## *Science in a rural comprehensive school: a case study*

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# SCIENCE IN A RURAL COMPREHENSIVE SCHOOL:

# A CASE STUDY

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ABSTRACT

SCIENCE IN A RURAL COMPREHENSIVE SCHOOL: A CASE STUDY

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The study is concerned with the evaluation of aspects of science education in a small rural comprehensive school.

A review of the literature establishes links between curriculum development and evaluation which are regarded as essentially two halves of the same process. Curriculum is defined as the sum of all formal and informal learning which occurs within schools.

A naturalistic methodology is used since it is claimed that the richness of the description obtained illuminates areas of concern far more effectively than purely quantitative techniques would allow. An eclectic approach, using a variety of data gathering strategies, is employed, then emerging issues are subjected to 'progressive focussing'.

Trials of the new Nuffield Combined Science course were considered with reference to the suitability of the materials for use with mixed-ability groups of first year pupils. Problems posed by scientific language are investigated through readability measures applied to textbooks and worksheets. A general lack of understanding reported by pupils on Integrated Science courses and reactions of teachers and pupils to girls in science form major areas of the research. Consideration of pupil-teacher relationships in science poses the question of whether teachers should involve pupils in the decision-making and curriculum development: reference is made to recent research conducted on this issue.

Seeking to illuminate those aspects of science teaching and learning which are perceived as important, the issues are presented, wherever possible, in the participants' own words supplemented by description with a view to achieving greater understanding of current practice.

The question of whether such methods are useful tools in the process of school self-evaluation and staff development is left for the staff of the school to decide when they have had the opportunity to assess the results of the study.

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# INTRODUCTION

The impetus to undertake an evaluation of the science department of this small rural comprehensive school came from the Head of Department who hoped that it would complement and also provide additional information for a report he was writing for the Secondary Science Curriculum Review.

After reading some of the available literature on evaluation the writer decided that an approach which attempted to be descriptive rather than attempting a quantitative assessment of the department might be most helpful to the teachers.

Through a literature study links are established between curriculum development and evaluation since they may be seen as part of the same process.

A number of curriculum models are examined including the behaviourist curriculum model supported by Tyler(1949) since this has had, and continues to have, a major influence upon the way teachers teach. This model is found to be inadequate since it is axiomatic that all changes in learning are capable of measurement. The view expressed by Stenhouse (1975) that there are many areas of study which do not allow precise measurement of outcomes is ignored, for example art or literature appreciation.

The view is taken in the study that teachers should be concerned with the processes of learning and should take a more eclectic view of the curriculum than the one which regards it as the list of subjects on the timetable.

One view of curriculum which is considered is that it must include all the formal and informal learning experiences to which children are exposed during the course of a school day. It is argued that learning does not simply take place when the teacher speaks or sets the class a task, it is taking place all the time through the implicit messages which each school transmits and which may be largely intangible, but which go to make up the 'ethos' of the school.

If the 'hidden curriculum' is an essential ingredient in the whole curriculum then it could be argued that curriculum development can only be successfully carried on by individual schools and cannot appropriately be served-up in neat packages in the form of national projects. There might be a case for saying that the people who work in the school, which might include pupils, must decide how to implement new ideas and they must establish the criteria for success through a continuous monitoring of their own performance - this is what is called self-evaluation.

The 'naturalistic' evaluation which is the subject of this study was conducted in the science department of a small rural comprehensive school. In providing a description of the location and context of the school along with a historical review of the department (See Appendix H) Hamilton's point is accepted:

'that an appreciation of the historical and cultural location of a "case" is pertinent to the development of a valid interpretative account' (Hamilton, 1977).

The invitation to conduct the evaluation was made by the Head of Department and it was decided to adopt the techniques of the anthropologist, enthnographer and the sociologist. A 'holistic' approach was adopted in collecting qualitative descriptive data with a view to identifying issues which emerged as being important in the functioning of the department.

