4, p 80). Such intrusion was, as Bernstein saw it, a consequence of integration (Bernstein, 1971, p 67). In terms of boundary maintenance, the more extensive the assessment, the more likely it was that some elements would cut across the whole of science and this would necessitate collaboration between the different teachers teaching the course. This collaboration was necessary in SCISP and has become necessary when assessing investigational skills and procedures in the national curriculum, the criteria for which span the three sciences. This has given teachers a joint agenda in assessment procedures.

Reducing the specialisation of school laboratories

The increase in science for everyone and the need to accommodate large numbers of students has heightened the need for laboratory space which can be easily adapted to a wide range of purposes rather than being focused on a narrow range of science. While in the Duckworth study this might be related to the introduction of Integrated Science courses, it is essentially a feature of balanced science for everyone up to 16. Generalised laboratory provision reduces socialisation of people into a specialism through weakening the identity which people gain from their surroundings.

Addressing the status of specialism

Bernstein argued that specialisation had a higher status than a broad curriculum: quoting the higher status of specialised honours degrees and the lower status of general degrees. This view was supported by the suspicion of SCISP, such that advocates felt obliged to justify it in terms of the existing syllabuses and its suitability for a move to the specialised A levels, emphasising the sensitivity everyone had to status of specialisation. There was similar suspicion of double science for fear of reducing the specialised route. There was, however, a softening of the position over the years brought about, not by integration, but by the requirement to provide all children with a science education which spanned the sciences. Statements elicited from say the Royal Society show the attempt to bridge the tensions of the demands for both breadth and specialism: they welcomed breadth in the curriculum, but they asked that the brightest pupils still be taught by subject specialists (Royal Society, 1982 and 1990). Bridging the gap to the specialised A level routes remains a challenge as evidenced by studies of the problem (QCA, 1998) and the recent publication of bridging texts for all science subjects.

Persistent boundary maintainers

While the boundary maintaining mechanisms have been weakened, there are factors which have worked in the opposite direction, namely: the epistemology of the sciences; the status attached to separate sciences being retained by the 'high status' schools; and the limited expertise of teachers.

Epistemology

Paul Black argued that the lack of one integrating idea could be attributed to the epistemologies of the different areas of science (Chapter 6, p156). Each area has, to some extent, different objects of study, different language and concepts. The concepts required, for instance, to describe the interactions of sub atomic particles are very different from those to describe the interactions of living organisms within a community. So while it is possible to regard both topics to be concerned with interactions, the nature of the two systems is so different that the concepts of one cannot be used in the other.

As a sociologist Bernstein made little comment about different epistemologies of the subjects which were being integrated. He did, however, indicate that differences did exist and probably his 'strength of integration' has embedded in it the sense of essential difference. In fact philosophically the term integration has embedded in it the notion of separate parts that need integration.

Expertise

Bernstein said little about expertise of teachers and technicians to cope with the wider demands of an integrated syllabus and yet in my own study teachers' inability, or perceived inability, to cross subject boundaries encouraged their maintenance. The problem was perceived by teachers, however, as how to teach across the content of the sciences (defined as chemistry, biology, physics and geology), not how to teach about the nature of science; the nature of measurement; the nature of investigations; the reliability and validity of results; the social responsibility of the scientist. This latter would, in fact, provide an adequate agenda for staff.

Status

Black was sensitive to the status of different labels in proposing the new double science course should be labelled 'science' or 'sciences', rather than 'integrated', 'coordinated' 'general' (see chapter 6, p 157). The question of status still, however, exists. What are regarded by many as the high status schools i.e. some independent schools and most remaining selective grammar schools, retain the separation of the science subjects in the organisation of their teachers into three separate science departments and in entering pupils for 'triple science'. (Entries for triple science as opposed to double science at GCSE come predominantly, although not exclusively, from the independent sector and from selective schools). The existence of the triple science route enables the certifications to be called physics, chemistry and biology, (whereas the double science certifications are labelled merely 'science'), and hence retains early socialisation into the differences between the subjects in contexts which by many are seen as 'high status'.

Framing of the science curriculum.

The discussion above has focused on Bernstein's concept of classification. I am switching now to his concept of framing which referred to the range of options open to the teacher and taught. He identified six parameters where choice might be exercised:

- selection of knowledge
- extent to which the selection permits the inclusion of 'everyday' knowledge
- organisation of knowledge
- pacing of knowledge
- pedagogy adopted
- assessment procedures

and recognised that framing was determined largely by the extent of central control of the curriculum. He could not have predicted at the time the shift to central control that was to appear in the following twenty years in England and Wales. What is difficult to distinguish in the study is the change in the framing for teachers brought about by change in syllabuses from that brought about by greater central control of the curriculum and assessment, and by the strengthening of the accountability and assessment culture. The number of summative assessment points had increased from zero or one to four (KS1, KS2, KS3 SATs and GCSE), the tests were set nationally, the options over which examination board to use was reduced as boards were amalgamated. Qualifications are used to judge teaching and schools, as well as to signify the level of achievement of an individual learner. Discussion with teachers during the second case studies in 1996 focused frequently, if not exclusively, on the externally imposed frames which had to be addressed: coverage of the syllabus at the appropriate times, assessment, Ofsted criteria, parents expectations, governors' critical eye, positions in league tables (see Chapter 7). I surmise that the creation in school life of off-timetable weeks or the 'after SAT time' when frames were explicitly weakened was a reaction to the stronger framing. During these times people were prepared to explore interdisciplinary studies or engage pupils' in some form of project work.

It is hard to know whether this lack of choice for teachers has been a major issue for science teachers. The research in Scotland indicated that if teachers had been required to teach courses then they did so (Chapter 4, p 91). The same appears to have happened with the national curriculum: once legislation had been passed, people worked within the guidelines given, even though the change involved a great deal of hard work. Choice for pupils has decreased, at one level, because they have no option over whether they study science; they have no choice about what aspects of science they study; they do however, have increased choice over the career path they follow later as they all have some basic education in science.

Bernstein argued that there would be greater uniformity in pedagogy in curricula operating under the integrated code - i.e. that teachers would have less choice about how they taught because they were all trying to achieve a similar outcome. There may be some evidence to support this from the thesis. SCISP writers for instance decided that all aims would be assessed. These aims covered a wide range of aspects including the way pupils worked on their own and in groups, and their attitudes to science. The more comprehensive the assessment, the more uniformity there is likely to be between teachers. The range of pedagogy may however not necessarily be reduced by this mechanisms; the range might increase for all teachers, while the diversity between one teacher and another might decrease.

What is more likely to restrict the pedagogy is teachers' lack of flexibility when teaching outside their specialism. The socialising through teaching which accompanies teaching outside areas of expertise might be more restricting as the teachers may define the subject from the examinations set for school and not themselves have access to the 'permeability' of knowledge. Teachers may be less able to challenge the way the subject is defined. There are however factors to do with the personality and teaching style of any individual teacher which can over-ride uniformity imposed by a common curriculum.

Problems of order in a curriculum operating under an integrated code

Young (1971, p 3) in the introduction to *Knowledge and Control*, in which Bernstein's article appeared, explained that the problem of order was an important part of the new sociology of education. This was 'order' in the sense of 'law and order'. If there is no control, then anarchy over educational knowledge can occur. Bernstein predicted that in curricula operating under an integrated code, problems of order would occur unless there was an integrating idea, a link between the integrating idea and separate parts of knowledge, an agreed form of assessment, and a committee system of staffing (see Chapter 3, p 67). The diversity of practice which was persistently raised by HMI and local advisers as 'a matter of concern', and which appeared to focus on closure of opportunity for pupils can also be looked at as a problem of order. There was lack of control of what was going on, the framing was too weak and there appeared to be too much freedom in the system. Some control and some sense of order was achieved by making everyone study a breadth of science up to the age of 16. Further control over the diversity has been achieved by national assessment during compulsory education with limited diversity in the summative assessment at 16 and by the much more explicit systems of accountability.

Much of what happened at Duckworth can also be viewed from the point of view of the need to address the problem of order. The committee form of the staffing for the double science, the agreement over the means of assessment, the agreement over how the syllabus would be subdivided into topics, the organisation of the staff to cope with the range of topics, the need to have written schemes of work, all contributed to preventing disorder. At one level the autonomy of individual members of staff was reduced, while at another level it was increased as teachers had access to a wider range of expertise through the sharing of teaching ideas with fellow teachers.

The control which is exercised by the way in which the national curriculum, and GCSE syllabuses are written, can easily drive the teaching to concentrate on making sure that all the facts are taught and there is some evidence from the discussions at Duckworth and Timburn, that this was strongly felt by teachers. It presents teachers with the problem of adding a sense of direction to the whole enterprise. Ogborn's suggestion for a 'vulgar curriculum' (Ogborn, 1994) which gave pupils access to the large important stories of science without necessarily learning all the detail is from a Bernstein perspective an interesting idea. It is allowing access to the core of the subject without the long socialisation traditionally demanded. Other formulations of the science curriculum in terms of the overall nature of the subject (Millar, 1996, Ogborn and Macaskill, 1996, Nuffield Seminar, 1998) may suggest solutions to problems of order in a way which also gives access to the permeability of the subject.

Interest in integration

Bernstein argued that the interest in integration in school in the 1960s and 1970s was to do with the growing differentiation of knowledge and integration of previously discrete areas, with flexibility of the work force, with the wish to break down social barriers and to integrate school work with life outside schools and with a response to a range of 'legitimising beliefs and ideologies' in advanced industrial societies. There is considerable evidence in the thesis that development of new areas of science, career related concerns and principles of egalitarian education contributed to arguments for integrated science and later for balanced science. There is less evidence from the thesis to support his last point, although the animosity of debates about science education during the time of integrated science was being advocated and in response say to the ASE policy documents in the early 1980s (see chapter 6, pp 148-150) did reveal deep-seated differences as to priorities people gave to different aspects of science education. The introduction of the national curriculum in science served to provide a temporary halt to those debates and to provide a framework to which everyone had to adhere. Whether such a framework is appropriate is a question not tackled in this thesis although the case studies in 1996 and the renewal of debates about the science curriculum in the moratorium on change from 1995-2000 have indicated that new frameworks are still needed.

Bernstein could not have foreseen the introduction of the national curriculum and assessment, supported by the force of legislation. The dominance of a curriculum defined by subjects and subjects close to those used in grammar schools would support his thesis about the power of subjects and the power of the high status subjects. He had predicted that within a system with weak central control, as England had in the early 1970s, large scale change would be difficult because of the many people who exercised individual autonomy within the system. Change occurred in pockets rather than generally and the story of integrated science supports this to some extent. Bernstein also argued, however, that resistance to change is equally a product of a strong centrally controlled system. What is apparent from this research both from the study of change in the schools and of the introduction of the national curriculum, is that change in education cannot be implemented rapidly because of all the interlocking systems which support it. There is an enormous amount of hard work involved in shifting such systems.

Before leaving Bernstein's theory on the effect of integration, it is worth reflecting on the effect of the national curriculum and its assessment on relationships between science and other subjects. While in science the introduction of the national curriculum and assessment has encouraged collaboration between science teachers, it has had the effect of closing the boundary between science and other areas of the curriculum, and thus prohibiting a collaboration which Black saw as equally important (see Chapter 6, p 157).

c. The limitations of the research

There are five limitations I want to discuss: the inadequate attention to the tension between school science and technology; lack of attention to the problems of teacher recruitment throughout the period; omission of the significance of research into children's ideas; minimal attempt to address gender issues; the approach to the case study.