Classroom observations generated data very rapidly in the form of field-notes and audio tapes so that it soon became apparent that it would not be possible to sustain the task of transcribing everything. Issues began to emerge quite quickly so that it was possible to begin the process of 'progressive focussing' on a limited number of areas (Dearden and Laurillard, 1977), as they were identified in conversations with teachers and pupils.

'Thus a major segment of a qualitative report should be devoted to descriptions of the school world the subjects live in as they see it. Two appropriate procedures employed to gather data are open-ended interviews and participant observation' (Spector, 1984).

The intention to record then transcribe all conversations before feeding them back to the participants was only partially successful not only because of the size of the physical task itself, but also because it wasn't always possible to arrange for staff and pupils to go through them in the limited time they had available to them. Practical lessons were difficult to record on a portable tape recorder because pupils were often very mobile and the level of background noise picked-up by the built-in microphone made transcription impossible.

Ideally data should be fed-back to participants soon after the event to ensure that memories and impressions are still fresh.

One of the criticisms of this type of evaluation is that its output is descriptive and based upon subjective observation which can permit bias to enter into the findings, but the analysis seeks to achieve understanding rather than assessment in this case.

This review of the literature led the writer to consider the following issues.

The new Nuffield Combined Science project became a focus of attention since it was seen as presenting science in a new and potentially exciting way although it was still at the trial stage. A survey of first and second year pupils was made to discover how they described scientists to see whether there was any evidence of sex stereotyping, also questions were asked to compare topics of interest between boys and girls.

A second focus of attention was the integrated science course which is taught to both O level and CSE groups in the third, fourth and fifth years and from which a number of issues emerged: the involvement of girls in science as a compulsory subject, language and understanding in science (which also arose in the study of combined science), textbook analysis and readability, and the question of classroom interaction. The identification of these topics as separate issues is however a distortion since they are very much interwoven and cannot properly be isolated.

A questionnaire was administered to these yeargroups to try to discover something about their general attitude towards science and this was compared with the information which pupils had written on their profile reports. By using these methods in conjunction with the taped lessons and conversations it was hoped by this process of 'triangulation' to build up a comprehensive and accurate picture of pupils' perceptions of science and to be able to assess whether there was any indication that as pupils get older their interest in science diminishes.

This particular methodology had certain similarities with the method which Gagne(1965) proposed for science and which coincidentally is the basis of the Schools Council Integrated Science project. From observation it was hoped to develop hypotheses which might be extended towards more generally applicable ideas, a method which Frankenberg supported when he maintained that 'only the particularistic can illuminate the universalistic'. (Frankenberg cited in Lacey, 1970)

The total amount of data collected on tape was substantial therefore it was necessary to follow Parlett's (1975) advice that data must be brutally edited and selected, but this may inevitably lead to the interpretation being personal.

'The uninitiated researcher tries to appreciate the sensitivity and skills of perception and interpretation that ethnographic techniques require, but these skills can only be developed through experience.'(McGarvey, 1979)

Pupils in schools do not all have the same 'knowledge' of their school lives: it is apparent from reading the transcripts which are included in Appendix C that even within tightly formed groups of pupils, perceptions and judgements which they make of their teachers and the work may be very different. Yet such groups come to be identified in ways which suggest that teachers often label them not as individuals but as members of groups of 'hard-working', 'quiet' or 'disruptive' pupils. Equally pupils have their own system for labelling teachers according to a variety of criteria.

It may be that by involving pupils in the process of evaluation a more accurate picture of school life would result. The present research was intended to use the opinions and views of the pupils alongside those of the teachers in order to present as full a picture of the work of the department as possible and to try to assess the value of involving pupils in this sort of development work. It may be that this will be a positive way of creating a genuine link between teaching and learning so helping to rid our schools of the feeling that education is about negotiating for survival. It may also provide teachers with a more satisfying and exciting avenue for professional development and enable pupils to feel that they too have an active and constructive part to play in creating a more effective educational environment.