I have probably not drawn sufficiently on curriculum histories which have shown the uneasy relationship which has existed between science and technology in the school curriculum and the separation of science education from technical educational before the turn of the century (Argles, 1964, Layton, 1994, McGulloch et al., 1985). I am aware that there was a short period when there was a burgeoning interest in science and technology in the early 1980s. This was manifested in the production of and in the large development of problem solving in science courses, but there is more detail to this part of the history which could usefully have been included.

Teacher recruitment, especially physics teacher recruitment, was a problem which Duckworth had to face. The need for a larger number of science teachers if everyone was to do science to 16 was recognised in the late 1970s . I have not addressed this in the study other than through a few passing references. This is a factor which deserves far greater attention, especially as the imbalance between teachers with backgrounds in physics, compared with those in chemistry and biology is becoming so marked..

The thirty years referred to has seen a large body of research into children's misconceptions in science. It has influenced the order in which the science curriculum has been written and has contributed to our awareness that much of what is in the curriculum will not be easily understood. I have made only marginal reference to this in the account, although I believe it has been instrumental in supporting current concerns that the science curriculum is still not right.

There is a hint of a gender thread in chapter 1. I was a woman who studied physics in the 1960s and was in a minority. I went to a girls schools and after teaching in Ghana taught in a girls school. Girls were some of the untapped scientific talent referred to in the Dainton report. At one or two places in the thesis I have picked up this thread. It was a strong theme in the SSCR discussion in the 1980s. The term 'girl friendly science' was invented, a concept which I found unpalatable. But there was a connection in many people's minds between the inclusion of a more human face to science, especially in social settings, and the appeal that this would add for girls. That integrated science courses aimed to put science in context was connected similarly in some quarters with attracting more girls into science.

The last limitation concerns my approach to the case studies, especially the first one at Duckworth. The way I conducted it was influenced by my tutor at the time, Helen Simons (now Professor Helen Simons). She had worked with the team of evaluators at the University of East Anglia. An approach to evaluation which was much discussed at the time was to start with a relatively open mind and then to explore significant issues which emerged. This begs the question of what is significant and how one decides. I selected the changing structure of the science department as probably the most significant issue. I cannot now, however, sort out how much this was a major concern of only one person who was, I believe, more conscious of his status than others. Two other people affected by the debates about who was responsible for what talked to me very little about it. Studying the structure of the science departments in the other two schools did provide some confidence that it was an issue worthy of addressing and was more widely significant. I should probably have explored more rigorously the criteria on which I decided this and acknowledged that however open minded I was, my mind was not a blank space. My own sets of ideas, explicit or otherwise, will have affected what I took from the situation.

This approach to the case study easily took me away from my original idea, seeking for a definition of integrated science which came from the school based development. I had not made this question explicit at the time, either to myself or the school, so there had been no clearly defined attempt to consider what information I needed to collect to find an answer. Had there been, I would probably have spent time teasing out the details of curriculum from schemes of work, studying science in action in the classroom, discussing with teachers in great depth what their aims of science education were and studying how aims were realised in the assessment objectives and practices. This would have been a different set of information from which to work.

d. Further questions

The limitations provide ample further questions to be explored. The omissions on gender, teacher recruitment and children's ideas could be ameliorated. There are however two slightly different issues which particularly interest me. The first is concerned with the curriculum as it is played out in the classroom and the second with the mechanisms science departments use to engage in dialogue about the nature of the science curriculum alongside the day to day detail of organisation and implementation.

Despite the straitjacket of the national curriculum there is a flexibility and freedom which is still enjoyed by teachers in how they teach. There are very real constraints such as time, but the evidence is that different teachers still provide an individuality which is their own. Heads of science often comment on how much difference there is between one teacher and another even though they are all working to the same schemes of work. Capturing something of that individuality and flair is important to identify the range of freedoms that still exist, in order to document the curriculum as it is mediated in the classroom

The second is to study how science departments keep alive debates about the purpose of science education, or create a climate in which such debates do take place even where they have not existed before. How do teachers share ideas about ways forward when so much of the work becomes surrounded by large checklists of other people's agendas? How do science departments become models of a learning community?

e. Personal Reflections

A PhD thesis is a research training, and through putting this study together I have learned a lot, much of it to do with the conduct of case studies. I began the research with a view that a case study was a research method, perhaps because books on research methods had chapters labelled 'case studies'. I now believe that the case was what was studied and the methods were those that I deemed were appropriate to the case. I have also learned the difficulty of having the intense detail which comes from a case study, all of which seems significant because it was important to the people concerned, but then trying to fit it into a wider framework. I have ended by fitting it into an historical context, using it to exemplify the sort of activity which was going on at the time. There were similar case studies carried out for the Hull and Adams research (1981); they fitted them into a discourse concerned with how to manage a department.

The negotiation of the research contract between myself and the teachers whose work I was studying was essential. I was probably lucky that on the first occasion of negotiating such a contract I was able to do it in a fairly informal manner, but I recognised later how important it had been to talk through exactly what was being researched, why it was being researched, and how it was to be researched. There were, however, loop holes that could have left me without access to the school. For instance no arrangement was made about the probable time involvement of teachers nor the period over which I would study the school. Had teachers become weary of having a researcher coming in, I could have had the access curtailed. I originally approached the making of the contract with some hesitation and uncertainty. I would in future undertake this task in a much more formal way and with greater confidence, and think through in advance what should happen given a wider range of eventualities.

I did not explore with the teachers at the outset how they might benefit from the research themselves. This seems to me now an essential part of the contract. The teachers at the schools took it on trust that the research might be useful to somebody and were prepared to tolerate my questions and presence, but neither they nor I questioned whether it would be useful to them personally or to the department.

The need to explain what I was researching presented a problem because of the changing nature of the case throughout the research. At the outset I was interested in the nature of integrated science. I had hoped that by working with teachers who were developing their integrated science courses I would be with a group of people who had to make their thinking about integrated science explicit. To some extent this did happen at the start of the research but within the first six months the frameworks for the courses had been developed. The case therefore inevitably moved to the discussions which were emerging as people developed the necessary schemes of work based on these frameworks and implemented them in the classroom. Conversations did not focus on the nature of the frameworks themselves but rather on the problems of preparing teaching material, of teachers implementing the teaching and assessment in their classrooms, and the effect of the curriculum change on the structure of the science department.

I now look back and wonder if I could have probed more on my original question about the nature of integrated science. It is possible, but the way events in Duckworth school turned out may indicate that once a plan is accepted (in this case the frameworks for the courses) time and energy is devoted to development and implementation and not to rethinking the plan in any depth. Perhaps therefore I was naive in supposing that I would be party to extensive discussion on the nature of integrated science. In any future case study I would be more aware of the way interesting events could draw the research away from the original question, and that it would be my role to initiate the discussion I needed. Significant issues can be those not talked about as well as those that are.

Undertaking the research has also taught me the rhythm and discipline of case study research. I became aware of the importance of writing up field notes immediately afterwards in order to capture as much detail as possible. It would be easier in future to be more realistic about the time needed for this and to manage a research diary better earmarking, in *advance*, about the equivalent time for writing up field notes as for collecting the field data.

I learned the importance of systematically talking with all the participants. I was not long into the research before I became aware that it was easy to be seduced by the willingness of some people to engage me in conversation and to collude with the reticence of others. The willingness to talk may have had several roots; was I used for counselling, for someone to 'let off steam' about the changes which were taking place, or merely to draw attention to themselves? In future I would identify sooner all the people involved in the study and keep this under constant review.

The fact that the research had spanned such a long time period presented both difficulties and opportunities. One difficulty was whether in going back to the schools I was going back to the same schools; they were the same school buildings but were not the same schools. Both Duckworth and Timburn had changed significantly. In the event however this became a finding rather than a difficulty. The twenty year span has also helped in the question of wider applicability of case studies. I have been struck by how each time I identified something as significant in one school, I found in contemporary literature that it was a general phenomenon of the time. The case study therefore sensitises the researcher to issues which are more wide spread than one might predict. The long time span has also driven me into attempting to provide a historical perspective. I am not a historian but the research has taught me at least to recognise and appreciate the skills of those who are. Reflecting on the story of integrated science through the theoretical framework proposed by Bernstein has enabled me to identify points which would otherwise have gone unnoticed, and to develop the skill of using a theoretical framework.

Most important of all the twenty or thirty year span has meant that I have told a story which at the outset I had no intention of telling, but which I believe will be useful to others: those interested in the history of science education, or in comparing what happened in UK with integrated science with what happened in other countries, or in using Bernstein's thesis in other contexts. I am aware for myself that in one sense I knew the story because I have lived through it and been part of many of the events I recorded. To put it all together is to know the story in a completely different way.

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Main Authors: Bill Hall (W. Hall) (Project Director), John Bausor, Brian Mowl

Publication: (1973/4) London and Harmondsworth: Longman and Penguin Books for the Schools Council

BUILDING BLOCKS

PATTERNS 1 Building Blocks (Pupils' book)

Teachers' Guide 1

Technicians' Manual 1

Topic Books

The Importance of Patterns

Rocks and Minerals

Length and its Measurement

Patterns of reproduction, development and growth

Population Patterns

Chemical Formulae and Equations

INTERACTIONS AND BUILDING BLOCKS

PATTERNS 2 Interactions and Building Blocks (Pupils' book)

Teachers Guide 2

Technicians Manual 2

Topic Books

The Diversity of Life

Science and Decision Making

ENERGY

PATTERNS 3 Energy (Pupils' book)

Teachers Guide 3

Technicians Manual 3

Topic Books

Machines and Engines

The Electrification of British Rail

Weather Patterns

Sound: Its Uses and Misuses

Electromagnetic Radiation

INTERACTIONS AND CHANGE

PATTERNS 4 Interactions And Change (Pupils' book)

Teachers Guide 4

Technicians Manual 4

Topic Books

Darwin and Evolution	*Human Behaviour*
Friction	*Earth Patterns*
Man and the Urban Environment	*Human Groups*

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Nuffield Junior science

1967 Nuffield Junior Science
Teacher's Guide 1
Teacher's Guide 2
Apparatus: A Source Book of Information and Ideas
Animals and Plants: A Sources Book of Information and Ideas
Three Teacher's Background Booklets

Nuffield O Level Science Projects

1967/8 *Nuffield O Level Physics* , Harmondsworth: Longmans/Penguin Books
Teachers' Guides I-V
Guide to Experiments I-V
Questions Books I-V
Guide to Apparatus
Test and Examinations

1977/8 *Revised Nuffield Physics*
General Introduction
Pupils' Guides I-V
Teachers' Guides I-V

1966 *Nuffield O Level Biology*
Teachers' Guide I-V
Pupils' Text I-V

1974 *Revised Nuffield Biology*
Teachers' Guide I-V
Pupils' Text I-V

1966 *Nuffield O level Chemistry*
Introduction and Guide
The Sample Scheme Stages I and II: The Basic Course
The Sample Scheme Stage III: A Course of Options
Laboratory Investigations
Collected Experiments
Handbook for Teachers
Background Books

1975 Nuffield O Level Chemistry
Teachers' Guide I-III
Handbook for Pupils

Nuffield Combined Science

1970 *Nuffield Combined Science* (started 1968)
Teachers' Guide I
Teachers' Guide II
Pupils' Activities Booklets 1-10

1978 *Nuffield Themes for the Middle Years* (Range of Topics)

Nuffield 11-13/Nuffield Science for Key Stage 3

1987 Lythe, M. (gen. ed.) (1987) *Nuffield 11-13*
Teachers Guide 1 and 2
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1990 *Nuffield Science for Key Stage 3*, Harlow: Longman Group
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Teachers' Books 1 and 2
Pupils' Books 1 and 2
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Sections 9-15 (Yr 2)
Republished as *Science for the Eighties*