# CHAPTER I

# TOWARDS CURRICULUM DEVELOPMENT THROUGH EVALUATION

# TOWARDS CURRICULUM DEVELOPMENT THROUGH EVALUATION
## -A REVIEW OF THE LITERATURE

If the contribution of the science department in the school is to be viewed in the context of curriculum development then it is necessary to be familiar with the major threads of curriculum thought which have developed in British education.

The history of curriculum research is relatively short in this country being only about 25 years, but during that period of time there have been fundamental changes in education as well as in society in general. The main thesis of this chapter is to consider the argu ment that if curriculum development is to be effective, it must be grounded in individual schools although developments may be supported by outside agencies at least initially. It is also part of the same case that any results in curriculum development must be regarded as tentative. As Stenhouse points out:

'The improvement of teaching is not the linear process of the pursuit of obvious goals. It is about the growth of understanding and skill of teachers which constitute their resource in meeting new situations which make old aspirations inappropriate or unattainable.......Progress comes as we deploy in the face of the new puzzle, what we learned from our intelligent failure to solve the old.' (Stenhouse, 1980, 244)

Out of this suggestion grows the belief that if curriculum development is to be meaningful and successful it must result from the continuous self-evaluation of the work of the school and this may require the involvement of the pupils, who, as recipients, have a major stake in its success. After a broad resumee of curriculum development the review of the literature is divided into 6 sections dealing with:

- The Objectives Model
- Curriculum as a selection of total knowledge
- Curriculum as induction into culture
- The Child-Centred Curriculum
- The Process Model of Curriculum Development
- Curriculum Development through Evaluation.

A Curriculum Development.

'What should children learn? What should the schools teach?' (Richmond, 1971, 3) Two apparently simple questions which have long presented curriculum planners and educators with the problem of defining curriculum, since it is a term which is in general useage, but seems to defy precise description. (Bell, 1971)

'...from the moment of his birth the child is in continuing interaction with many curricula in many educative institutions, or if one prefers with an extended curriculum taught and learned (and mistaught and mislearned) in a variety of situations.'(Dewey cited by Cremin,1975,31)

One can only assume that the emphasis on the curriculum of schooling arises from the relative ease with which it may be studied and controlled when compared with the problems which would arise if curriculum theorists tried to explain curriculum in terms of all the experiences of an individual.

The practice of systematic consideration of curriculum is a relatively recent phenomenon in this country. It is perhaps twenty-five years since curriculum development, as a serious study, entered the conciousness of teachers, but it remains contentious as new ideas must compete with existing ones in the struggle over what should be taught. (Taylor and Richards,1979)

The first major curriculum development took place in the private sector of education with the development of the Schools Mathematics Project, a move which prompted initiatives from industry and universities to assist the curriculum in state grammar schools: the Nuffield Foundation quickly followed the lead with assistance for work on science and technology. (Stenhouse,1983)

The establishment of the Schools Council in 1963 gave curriculum development its credibility. For many people though, tensions soon emerged over whether it should be school-based with teacher participation as a form of staff development or whether it should be centrally-directed with emphasis upon monitoring and accountability. (Stenhouse, 1983)

Curriculum development as the applied branch of curriculum study was seeking links between theory and practice through a research and development approach to group or individual teaching. (Stenhouse, 1975) A thorough study of the curriculum was conducted by a working party of the Schools Council which produced a document called 'The Whole Curriculum 13-16' in 1975. Seven major issues were identified which, stated briefly were: aims, content, teaching and learning methods, availability, constraints on curriculum (i.e., structural, financial, organisational, etc.,), community context and assessment.

Three other factors were included:

1. curriculum development and professional self-development were inter-related since teachers now have a large measure of responsibility for making decisions about curriculum issues which concern values and matters of judgement. But just as there are differences among people in any discussion of social, philosophical and political issues, so there are over curriculum matters, it is out of these discussions that new ideas of thinking develop;

2. curriculum should be seen as dynamic since the school is under continuous social, economic and political pressure: change is a facet of our society and schools must adjust to these changes, yet should maintain a direction - curriculum

in this sense is therefore a compromise of conflicting opinions and attitudes;

3.the 'hidden curriculum', a unique feature of each school, must be considered because it often presents the greatest learning problem to children since it is not explicit. It may in fact conflict with the pupils' previous experiences and expectations yet it is part of the process of socialisation.It is possible that the force of the hidden curriculum is sufficient to undermine the stated aims of the curriculum.