Nuffield Secondary Science

Misselbrook, H. (Project Director) (1971) *Nuffield Secondary Science*
Teachers' Guide
Theme 1 Interdependence of Living Things
Theme 2 Continuity of Life
Theme 3 Biology of Man
Theme 4 Harnessing Energy
Theme 5 Extension of Sense Perception
Theme 6 Movement
Theme 7 Using Materials
Theme 8 The Earth and Its Place in the Universe
Examining at CSE (1972)

Nuffield 13 - 16

Schofield, B. (ed) (1979-1981) *Nuffield 13 - 16,* York: Longmans
Pupils' and Teachers' booklets for the units
Basic Modules (year 9),
S Modules (single science);
D Modules (double science CSE);
X Modules (additional for those doing GCE)
(for titles of modules see Appendix 2, Figure 2.8)

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LAMP

ASE (1977-1979) *LAMP* Hatfield: ASE

Teachers' Handbook 1: A General Introduction
Teachers' Handbook 2: Modular Course Organisation
Topic Briefs

Fuels
Pollution
Photography
Health and Hygiene
Paints and Dyes
Science and Food
Problem Solving
Electronics
Heating and Lighting a Home
Materials
Gardening
Space and Space Travel
Flight
Science and the Motor Car
Fibres and fabrics

Science at Work

Taylor, J, (Project Director) (1979) *Science at Work* , London: Addison-Wesley
Teacher's Guides and *Pupils' Books* for the following topics:

Fibres and Fabrics
Forensic Science
Cosmetics
Pollution
Domestic Electricity
Body Maintenance
Electronics
Gears and Gearing
Photography
Food and Microbes
Building Science
Dyes and Dyeing

Suffolk Co-ordinated Science

K. Dobson (ed.) (1987) *Coordinated Science The Suffolk Development* Collins Educational

GCSE Introductory Book
Lesson Notes Physics, Chemistry, Biology

GCSE Book 1
Lesson Notes Physics, Chemistry, Biology

GCSE Book 2
Lesson Notes Physics, Chemistry, Biology

Nuffield Co-ordinated Science

General Editors: Dorling, G., Hunt, A., Mopnger,G.
1988 *Nuffield Co-ordinated sciences*, Harlow: Longman (Revised 1992)

Teachers' Guide
Physics, plus file of Worksheets
Chemistry, plus file of Worksheets
Biology, plus file of Worksheets

SATIS, Science and Technology in Society (ASE, started in 1985)
ASE *SATIS, Science and Technology in Society*
1993 SATIS (8-14) (Large collection of Units)
1987 SATIS (16-19 (Large collection of Units))

Selection of Other Text Books

Hill, G. (ed.) (1991) *Science Scene, Books 1, 2 and 3*, London: Hodder and Stoughton

ILEA (1984), *Science in Process*, London: Heinemann Educational Books

Michell, M. (ed.) (1987) *Macmillan Integrated Science: An Examination Course, Book 1 and Book 2*, Basingstoke: Macmillan Education

Pople, S. (1997) Foundation Science to GCSE, Oxford, Oxford University Press

Pople, S. and Williams, M. (1979)*Science to Sixteen*, Oxford: Oxford University Press

Screen, P. (1986) *Warwick Process Science,* Southampton: Ashford Press

Tinbergen , D,. (ed.) Thorburn, P. (1976) *Integrated Science: The Wreake Valley Project*, London: Edward Arnold

Book 1
Book 2
Book 3

1991 *Nelson Balanced Science,* Walton on Thames: Nelson

Dobson, K. (1991) *The PhysicalWorld*, Walton on Thames: Nelson
Holman, J. (1991) *The Material World*, Walton on Thames: Nelson
Roberts, J. (1991) *The Living World*, Walton on Thames: Nelson

References: Secondary Science Curriculum Review

Better Science Curriculum Guides

SSCR (1987) *Making it Happen*, Heinemann Educational Books/Association for Science Education

SSCR (1986) *1. Better Science: Key Proposals,* Heinemann Educational Books/Association for Science Education

SSCR (1986) *2. Better Science: Choosing Content*, Heinemann Educational Books/Association for Science Education

SSCR (1986) *3. Better Science: Making it relevant to young people* Heinemann Educational Books/Association for Science Education

SSCR (1986) *4. Better Science: Approaches to teaching and learning*, Heinemann Educational Books/Association for Science Education

SSCR (1987) *5. Better Science: How to plan and manage the curriculum* Heinemann Educational Books/Association for Science Education

SSCR (1987) *6. Better Science: For both girls and boys*, Heinemann Educational Books/Association for Science Education

SSCR (1987) *7. Better Science: Working for a multicultural society*, Heinemann Educational Books/Association for Science Education

SSCR (1987) *8. Better Science: For Young People with Special Educational Needs,* Heinemann Educational Books/Association for Science Education

SSCR (1987)*9. Better Science: Health and Science Education*, Heinemann Educational Books/Association for Science Education

SSCR (1987) *10. Better Science: Building primary-secondary links*, Heinemann Educational Books/Association for Science Education

SSCR (1987) *11. Better Science: Assessing progress,* Heinemann Educational Books/Association for Science Education

SSCR (1987) *12. Better Science: Learning how to teach science*, Heinemann Educational Books/Association for Science Education

Overall guides

SSCR (1987) *Better science: a Directory of Resources*, Heinemann Educational Books/ Association for Science Education

SSCR (1987) *Better Science: Making it happen*, Heinemann Educational Books/ Association for Science Education

Other

SSCR (1984) *Towards the Specification of Minimum Entitlement: Brenda and Friends*, London: Schools Council

Selection of Regional Publications

SSCR Avon *Problem Solving in Science 11-13* Resources for Learning Development Unit, County of Avon

References: In-house documents from schools

Documents from Duckworth School, 1977-80

Notes for Staff September 1979, Whole School document

6th form options 1977/78, January 1977

Advice to third year students (about courses in 4th and 5th years), March 1977

Advice to third year students - choosing your science course for 1977/8

Third Year Course, 1976

Third Year Course, 1977/8

Lower school science syllabuses (yrs 1 & 2); separate sheets with homework topics

Mode 3 Science. Specification for first examination in 1980 Single Science

(1978/9) End of section tests for single science

Jameson, Martin (1977) *Mode 3 Integrated Science (single) Preliminary Ideas for the course, Nov 1977*

(1978/9)*Teachers Guides for all the units of the single science course*

Ackroyd, Tom (July 1976) *SCISP A Scheme for the two year course*

Integrated Science Double CSE Mode 3 Specification SO2 & S15, with effect from 1980 - submission to the examination board.

Biology Content of SCISP material (Dec 1978)

Chemistry content of SCISP material

Notes from an open meeting held on 15 Dec 1977 concerning the 4th and 5th year double science course

Jameson, Martin (1976) *Duckworth School: Technical staff structure 1979-80*

Duckworth School Science Department: Areas of Responsibility for 1978 to 1979

Duckworth School Science Department Structure 1979/80 (III) 9/7/79

Jameson, Martin (1976) *Duckworth School: Responsibilities in the science department 18.6.76*

Jameson, Martin (1977) *My role as head of science. Public lecture for 80 heads (or potential heads) of science at an inservice course in the County.*

Clark, Fred, (Harmsworth, Sandra, Bardsey, Peter) (1976) *Roles of Head of Department, 10 June 1976*

Documents from Duckworth 1995/6

Duckworth Science Department Handbook

KS3 old unit and multiple choice test (laboratory-based one and an ecology one)

KS3 new unit (etc) End of term test

Similar for KS4

Documents collected from Timburn School in 1980

TImburn School -2 page document about the school, its aims, facilities, curriculum, written by headmaster 1980

Science Faculty- general information for new staff and student teachers - written by Colin Gavin 1978

Science And Technology Faculty And Staffing Structure, drawn up in April 1980 when the post of head of faculty was advertised.

Integrated Science Mode 3 - Course Document- containing an outline of the course, assessment procedures and an appendix on visual aids available in the department.

Area Schools Common Core Chemistry (mode 3 CSE syllabus) 1973

An Outline Of The Subject Matter Which Constitutes The Core Common To Mode 3 Syllabuses In Physics And Secondary Science In The Area Schools. (as collated at a meeting of local physics teachers 5.2.73)

Two units of the Integrated science course.

Revision Of Patterns 1 - a document containing useful information about teaching this section - the result of accumulated experience! Written by Janice Osborn June 1980.

Documents from Timburn 1995/6

Timburn Science Department Handbook

Units and revision books from KS3

Units and revision booklet from KS4

Technical team - organisation and job specification

Letters explaining Y10 & 11 and Y12 & 13 optionss

Minutes of a cluster meeting

Report of OFSTED inspectors 1994

Documents from Sixford School, 1980

Goff, Dennis (1980?)*Faculty Policy and Philosophy*

Advert for a science post at the school -1977

The Effect of 'cuts' on the Development of Science at Sixford School Memo from Dennis Goff to the Headmaster, 2.6.80

Plan of the science laboratories at the school

Science timetables for years 2, 3, and 4. These indicate the teachers taking the classes for the whole year and the topics that they will be doing in any particular week throughout the year. Classes are shared between 2 teachers from year 3 onwards and a slightly more complex system operates in years 4 & 5.

Goff, Dennis (15.10.79) *Some personal thoughts about language skills.*

Lower School Course Units 1979/80

Fourth And Fifth O Level Science Course 1979/1980

Fourth And Firth Year CSE Science Course 1979/80

Goff, David *(1980/7/3) Criteria For The Assessment Of First Year Science*

Assessed Practical Scheme (for CSE Course) 1979/80

The Flame Test ; an example of an assessed practical exercise

Sixford School Sixth Form Report Self Assessment Sheet(Students fill this in)

Sixford Sixth Form Report (staff fill this in)

Proposed CSE Mode 3 Syllabus in Integrated Science (submitted to SEREB Nov. 1977)

Integrated and Applied Science Papers One, Two and Three April/May 1980

Goff, Dennis (1980, Spring Term) *Measuring Student Achievement Sixford School Staff Course* (course on Assessment run by Dennis Goff for the rest of the staff (not just science).

Appendix 1

Letters and questionnaire to Duckworth and Timburn Schools, 1996

Figure A1.1 Letter sent to Timburn and Duckworth Schools, 1996

13 May 1996

Mr
Headteacher
Duckworth School

cc Iola Mason. Head of Science

Dear Mr

Over fifteen years ago (1978–1981) I did some research in the science department at your school, at a time when the staff were introducing integrated science courses for all the stûdents in years 10 & 11 (4th and 5th years at the time). I knew many of the staff as I had been involved with the Schools Council Integrated Science Project (SCISP) which later became the double science course run by the Southern Examining Board. Duckworth had been one of the 'pioneer' schools to try out SCISP. I also met Iola Mason after he took over as head of science when Martin Jameson left.

The research gave me much information about the process of change, and about the issues that a school faced when implementing a science curriculum of this sort, which has already been useful when working both with student teachers on initial training and with experienced science teachers on various courses. I would like now, however, to extend the research and wondered if you would allow me to revisit the school and talk with the current science staff. The questions would be about the nature of the science courses running in the school now, the time allocated, the element of choice that students have, assessment procedures, the way in which science fits into the whole curriculum, and the way courses are resourced both in terms of staffing and other resources.

The staff in 1978 knew that I was using the research towards a PhD; and that is still the case. For various reasons the research had to be put onto the 'back burner' and I am only now returning to it. I negotiated various conditions for the research; I have summarised those on a separate sheet. I would expect them still to apply, but would be happy to re negotiate any of them.

The thesis is not about the school as such but about the hunt for a framework for *science education for all* especially in the 13-16 age range. The case studies of your school and two others, will form examples of the issues as they impinge on three particular schools. The real names of the schools are not used (Your school was named as Duckworth). Theses are not read by many people, but typically articles are subsequently written distilling, for a wider audience, the main points of the research.

I would anticipate that I would need to visit the school on two occasions. I would want initially to talk with the head of science and this will inevitably take his/her time. If I am able to visit, the second half of June and the first three weeks in July is the most suitable period for me.

I look forward to hearing from you, and hope that I shall be able to return to Duckworth. I have enclosed a stamped addressed envelope.

Yours sincerely

Jenny Frost
Senior Lecturer. Science and Technology Group

Case study research

Jenny Frost, Institute of Education, University of London

Negotiations for research

A summary of the way in which I worked with the schools in 1978/80 and would want to continue working is given below. Obviously with renewing links with the schools, negotiations would have to be renewed.

1. Data was collected mainly by talking with members of staff. In addition I was shown, or given copies of quite a lot of the school documentation (plans of laboratories; staffing structures for the department; course outlines; examples of the material which staff had prepared for teaching units of work; staffing arrangements for the yr. 10 & 11 courses; information about how science fitted in with the rest of the curriculum etc.).

2. I did not tape interviews, but took lots of notes. I think I would like to use a tape recorder for the next phase, just as a back up for the notes, if this were acceptable.

3. Information given by one person was not shared with others (especially those in the department) unless permission had been given by that person.

4. I wrote a summary report for the school of what I had collected and gave copies to all members of the science staff and the headteacher for comment. This was done as a means of validating the information.

5. In the thesis the case studies will be written up using pseudonyms for the schools and the staff involved. A copy of these final case studies will come to the school for comment and correction.

6. Subsequent articles written from the research will be checked with the schools concerned if material from the case studies is used.

May 1996

Figure A 1.2 Questionnaire sent to Duckworth School, 1996

BASIC ORGANISATION OF SCIENCE

School____

mixed/boys/girls/ 11-16/11-18/12-16/12-18________________________

No on roll____

Selective/comprehensive/grant maintained/independent/other

____

Class groupings for science lessons

	Mixed ability	Banded/Setted	Streamed
Y7			
Y8			
Y9			
Y10			
Y11			
Y12			
Y13			

No. of teachers per science class

	One	two	three
Y7			
Y8			
Y9			
Y10			
Y11			
Y12			
Y13			

Science Courses

Y7

Y8

Y9

Y10

Y11

Y12

Y13

For Y10, 11, 12 & 13 specify the examination boards

Figure A 1.2 (cont.) Questionnaire sent to Duckworth School, 1996

Supporting science textbooks

Y7

Y8

Y9

Y10

Y11

Y12

Y13

Which science courses are compulsory and which are optional for students at Y10 & 11____

____

____

____

What proportion of students are NOT entered for GCSE science of some sort?__________

____

____

No of science teachers________________________________

Staffing structure in the science department? (Indicate heirarchy and distribution of responsibilities)

No of science technicians________________________________

No of laboratories________________________________

PLEASE USE THE REVERSE SIDE FOR EXPLANTORY NOTES FOR ANY OF YOUR ANSWERS

Appendix 2

Excerpts from SCISP and from Nuffield Science 13 - 16

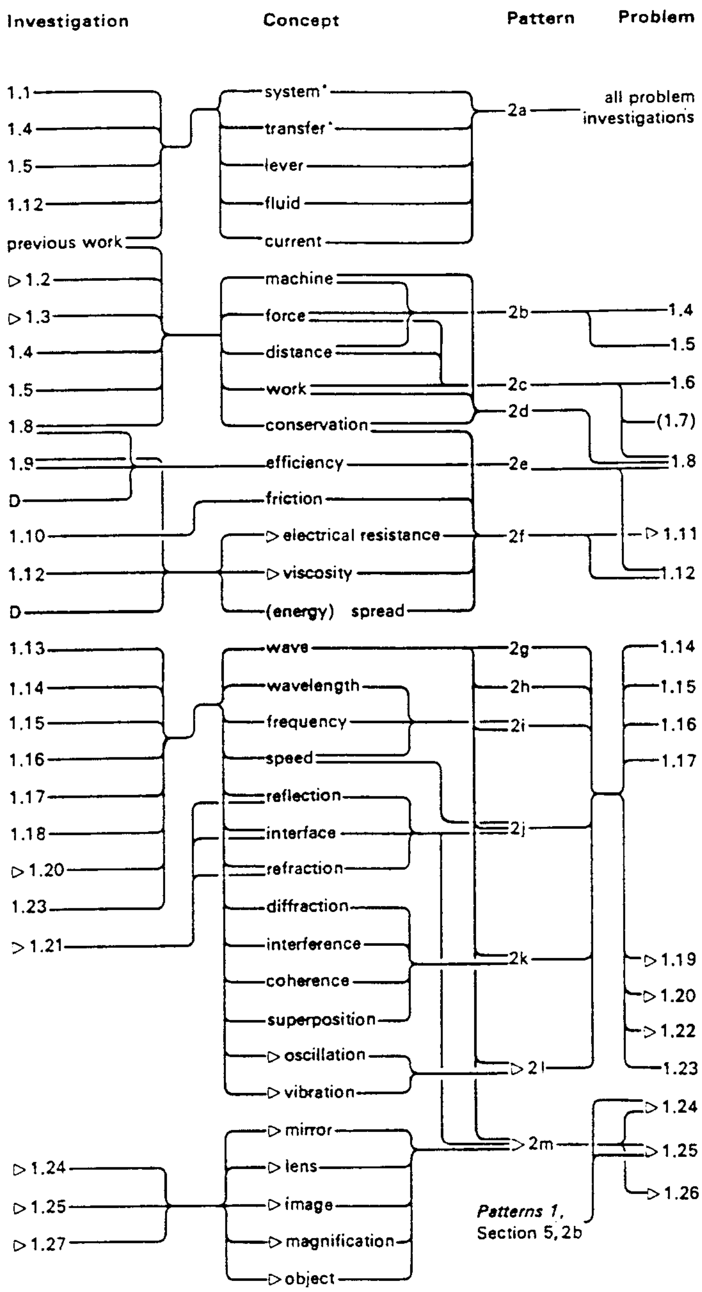
Figure A2.1 SCISP content written as a list of concepts and patterns (*Patterns Teachers Handbook*, p64)

	Concepts and patterns:	*the Project Model*
	Concepts	Patterns
52	Force Rate Momentum Acceleration Mass Proportionality	When two objects interact, the mutual force is proportional to the rate of change of momentum (Newton's second law). This leads to the equation force = mass x acceleration
53	Acceleration Velocity Vector quantity	In circular motion the acceleration is directed towards the centre
54	Earth Rock Soil Weathering Erosion Sedimentation Metamorphism Stratum Fold Fault	Patterns in the Earth's crust can be explained in terms of a series of interactions collectively summarised as the rock cycle.
55	Distribution Vegetational zone Environment Climate Latitude	A broad correspondence between the distribution of vegetative zones and latitude can be explained by their interactions with environmental factors summed up as the climate.
56	Population Birth Death Immigration Emigration	Population change can be measured in terms of the relation: population change = (births + immigration) – (deaths + emigration)
57	Community Succession Climax	Communities change with time (succession) leading to a climax community which, in spite of short-term seasonal changes, shows little overall change, or changes only very slowly.
58	Population Organism Competition Predation	Organisms and populations interact with each other (e.g. in competition or in predation)

Figure A2.2 Flow chart to indicate the interrelationship between problems, patterns, concepts and information in one section of the Patterns sample scheme

Transferring energy

Flow diagram



16

SCISP Patterns Section 3 Energy Teachers' Guide 3 p 16

Figure A2.3 Assessment criteria for SCISP aim 10 b (willingness to search for and test patterns)

Assessment Criteria for aim 10		
Aim Assessed	Marks awarded	Criteria for award of mark
10 (b)	5	Enthusiastic about collecting data for the purpose of forming generalisations and open-minded in the approach to pattern-formulating. Eager to question the validity of data and yet enjoys pattern finding. Capable of suggesting what additional information is needed to obtain a possible pattern.
	4	Undertakes testing of patterns enthusiastically but not so keen to search through information to find patterns. More competent in testing of already known patterns.
	3	Needs considerable help in pattern finding from data but will willingly test for patterns if given instructions.
	2	Rarely sees beyond the actual data from an individual experiment. Must be encouraged to make generalisations
	1	Sees little point in the exercise of pattern searching

Figure A2.4 Assessment criteria for SCISP aim 9b (ability to work in a group)

Assessment Criteria for aim 9b		
Aim Assessed	Marks awarded	Criteria for award of mark
9 (b)	5	Has the ability to act either as a team leader (e.g. planning the group task and participating in this) or as a team member (e.g. carefully carrying out his part of the whole task). Does not monopolise a discussion. Deals with peers with tolerance and respects opinions.
	4	Takes part in class discussion. Anxious that the purpose of the whole group should come to fruition.
	3	Reliably carries out instructions which are given. Always has to be invited to participate in class discussion but does so when asked.
	2	Prefers to watch rather than to do but will carry out assigned tasks. Little contribution to class discussion.
	1	Does not contribute to group discussion. Allows other members of the group to do all the work. Passive involvement in all group activity.

Figure A2.5 Three questions from 1974 SCISP Examination paper

1. *You should spend about* 30 *minutes on this question.* (20 *marks.*)

In an investigation of the effect of temperature on the rate of a chemical reaction in which a gas is evolved, the total volume of gas was recorded every half-minute.

The results obtained when the reaction was carried out at 25°C were:

Time/minutes	0	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7
Volume of gas/cm³	0	1·0	3·5	7·0	10·5	14·5	18·5	22·0	26·5	30·0	34·0	37·5	40·0	40·0	40·0

4 (*a*) Plot these results on a graph.

1 (*b*) During which of the following one-minute intervals was the rate of reaction greatest: first minute, fourth minute, sixth minute, seventh minute?

2 (*c*) The experiment was repeated with the same quantities of substances and under similar conditions but at higher temperatures, the results being:

Time/minutes	0	½	1	1½	2	2½	3	3½	4
Volume of gas (35°C)/cm³	0	2·4	8·3	16·0	24·7	32·9	40·0	40·0	40·0
Volume of gas (45°C)/cm³	0	8·0	24·4	40·0	40·0	40·0*	—	—	—

The volume of gas evolved in each case was measured at the same temperature and pressure as for the reaction at 25°C.

Plot these results on the same paper using the same axes as for the results obtained at 25°C.

3 (*d*) Use the pattern which can be seen in these three graphs to *sketch* on the same axes the graph you would expect to obtain from results recorded at 55°C, using the same quantities of substances and otherwise similar conditions.

2 (*e*) Record in a table the time taken for the completion of the reaction at 25°C, 35°C and 45°C.

1 (*f*) Using your answer to part (*e*), state how the time for the completion of the reaction is affected by raising the temperature by 10 degrees C.

2 (*g*) What is the relationship between the rate of reaction and temperature?

5 (*h*) An industrialist has to make a decision about the temperature at which a certain manufacturing process will be operated. Give three reasons why he may **not** simply take the view that the higher the temperature the better.

2. *You should spend about* 30 *minutes on this question.* (20 *marks.*)

Read this short passage, which is about some of the problems associated with supplying electricity, and then answer the questions which follow it.