It is the 'hidden curriculum', though never publicly acknowledged,with which pupils and teachers must come to terms if they are to be successful. (Jackson,1968,33-34)

A curriculum exists in all schools, and a curriculum model may also exist as an ideal type in the minds of the curriculum theorist, but it is the relationship between these two which Stenhouse (1975) suggests might form the true curriculum, but he warns against over-optimism that the two might eventually match-up, we must be prepared to confront our failures. The curriculum in schools very often falls short of the ideal because of variations in teachers and pupils' abilities and skills, availability of resources and social, political and economic pressures. It may also be because of the failure to achieve understanding of the nature of curriculum.

B The Objectives Model.

Serious and systematic consideration of curriculum theory probably began in America, when one of the earliest writers, Franklin Bobbitt, developed the concept of 'scientific management' which sought to adapt the techniques of business organizations, with their emphasis on productivity and efficiency, to the school situation.Bobbitt firmly believed in the setting of very specific and detailed objectives. (Kliebard,1975) It was this perspective of curriculum which with few changes became enshrined in the well-known rationale by Tyler (1949).

What then is the purpose of education? Tyler (1949) saw it as a means of changing pupil behaviour, he was not interested in teacher activity since it could not be assessed in his opinion. He believed that changes must be pre-specified in the form of objectives.

'One can describe an objective with sufficient clarity if he can describe or illustrate the kind of behaviour the student is expected to acquire so that one could recognise such behaviour if he saw it. (Tyler,1949,59-60)

Objectives setting gives direction to the main emphasis of the studies, (Taba,1962), allows the decisions of the 'why','what' and 'how' of the curriculum to be decided, and forms a platform for assessment purposes.Bloom (1956) and Krathwhol (1964) made significant contributions to the objectives model with their studies on the 'cognitive' and 'affective' domains.

The objectives model was applied to the Nuffield Science

5-13 project with the broad aims being specified as a list of objectives. The reaching of understanding in a sequential and ordered way was also seen to be very useful in systems analysis where it was easy to judge effectiveness and identify problems, making it cost effective.

The curriculum is often seen in terms of measurable changes in pupils, these may be specified in terms of 'intended learning outcomes' or 'behavioural objectives'. (Stenhouse,1975; Kelly,1977) The problem which Kelly identifies is that behavioural outcomes which are precisely defined may not cover a range of objectives across the cognitive, affective and psychomotor 'domains'.

Hierarchical lists of objectives may appear to be effective but they do not take account of the fact that objectives may be inter-related. Wheeler accepts objective setting as a suitable plan for initiating the young into 'some of the appropriate ways of society', though he does not imply a hierarchy. (Wheeler,1967)

Stenhouse was sceptical about the value of such an ambitious and comprehensive curriculum model, particularly when related to the many variables, problems and activities which exist in the schools situation. He suggests that any findings based upon such a model would be highly speculative firstly because of the lack of firm understanding of how the school works and secondly because the available data simply would not fit the model.

'We must beware of believing that in the objectives model - or in any other model or theory - we have a systematic solution to our curricular problems, much less an educational panacea.'(Stenhouse,1975,71).

Some areas of learning may simply be rewarding because they add something to the quality of life rather than because they help to meet a set of objectives. (Peters cited in Stenhouse,1975)

By translating procedures, concepts and criteria into objectives, schools distort knowledge and by prescribing boundaries of knowledge through the use of the teacher as the 'master of knowledge', the field of knowledge available to pupils is severely limited. (Young, Bernstein and Esland in Young,1971).