The various energy crises and industrial disputes of the past few years have served to emphasise the extent to which we are dependent upon electricity. However, even if such troubles were absent the job of the Central Electricity Generating Board would still not be easy. Not only does it have to cope with a demand which varies from time to time and from place to place, but it also has to try to forecast the demand six years ahead because it takes this length of time for a new plant to be built into the system. In addition, electricity's share of the total national energy supply continues to grow at a time when coal, which provides over two-thirds of the Board's requirements, is becoming less plentiful and more expensive. The main challengers to coal are oil and nuclear fuel, but there are problems associated with these and, in any case, they cannot replace coal quickly.

6 (*a*) (i) Suggest some reasons for supposing that the demand for energy supplied electrically will continue to grow.

(ii) There are reasons for thinking that the rate of growth of demand for electrical energy in Britain might not be so great in the future. What might be the reason for this ? (Consider a time scale of ten to twenty years.)

6 (*b*) Why does demand vary from hour to hour and also from day to day? Illustrate your answer with a simple sketch graph which shows how the demand for electricity in a town might vary from 6 o'clock one morning to 6 o'clock the following morning during winter. Indicate with reference to your graph the possible reasons for the variation.

8 (*c*) (i) Suggest some ways in which a nuclear power station might be different from a coal-fired station, bearing in mind the different natures of the two fuels used.

(ii) What reasons are there why other fuels cannot quickly be brought into use instead of coal?

(iii) Suggest three sources of energy, other than fossil fuels and nuclear fuel, which could be used.

3. *You should spend about* 30 *minutes on this question.* (20 *marks.*)

This question is about the effects of scientific research on society. Read the following passage and then answer the question which follows.

With the expansion of knowledge which is occurring today, man has the power to change his environment to a very large degree—for good or ill. Some people have looked to science almost like a magic wand to cure society's ills and to solve all problems. It cannot do this, but certainly it can help, provided it is used in the correct way. But what is " the correct way "? Who is to decide on such matters? Where should scientists concentrate their new research ideas?

Two main kinds of research can be done. The first one (like Rutherford's investigation of the structure of the atom) is " pure research", for here the scientist does not know the effects of his thinking but instead pursues knowledge for its own sake. The second kind of research (like investigations into the relationship between cigarette smoking and lung cancer) is called " applied research ", and here the scientist sets out to discover facts which will be directly or immediately useful to mankind.

20 Write an essay which illustrates the effect of scientific research on society.

Base your essay on one example of " pure research " and one example of " applied research " and make clear both the good and the bad effects of the research. The examples you use should be different from those given in the above passage.

Figure A2.6 The weighting of the assessment objectives in the SCISP examinations

Aims assessed	Integrated Science A	Integrated Science B	Aims assessed	Integrated Science A	Integrated Science B
1a and 2a	16	2	8a	0	6+(4)
1b and 2b	20	24	8b	0	(4)
3	10	8	9a	0	(4)
4a	4	30	9b	0	(4)
4b	6	4	10a*	8*	0*
5	8+(8)	4	10b	(4)	0
6*	8*	2*	11	(8)	0
7	o	(4)	TOTAL	100	100

* Marks allocated to aims 6 and 10a could vary from examination to examination but the total for the two aims taken together would remain constant.
Marks in brackets indicate those provided by teacher assessment.

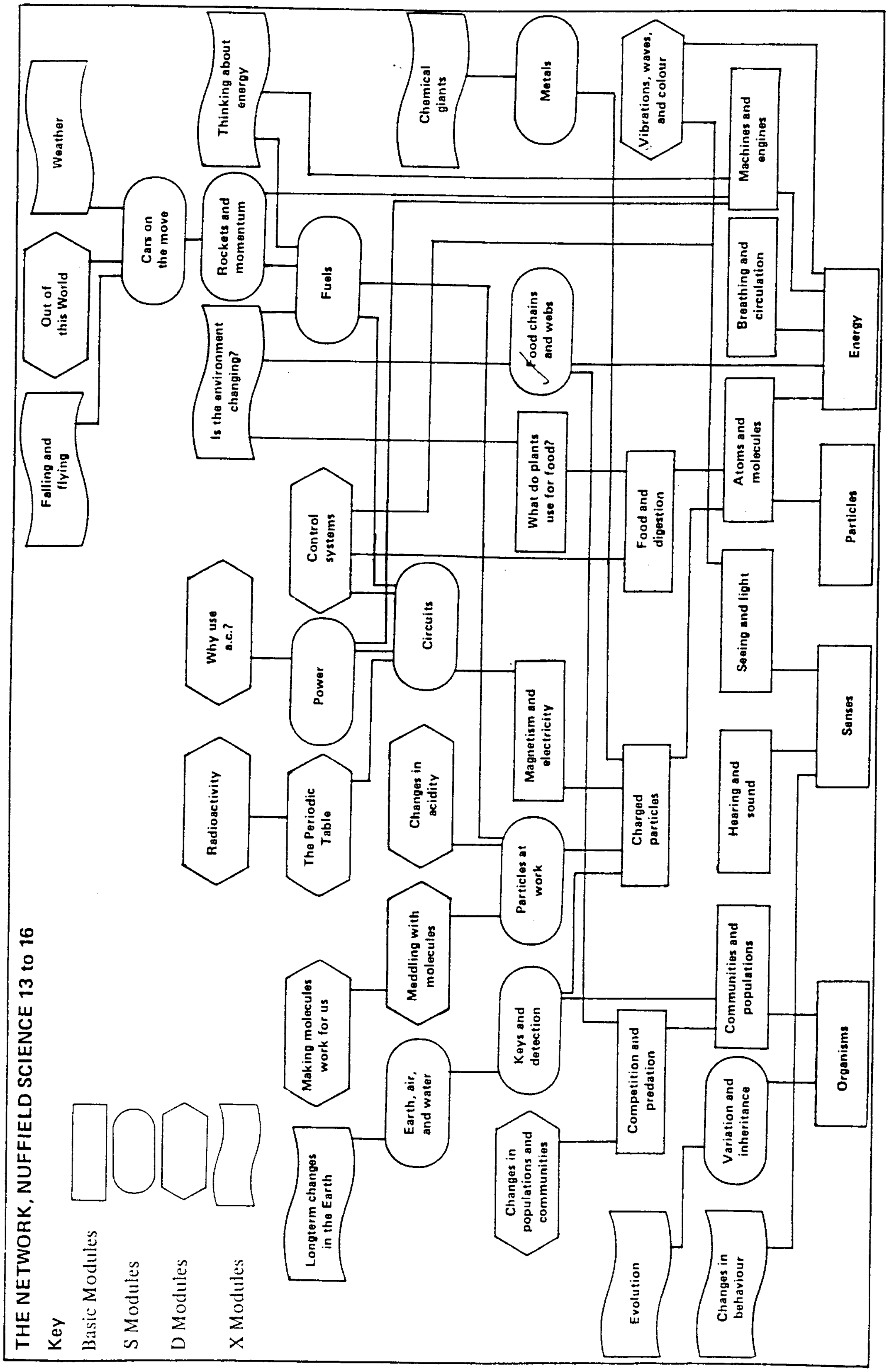
Figure A2.7 The contribution of the different modes of examination to the awards of Integrated science A (principles and problems) and B (principles and applications)

Paper	Time	Type of questions	marks	Contribution to A & B
1	2 hours	Section A made up of short answer questions Section B made up of questions requiring more extended answers	30 marks 50 marks	40% of marks for Integrated science A
2	1.5 hours	Objectives test paper consisting of 50, 4 option coded answer items	50 marks	40% of marks for Integrated science A
3	1.5 hours	Paper made up entirely of questions which require short answers	60 marks	40% of marks for Integrated Science B
4	2 hours	Section A made up of short answer questions Section B made up of question requiring more extended answers	30 marks 50 marks	40% of marks for Integrated Science B
TA		Criterion referenced teacher assessment of aims 5, 10b and 11		20 % of marks for Integrated science A
		Criterion referenced teacher assessment of aims 7, 8a, 8b, 9a, 9b		20 % of marks for Integrated science A

Figure A2.8 Patterns Expansion

PATTERN	THEORETICAL (ABSTRACT) SUB-PATTERN	OBSERVATIONAL (CONCRETE) SUB-PATTERNS	CONCEPTS
Substances composed of giant structures commonly have higher melting points and boiling points than those composed of collections of molecules. Solids are usually composed of giant structures or collections of large molecules; gases and liquids are usually composed of collections of smaller molecules.	• The chemical building blcks are ions, atoms and molecules. • Molecules consist of (interacting) atoms • Giant structures consist of (interacting) atoms or ions. • Elements consist of molecules (e.g. hydrogen) or are giant structures (e.g. copper) made from identical structures. • A compound is a collection of single molecules (eg. methane) or a giant structure made from different atoms (eg. silicon dioxide) or ions (eg. sodium chloride)	•Electron diffraction photographs show patters which give clues to the structure of the material • Spectral lines show patterns which give cluses to the composition of the material • The energy required to change state depends on the substance and is proportional to the mass. • All pure substances have precise melting and boiling points. • Liquids and gases can be seen to diffuse • All substances are elastic • Gases are compressible	atom ion molecule giant structure element compound solid liquid gas melting point boiling point

Figure A2.9 *Nuffield 13-16* plan of units to make up different courses



Appendix 3

The Organisation and Management of Integrated Science Courses: Timburn and Sixford Schools, 1980

Appendix 3 The Organisation and Management of Integrated Science Courses: Timburn And Sixford Schools, 1980

Timburn and Sixford Schools had similar science courses to Duckworth but neither were in the process of changing the pattern of courses at the time of the research. Features that were being institutionalised at Duckworth were already part of the structures of these other two schools. The Timburn study is reported at length, followed by a short account of Sixford.

a. Timburn School

Introduction

Timburn school opened in 1958 as a new purpose built 11-18 mixed comprehensive school to serve the growing population of a new town. As an early comprehensive it attracted pupils from well outside the town. Just over twenty years later it was more of a neighbourhood school, serving predominantly four areas of the new town. In 1970 it became a 12 - 18 comprehensive school as first and middle schools replaced infant and junior schools in that part of the town. In 1978 it was formally recognised as a Community School. The move towards Community School status had been part of the school's development since 1973 when a working party of governors, parents, pupils and staff reported in favour of this move and drew up plans for its inception. There were 1500 pupils on roll in 1980.

The buildings were extensive. Subjects were housed in well defined areas and had reasonable resources. The lower school building housed the 12 and 13 year olds, who were still referred to as 'second' and 'third' year pupils even though the school had ceased to have 11 year olds as a first year. The upper school building which housed the rest of the school was about 400 yards away on the same campus. Both buildings were surrounded by about 20 hectares of playing fields and were close to wooded park land.

For administrative purposes the school was divided into academic and pastoral units but with all teachers carrying both responsibilities. The academic organisation rested on a mixture of faculties and subject departments. Faculties were established in those areas of the curriculum commanding a large number of teaching specialists. They had both a head of faculty based in the upper school and a head of department based in the lower school. Other departments had heads of department who had responsibility throughout the school. Figure A3.1 gives the list of faculties and departments.

Figure A3.1 Faculties and departments at Timburn School 1980

FACULTIES:	DEPARTMENTS
English	Remedial (basic skills and assessment
Mathematics	Physical Education(boys)
Science and Technology	Physical education (girls)
Humanities	Craft design (wood/metal)
Art Design	Home Economics
Languages	Music
	Drama
	Secretarial skills (Upper school only)
	Careers

By 1979, the school had implemented a core curriculum for 4th and 5th year pupils comprising:- mathematics; English; science (2 subjects); humanities and physical education. Unlike Duckworth school, 'double science' was compulsory for all pupils in years 4 and 5. Pupils also chose three additional subjects from:- home economics; commercial subjects; parent craft; office skills; art (fabric); art (painting); pottery; history; engineering metalwork; craft metal work; craft woodwork; technical drawing; motor mechanics; needlework; drama; French; German; European studies; music; geography.

Up to 1974 the courses available in science were biology, chemistry, physics, human biology, applied physics and secondary science (see figure A3.2 below). In 1974/5 the Schools Council Integrated Science Project (SCISP) was introduced into the options by the new head of biology who had moved from Duckworth school. From 1977 onwards, there were essentially two science courses; one was based on SCISP and the other was a mode 3 Integrated Science CSE double certification. The SCISP course was subdivided in the fifth year into an O level course examined by the Associated Examining Board and a CSE course examined as a mode 3 by the Southern Board. This pattern of courses had developed gradually between 1973 and 1978. Reasons given for the change were similar to those at Duckworth; in addition staff wished to remove 'applied physics', 'secondary science' and 'human biology' courses because they had become 'sink' groups.

Figure A3.2 Science courses at Timburn School, before and after 1977

Year	Courses	level	no. of teachers
Up to 1977			
2	Combined science	mixed ability	1
3	Combined science	mixed ability	1
4&5	biology	O & CSE	1
	chemistry	O & CSE	1
	physics	O & CSE	1
	applied physics	CSE	1
	human biology	CSE	1
	secondary science	CSE	1
6&7	(as for 'after 1977')		
after 1977			
2	Combined science	mixed ability	1
3	Integrated science	mixed ability(with top set)	1
4&5	SCISP	O & CSE	2
	Int. science	CSE	2
6&7	Physics	A	2
	Nuffield chemistry	A	1
	Nuffield Biology	A	1
	SCISP	O & CSE resit	1
	biological science	CEE	1
	physical science	CEE	1

The first change came in 1975/6 when a mode 3 in integrated science was introduced for 4th year pupils. Half the time for this course was in the core and half in the options. Not all CSE pupils followed this course but those who wanted to do two sciences were advised to do so. In 1976/7 all science subjects except Integrated Science were dropped as CSE subjects, and by 1977 the only O level was SCISP.

Towards the end of the academic year 1976/7 there were extensive discussions about the total school curriculum and the nature of the core. At the time a double humanities course and a language course were part of the core. The language course consisted of European studies for about 50% of the pupils. Eventually the common core described above emerged. The science teachers believed, in retrospect, that they managed to persuade colleagues of the value of a double science for everyone partly because the double humanities programme was in disarray. Colleagues were willing to reduce humanities to a single subject while the course was sorted out, hence releasing curriculum time. As part of the agreement, however, the science department undertook to teach a two week intensive careers programme for fourth year pupils in science time; hence the origin of this department being responsible for careers education. There was little doubt that the headmaster liked the double science programme as a means of retaining opportunities for pupils for as long as possible.

He understood and accepted the educational arguments for the particular course but for him these were not a priority.

By 1977 the science staff were offering two mode 3 courses in 4th and 5th years; the main integrated science course and a mode 3 based on SCISP. The faculty had a policy that if candidates were entered for O level, they could not also be entered for CSE. If they were entered for CSE, parents could pay for them to be entered for O level if they wished. Out of a typical 4th year group of 350 pupils, 100 followed SCISP of which 60 were entered for O level by the school and a further 40 by parents.

Physics, chemistry and biology were offered as A level subjects with from 7 to 20 students in each class. The move to SCISP had not altered the science/ arts split in the school, nor the numbers of pupils studying A level sciences. English was a popular subject in the school and 45% passed O level English (the school's own mode 3) whereas only 20% passed O level science. The science department, however, lost some of their most able science candidates to apprenticeships in the local industrial estate.

The 2nd year course was based on Nuffield Combined Science and the third year course was, after 1977, an integrated science rather than a combined science course.

The organisation of the science and technology department

As at Duckworth School the structure of the science department had changed and adequate descriptions were illusive. The flow chart shown in figure 3.3 was drawn up when a new head of faculty was to be appointed for Sept. 1980 as an attempt to describe to applicants how the department worked.

Seven years previously when Colin, head of faculty, joined the school, there were posts of heads of physics, biology and chemistry. Other members of the department were assigned to the chemistry, physics and biology departments (at least in the upper school). When Janice was appointed in 1978 she was head of chemistry and Robin was appointed as the head of physics when he joined in 1974. These titles had not vanished although they had become less visible in the departmental description. The lines between various members of staff represented shared areas of responsibility and expertise. For instance, the link between Janice and Gwen was still a chemistry link, reinforced by the fact that they occupied adjoining laboratories in what was the old chemistry department; they also shared the teaching of A level chemistry.

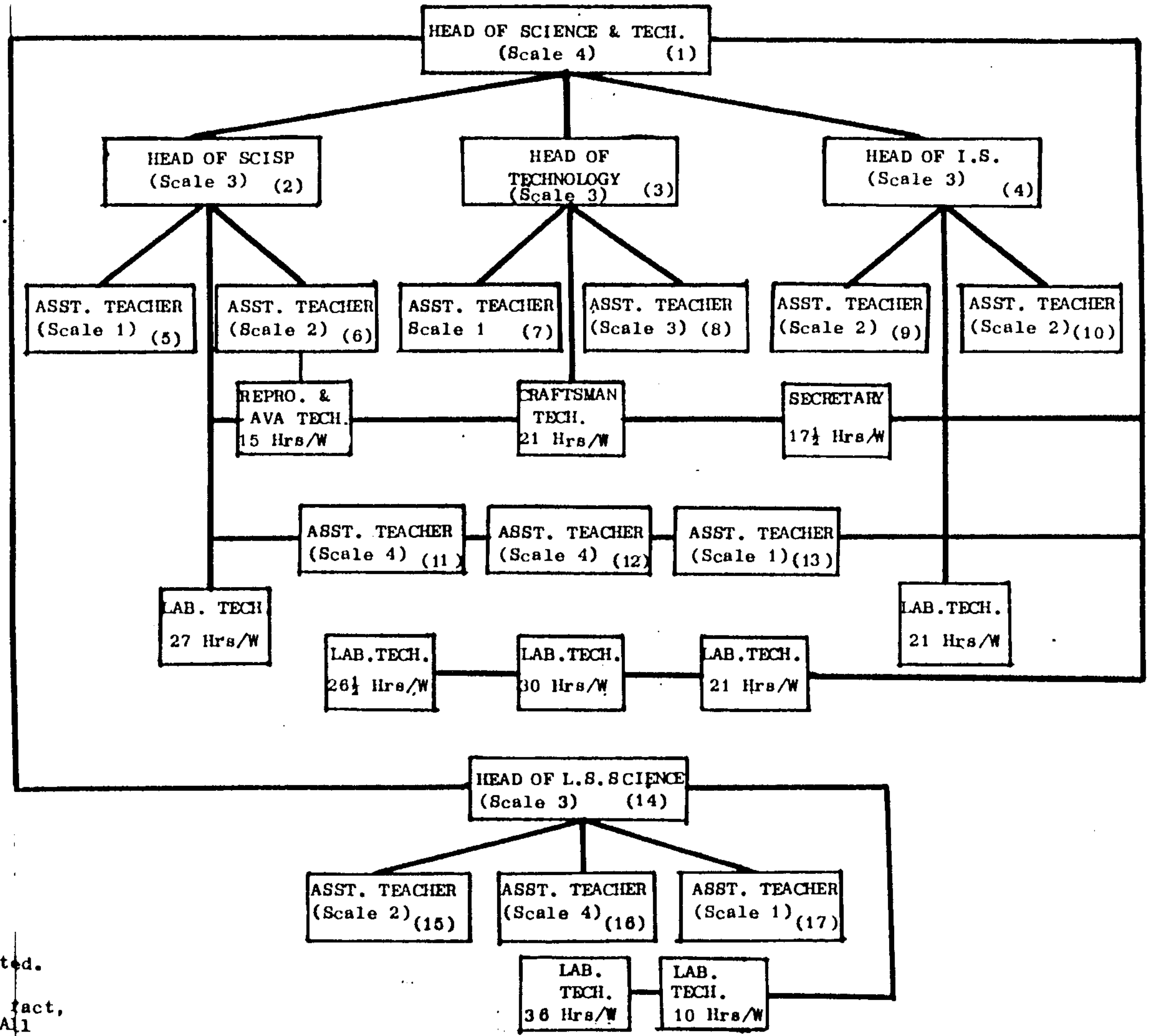
Similarly the link between Robin and Paul was a physics link and they also occupied the laboratories that were the old physics department.

Figure A3.3 Science staff Timburn School June 1980

Name	Date of appt.	Subject	Notes
Colin Gavin	Sept 1973	biology	initially head of bio. head of science 1974 left July 80-dp.hd
Robin White	Sept 1974	physics	initially head of phys. head of IS 1975 head of tech 1980
Janice Osborn	Sept 1978	chemistry	initially head of chem head of SCISP 1979
Gwen Barker	Jan. 1979	chemistry	taught in Africa left July 1980
Jonathan Thornton	Apr. 1979	physics	industrial exp. PGCE with Mike Lyth Hd.of sci. sept. 80
Paul Hopkins	Sept 1975	physics	computer expert
Grantham Howard	Sept 1979	biology	
Ronald Dawes	Sept 1972	chemistry	but 'very integrated' head of house
Joanna Brooker	Sept 1967	biology	head of house
Michael Friend	Sept 1979	biology	
Inga Lamport	Sept 1979		head of science lower school
Mark Barwood	Sept 1973		lower school science
Andrew Davison	Sept 1959	chemistry	
Judith Saeger	Sept 1975		lower school
Chris Halford	Sept 1974	engineering	head of technology
James Mckinney	Sept 1974	tech drawing	technology
Robert Arnold	Sept 1978	engineering	technology

The position of staff within the department was not an issue that had been raised to conscious level by the curriculum change, although there was consultation before new responsibilities were allocated. The task of drawing up the staffing chart, however, had made the teachers analyse the position as best they could. What was significant is that the old description of three separate sections of a larger department did not adequately match the situation.

Figure A3.4 Diagram of the science and technology faculty at Timburn 1980



NOTES

1) Present also i/c Biology.
2) Also i/c Chemistry.
3) I/c Motor Mechanics, Engineering Metalwork & T.D.
4) Also i/c Physics
5) Teaches 'A' Chem. SCISP & I.S. organises 4th yr. careers in Science time.
6) Teaches 'A' Physics, i/c AVA & SCISP Mode 3, C.S.E.
7) Teaches T.D., Motor Mechanics and Engineering Metalwork.
8) Teaches T.D., Motor Mechanics. Also Head of Careers for the School.
9) I/c 6th form Physics.
10) Teaches 6th form Biology. Also i/c I.S. resources.
11) Head of House. Teaches SCISP and I.S.
12) Head of House. Teaches I.S.
13) Teaches 'A' Biology, SCISP & I.S.
14) I/c years 2 and 3.
15) I/C L.S. Resources.
16) Also Deputy Head, Lower School.

SCIENCE & TECH. FACULTY

STAFFING STRUCTURE

N.B. This sheet shows only how responsibilities are delegated. It does not imply a rigidly hierarchical structure. In fact, we are quite the opposite! All teachers teach all courses if they wish.

The technology department appeared on the same faculty staffing chart as the science department although the subjects were taught separately. In 1980 one of the science staff was to become the head of technology. This automatically increased links between the two, but there was debate about how meaningful these were.

Designing and writing the double science courses

Writing the Integrated Science CSE course had been the main curriculum development task undertaken. The double O level course was based on SCISP which staff did not begin to modify until 1980. The first term of the CSE course was similar to the first term of SCISP so that pupils could transfer between SCISP and Integrated Science sets if necessary. The aims of the course had similarities to SCISP aims (see figure A3.5).

Figure A3.5 Aims of the integrated science course, Timburn 1980

Aims of the double science course, years 4 & 5, Timburn

A. To help pupils enjoy science and take an interest in <u>all</u> aspects of the subject.

B. To show the common method used by all scientists and its application to a wide range of different topics.

C. To familiarise pupils with essential scientific concepts so that they can understand matters related to science which they will meet after leaving school e.g.. from television programmes and the popular press

D. To allow some grade 1 candidates to reach a sufficient standard to continue science to A level.

E. To develop the ability to carry out simple experiments and solve problems.

F. To teach the reading and understanding of simple instructions and the correct use of scientific terms.

G. To develop the ability to work systematically as part of a group.

H. To show the relevance of science to everyday life. The application of science will be stressed in all topics.

The course comprised 18 units covering 'fundamental concepts' in Biology, Health, Chemistry, Physics, Geology and Astronomy. The first seven units had to be taught first because of the need to overlap the SCISP course. Later units could be taught in any order, as they were self contained and not inter-linked as in SCISP, because 'at this ability level, pupils prefer to achieve short term goals and are better motivated when they see the end of a unit easily in sight'. See figure A4.6 for titles of the 18 units.

Examples of everyday situations were included:- industrial extraction of metals from ores; electroplating in jewellery etc.; wine making; sewage disposal; water treatment; levers in the body and motor cars; musical instruments; fertilisers; world food problems; relationships between individuals; marriage; homosexuality; birth; solar cells; photography; long and short sight; understanding of human body, digestion in particular; energy supplies, alternatives as well as traditional; structure of nuclear power stations; hygiene and personal care including first aid; refrigeration. Some related to personal care; some how gadgets worked; some to the management of the environment; some to matters of decision making in complex social circumstances.

Figure A3.6 Structure of the integrated science double certification mode 3, Timburn 1980

Component A

Core Compulsory 18 Units

Measuring	Astronomy	The planet Earth
Electrons and Ions	Communities & Organisms	Particles
Cells & tissues	Motion, force and circulation	Water
Sound	Soil	Sex Education
Light	Fuels	Food
Electricity	Hygiene and personal care	Heat

Each unit assessed by a written test but mark not included in CSE mark. Written papers used for CSE.

Component B

Optional units (4 to be selected)

Electronics	Photography	Plastics
Flight	Industrial chemistry	Genetics
Nat. Hist.	You and your body	Gardening
Microbes	Evolution	Space travel

Each unit continuously assessed by the teacher, with overall guidelines. Marks given for: understanding; sustained effort; written coursework; initiative and practical skills.

Assessment for CSE

Double award 1 Physical science
2 Biological science

Physical science		Biological science
60% Paper 1		Paper 2 60%
40%	4 modules: 10% each	40%

Optional modules were a feature of the Integrated Science CSE course; they ran alongside the core modules in the 5th year (see figure A3.6). They were based on *staff* interests and enabled teachers to teach topics for which they had particular enthusiasms. Such modules might be taught 4 times during one year to different groups and hence could be thoroughly evaluated and modified appropriately. Everybody was encouraged to offer an optional module; draft outlines had to be submitted to the department for approval first.

Core units, which included end of unit written tests, had usually been written by one person but often after consultation with others. A few of the units had been written by two or three people. Several had been rewritten. Staff found that if there were problems with a unit it was usually best to find another person to rewrite it completely rather than modify small sections.

Assessment of the integrated science course

Each unit in the core was assessed by a written test. The mark did not contribute to the CSE grade but gave an indication of progress. The core was tested by a written examination divided into biological and physical science because 'we have found in the past that employers wish to see some reference to physics on the pupil's certificate'. Optional units were assessed by teachers for 'understanding, sustained effort, written coursework, initiative, and practical skills'. Marks for the four optional units contributed to 40% of the total marks for each CSE certificate.

The outline of the course, its content, structure and examination specification was contained in a professionally produced booklet as the submission to the board and as information to the staff.

Teaching the double science courses, Timburn

Pupils came to science in house groups. Each house was then divided into four new groups for science. The most able were selected for SCISP and the others were divided into mixed ability groups, maintaining tutor groups as much as possible. Because of this arrangement, science in 4th and 5th years was one of the first subjects to be put on the school timetable each year.

As at Duckworth school teaching was divided between two teachers, a physical science teacher and a biological science teacher, if possible. For the Integrated Science CSE course the two teachers divided the course units as they wished while keeping adequate coherence and continuity between the sections. They chose the order of the units although Robin specified starting units to avoid clashes over apparatus. Subsequently the main constraint was that two classes should not study the same unit simultaneously to avoid particular apparatus being wanted in too many places. Teachers recorded their units on a chart kept in the preparation room of 'new science'. A further constraint was that sex education should be taught in the first part of the summer term of the 4th year and that careers should be taught in the last two weeks of that term.

The SCISP course did not allow much selection of teaching order as course units and chapters were closely linked. The two staff concerned divided the course between them as they wished but little variation was possible. As a result teachers found they consulted more with their 'SCISP partner' than with their IS partner. Both courses, however, required collaboration over the component of the assessment carried out by the teachers.

Some variations of this two-teacher scheme occurred. Colin had taken one class for all its science in 1979/80 and Jonathan would do so in 1981 onwards. Michael and Paul were timetabled together so that they could team teach if they wished. They had tried a number of arrangements during the year; team teaching, a lead lecture from one of them to the two classes, meeting together for 3 lessons of the week and separately for the rest. Both teachers had reported that they found the experiment valuable because they had for the first time seen one of their colleagues teach!

Several teachers reported that the assessment in SCISP helped to maintain the full range of aims of the course. Ronald said that during 1979/80 he had taken more time at the start of the year to plan learning material that would help in particular assessments and felt that his teaching had improved. He reported that when he became familiar with a particular topic he taught it as he had always done and forgot the linking of ideas in SCISP. He went on to say that it was important for the aims of the examination to reflect the aims of the course 'to keep teachers up to the mark'.

Inservice work - teacher specialisation.

Comments about teaching unfamiliar topics were similar to those heard at Duckworth School. Michael reported that when he was teaching a topic with which he was unfamiliar he tended to teach the facts and less of the processes of science. Several staff reported that topics they did not know well they taught quickly!

The same channels of communication and means of inservice education were found here:- individuals helping colleagues on an informal basis after school, in the lunch hours and at break time; individuals watching each other teach, (Martin found in the team teaching that having a colleague there as support helped him to develop beyond that point where he focused too heavily on facts); the teaching itself and writing units. Staff development was one of the department's explicit aims. 'It will be necessary, however, for all teachers joining us to aim at eventually teaching a wide range of science to CSE and O level.' (part of a document for applicants for a job in the department). The structure of the integrated science course demanded this skill especially in the 5th year as only one teacher taught the core part of the course.

Once again the help needed was only partly in understanding the science; more frequently it was in doing the practical work and finding ways of involving youngsters in the science so that they learnt effectively. One of the biology staff had taken a lesson for Janice which involved a dissection. Having seen this colleague handle the dissection and associated teaching Janice gained confidence to teach this part herself in future. Colin ran a session for two new members of staff on teaching sex education. This required skills outside the traditional skills of a science teacher as the course involved discussion of social, moral and emotional issues.

Acceptability of GCE and CSE courses to people outside

The school had experienced only a few problems here. When the scheme started Colin had meetings with industrialists on the industrial estate (usually the personnel officers of firms) to explain the new courses. One or two pupils had had problems when they started work as they were not working directly with the personnel officers. Teachers had trained pupils how to explain SCISP at interviews but found that some forgot what to say. Consequently the school had written a short statement about the courses for interviewees. The headteacher wrote again to employers in May 1980 explaining the course and the various national bodies that had found the course acceptable. In 1980 the staff began a programme of inviting technical training officers to the school for a day as these were the people pupils met in their apprenticeships, which proved particularly useful. Collaboration with local industry went back to the early 1970s when science staff from several local schools had met with industrialists to specify the physics and chemistry content that would be included in any mode 3 syllabuses they might write.

The school had not had many inquiries from parents most of whom accepted without question what the school was doing. The headmaster commented that he wished they would question more.

The lower school science courses

First year course taught in the middle school

When the school had become a 12 - 18 school instead of an 11-18 (1970), there had been discussion about the syllabuses for the 11-12 year olds in the middle schools, and an agreed science syllabus drawn up. It outlined basic skills that students should have (observation, measurement and use of basic apparatus), alongside the main topics (separations; acids and alkalis; air and gases; water and solutions; energy; electricity; cells and reproduction; forces; heating - change of state/behaviour of particles; microbes; earth; pressure and force; environment). Biological topics were described in terms of the *main concepts to be learnt, suggested investigation* and *extension work.* Other subjects just had a list of the main ideas to be taught.

Second year course

This course was based on Nuffield Combined Science, Book 2. Middle schools were covering the contents of Nuffield Combined Science, Book 1.

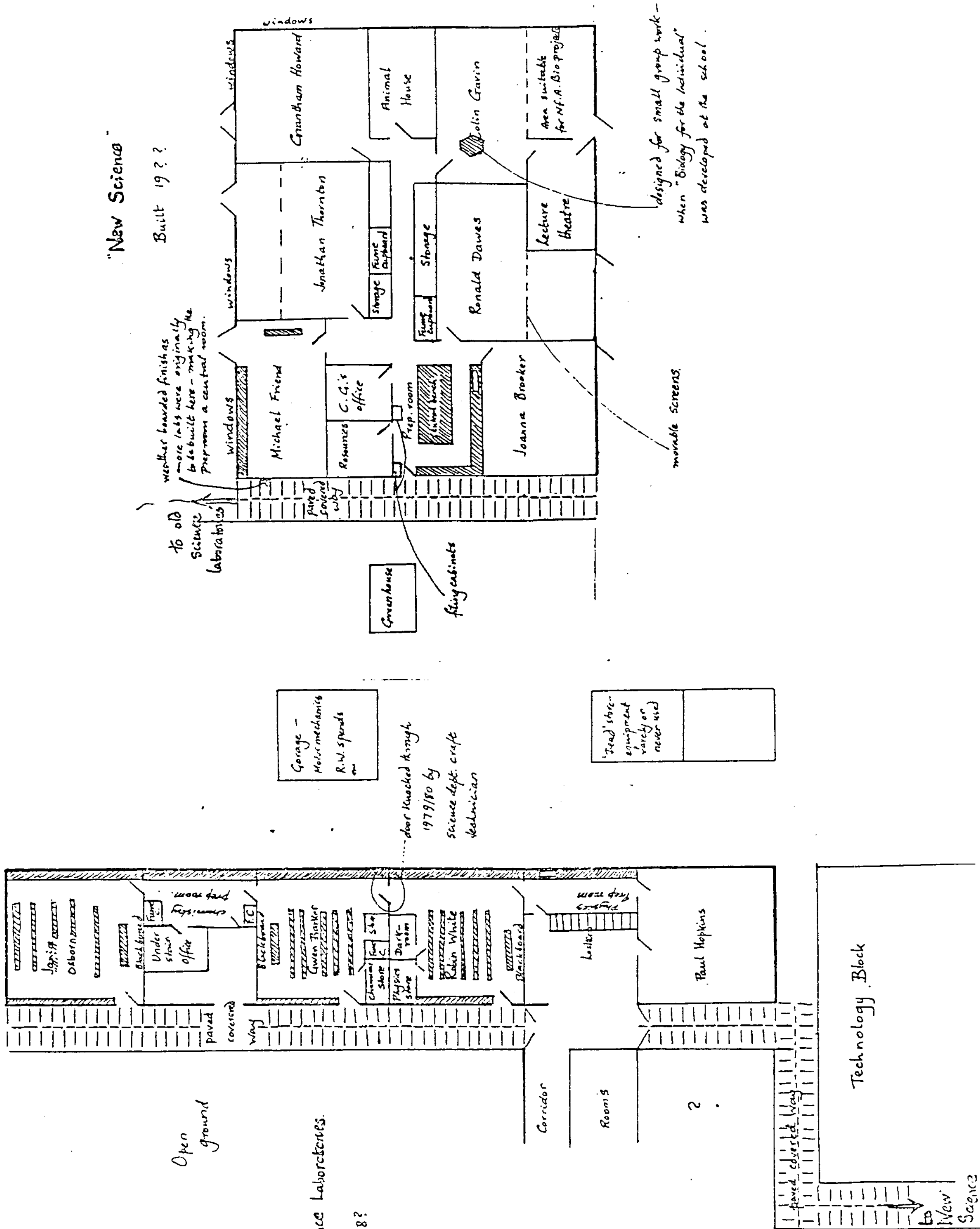
Third year course

The top set were taught the school's version of the first year of the SCISP sample scheme (as published in *Patterns 1* and *Teachers Guide 1*). Much of the staff's writing time had gone on developing the fourth and fifth year courses so teachers worked directly from the books. In 1980 Janice Osbourne did put together a guide to teaching Patterns 1, based on her (and colleagues') experience of teaching it. The guide contained useful information about roughly how long to spend on each section, and a commentary on each investigation, focusing on: basic practical details; on the associated thinking that had to be done in each investigation; sections to be left to another time; and of course, safety precautions. The guide also had summaries of main points in each chapter and in some cases, revision sheets.

Other third year course

The science course for the rest of the third year was based on Nuffield Sciences and the materials from the Nuffield Resources for Learning Project, some of which had been developed at the school.

Figure A3.7 Plan of science laboratories, Timburn School 1980



The laboratories

The laboratories were in two different buildings (see figure 3.7), referred to as the old and new laboratories. They were about 100 metres apart on the ground floor, connected by a covered way. When the new laboratories had been built in the 1960s there had been an intention to extend them so that all the science laboratories could be together. The science area would have been a self contained area with a central preparation room. This would now never come about. The old laboratories housed chemistry and physics and some of the material for IS and SCISP and the new ones housed biology and a high proportion of the IS and SCISP material.

Members of staff each had a laboratory entirely to themselves; so teachers could use their laboratories for marking or preparing experiments; a facility enjoyed by very few science departments. The school roll was falling and this released one of the laboratories in the following year (1981/2) for use as a resource room to house many of the books and visual aids.

Preparation rooms formed social areas with facilities for coffee and tea. Two centres had developed, one in the new building and one in the physics preparation room. The latter had an identity of its own; it was the place that staff went if their cars, radios and other gadgets didn't work. Robin and Paul were electronics and computer experts and Robin could mend cars. The motor mechanics garage was close by. The technology block was in fact nearer to the old laboratories than the new laboratories and the head of technology was often in the physics preparation room (so was head of drama). This area had certainly become a subculture within the department. The chemists oscillated between the two groups.

Science teachers had keys to laboratories and came and went as they pleased after school hours and in holidays. The physics area was more likely to be populated than any other at such times, particularly during the development of computer studies. Paul became fascinated by computers and was to be found in the building from early morning to late at night. A few pupils kept equally long hours.

There was informal communication about day to day work. Several people commented that this had improved significantly when a connecting door was put between Gwen's laboratory and Robin's in 1979. This enabled staff to walk from the physics preparation room to the chemistry without going outside. It not only increased the flow of information about administration but enabled teachers to learn from seeing each other teach as they passed through. Informal channels were not sufficient, and regular staff meetings were essential and held each week.

Technicians and the maintenance of apparatus

Technicians were indicated on the staffing chart. There were two technicians based in Old Science, one mainly responsible for physics and one for chemistry, but they also serviced the integrated science courses in their own laboratories. If material stored in New Science was needed it was brought across on a trolley over the often bumpy paving stones. Routine, moderately cheap apparatus was duplicated but sometimes expensive equipment like microscopes had to be moved.

Technicians in New Science shared the same preparation room with little demarcation of duties. The priority was to prepare material for teaching and then tasks were shared (routine maintenance, washing up, cataloguing or checking books, storing apparatus etc.). A craftsman/technician worked during the mornings only and played an invaluable role in the department. As a retired pattern maker, he could quickly make devices for coping with all sorts of difficulties and mended pieces of apparatus and cupboards. He saved everyone a great deal of frustration. There had been a similar post at Duckworth until economic cuts ended it.

Two of the technicians, Pauline and Vivien, were employed to help with reprographic and secretarial tasks. Colin had persuaded the county to give this extra staffing when the department embarked on the development of its Mode 3. It was interesting that this need had been recognised. Martin Jameson at Duckworth had recognised it but had not been able to secure extra funding.

Several technicians thought that wear and tear on the apparatus had increased since the start of integrated science courses. The following points were raised:- apparatus was moved more than before and pathways over which the trolleys ran were bumpy (partly a result of the geology of the area; the school was on clay just next to a sandstone rise; rain percolated through the sand and ran onto the clay where it took a long time to soak away, the paving stones were often under water and easily moved); apparatus was used more because science was taken by a larger number of pupils: staff were not quite so protective about equipment that was not theirs, or which they did not understand well. A teacher who had not had to look after a piece of apparatus for years may not think to emphasise to pupils how to handle it carefully. If apparatus was taken to another preparation room to be sorted and returned to storage, the teacher concerned did not hear the remarks of the technicians like 'How did you manage to break so many of the connections? This set has been complete for 4 years until you had it!'

Paper storage

Worksheets, diagrams and course materials were stored centrally in New Science (see plan). The resources room was lined from desk top to ceiling with pigeon holes. Again Colin had managed to persuade county to pay for this as it might have become a model for other schools. One technician ensured adequate numbers of printed sheets were available in the pigeon holes. At the time of the research, money was becoming short and staff were as economical as possible about use of paper. Instructions for experiments were not given to pupils to keep in their files. In addition to the pigeon holes there were about 10 filing cabinets in the department. Colin agreed that the volume of paper generated was partly a consequence of course development and also of a course shared by everyone.

Books

In comparison with many schools the department had a large collection of books. SCISP pupils had a complete set of Patterns books that they were able to keep at home throughout the course, bringing them in when needed. In addition one complete class set of the books was kept at school to cope with pupils who inevitably forgot theirs. The department had just bought *Science to Sixteen* by Pople and Williams for the Integrated Science course.

Audio visual aids

The audio visual aids were stored and catalogued centrally. A comprehensive list was given to all staff and regularly updated. In 1978 the list comprised 44 videotapes, 12 tape slide sets (several were radio-vision programmes produced by BBC); 3 sound tapes; 40 sets of slides; 19 filmstrips; 114 8mm film loops.

Science faculty - general information

In 1978, the head of science had put together a short introductory file of information about the science faculty for 'New Staff and Student Teachers'. It contained general information about the department and its courses, and was sent to applicants for jobs in the science department. The second section entitled 'Information - When You Start', helpfully outlined the main things someone new to the school would need to know. The writing was addressed to the new teacher and explained resources, responsibilities and procedures. The 'tone' was helpful, friendly and business like. The whole document covered only six sides of typescript.

b. Sixford school

Only a short summary is given of Sixford School, highlighting the differences from the other two. It was three miles from Duckworth School and had opened in 1974 to accommodate the increasing secondary school population in the area. It started with 180 pupils in the first year who by 1980 were entering their 7th and last year, and the school population had risen to 1050. The intake of the school was close to a normal distribution although it lost about 20 pupils each year who elected to go to a grammar school. The headmaster expected 16+ achievement to be close to the national average. He described the school as planned on Hirstian lines (Hirst, 1965), with a faculty structure as shown in figure A3.8 and a 4th and 5th year curriculum with a strong core as shown in figure A3.9.

Figure A3.8 Faculty structure at Sixford School in 1980

Faculties At Sixford School, 1980

Science
Mathematics
Humanities
Communication (English, Modern Languages and Drama)
Creative Arts (Home Economics, Craft and Technical Drawing)
Physical Education

NB Art and Music operated as separate departments outside this faculty structure.

The science courses throughout the 11-16 had been planned as broad and balanced science from the start, and were similar to Duckworth's but without the single science course in yr 4 &5. This was not entirely surprising given that the first head of science at Sixford had originally been head of biology at Duckworth. The science course in years 1 & 2 comprised a series of biology, chemistry and physics units; the third year course had more integrated units. In years 4 & 5 there were two double science courses, one designed for pupils doing O level (SCISP, examined by AEB) and one for CSE (mode 3 with SEREB). There was no mode 3 for SCISP, as at

Duckworth, but staff were able to move pupils between the two groups as late as the Spring term in the 5th year and were confident that their selection procedures were reliable.

Figure A3.9 The curriculum for 4th and 5th year classes in 1980, Sixford

4th And 5th Year Curriculum In 1980

60 periods per fortnight are divided as follows:-

Science	12 periods	2 subjects
Mathematics	8 periods	1 subject
Humanities	11 periods	2 subjects
English	6 periods	1 subject (Eng lit. CSE mode 3)
Language & Com	9 periods	2 subjects
Option	6 periods	1 subject (creative arts, art, music, 2nd modern lang.)

The rest of the time was spent on RE and PE.

There was one teacher per class for the first two years, with two teachers per class for the third year, where units were divided into two groups, one with a physical science emphasis and one with a biological emphasis. There were four different routes planned through the third year units so that there was no clash over apparatus .

In the 4th and 5th year the pattern was distinctly different. The pupils came to science in half year blocks, comprising three lots of 30 pupils. They were then divided into four groups; one a SCISP group and three CSE groups. The 12 lessons per fortnight were divided into two groups of 6, each group taken by a different teacher. Unlike the 3rd year scheme both these teachers could hand over to other teachers for the next section of the work. Each group therefore saw *four* different teachers in the two years. The order of the teaching of the units and the staffing was carefully organised at the start of the year and both teachers for any science group did not change at the same time. The reason for this pattern was to enable specialists to be teaching their subjects as much as possible and to ensure that staff could handle the questions that came from the brightest pupils. Of the three schools this one had the most tightly organised staffing. Lists were kept in the preparation room and the laboratory technician kept a careful record of how far people had got within a unit and warned them if they were getting behind.

Unlike the other two schools the laboratories for the 11-16 curriculum were all together in a one storey building, so there was no problem of moving equipment upstairs as at Duckworth, nor of moving it from building to building as at Timburn. The main block of laboratories were in use 98% of the time which left no time for laying out practical work beforehand nor for maintenance during the day. All equipment was put onto trays and large heavy equipment went onto trolleys in the trolley park. Teachers collected their apparatus from this central area and returned it themselves.

The courses were all in the process of being well documented. The first head of science had written the course for years 1 & 2 himself and drafted the outline of the third year course. The new head of science (appointed 1976) undertook developing the course from the framework and then worked with the rest of his staff (including the old head of science who had become the deputy head) to develop the 4th and 5th year course. Nuffield Secondary Science had been used as a base for the CSE course, with a lot of additional material added. Storage systems were in place, with several filing cabinets for units and worksheets and similar resources.

The departmental structure had no heads of subject. Subject specialists were appointed to 'fly the flag for their subject' but not to run separate departments. Posts of responsibility were for the head of science, the second in the department, and one or two points for other coordinating responsibilities within the department. There was, of course, the possibility that as the post-16 cohort grew then subject specialisms would be more prominent.