The locus of Stenhouse's argument rests upon his contention that setting behavioural objectives in the arts or creative studies is totally inappropriate since it is not possible to foresee outcomes or specify situations when teachers would not have to make judgements of quality or worth in the sense that behaviourists would describe them. Creativity cannot be prespecified in Stenhouse's opinion and philosophical arguments are conducted according to procedures not on the basis of a set of behavioural outcomes. He maintains that specifying content rather than objectives would enable us to treat student learnings as outcomes which in his opinion is fairer to the needs of the individual since it is liberating rather than restricting.

(Stenhouse,1970,73-83)

Eisner (1967) made a similar point when he identified 'instructional' objectives, which correspond to behavioural objectives, and which enable the individual to gain mastery of those cultural tools which already exist and may become common to all pupils.'Expressive' objectives which are non-prescriptive in terms of learning, relate to the possibility of making creative responses and generating new understanding, since they provide a genuine learning context and evaluation is the process of reflecting on what has been achieved.

It could be argued that classrooms cannot be stereo-typed because each is different, especially since teachers often disagree about what is important and what is unimportant:this diversity of value systems appears to make the setting of specific objectives quite meaningless.

On a very practical point Stenhouse questions the ability of any teacher, with a normal teaching commitment, to be able to maintain an accurate picture of how each pupil is progressing in relation to the multiplicity of objectives which would be set for each course he taught.

C. Curriculum as a selection of total knowledge.

Some curriculum theorists view the curriculum as a selection from the total of human knowledge selected to form a coherent whole which is useful, lasting and accords with the development of democratic ideals. (Smith et al,1957)

This idea that it is possible to make such a selection is sometimes regarded as impossible and absurd. (Holt,1969)
'...what we really say, that some knowledge is essential and the rest, as far as the school is concerned, worthless.....'(Holt,1969,172-173)
This may be a somewhat extreme position, but it is one supported by Postman and Weingartner (1969) who claim that people over twenty-five have to accept that what they were taught at school is outdated information, so how can it be essential?
This question was addressed by Benjamin(1971) in his satirical account of curriculum in a prehistoric tribe, when traditional subjects are challenged as being obsolete and irrelevant to the needs of a changing society, but they are defended by some on the grounds that they are part of a timeless cultural heritage.
As knowledge continues to increase and society changes,so the curriculum must be treated as open-ended, constantly changing and tentative, if it is to keep pace. (Kelly,1977)
But tradition in English education has emphasised 'subject', 'syllabus' and 'scheme of work' (Richmond,1971), since many teachers seem to have only half-formed notions of why they teach what they do - except that they went through a similar process:
'What was taught yesterday tends to be taught today unless conscious efforts are made to change it through developing alternatives.'(Taylor and Richards,1979,15)

In England decisions about what should be taught have often been a question of adapting or adopting what was already in existence bearing in mind the requirements of the public examinations system. (Watts, 1980)

D. Curriculum as induction into culture.

Curriculum is sometimes identified as a way of inducting children into the culture (Hirst, 1971. Bell, 1971) and of providing for the continuity of values in society. Peters (1969) accepts the idea of initiation into knowledge which he seems to regard as synonymous with culture. Hirst believes that access to culture is the right of all and not the privilege of the elite. Stenhouse (1975) questions whether in a pluralist society it is possible to talk in terms of a single culture in any meaningful way since the individual may experience many cultures as he moves about in daily life: it may be possible to think in terms of education providing access to many cultures which enable effective communication to take place between groups. In a sense Shipman's view accords with the culture model, in that he sees education being used as a means of social control by which children are taught to accept their status in life (Shipman, 1971), presumably by the decisions about what is selected by the school for transmission. This still leaves several unanswered questions about whether teachers are competent to make the selection, whether selection is on the basis of relevance, interest or what is considered to be worthwhile.

Access to the culture (usually left as a vague and nebulous term) may be prevented by the ways in which schools are organised. The provision of separate courses for slow learners may separate pupils just as effectively as separate schools. Equally the individual teacher in his own classroom can effectively 'stream' groups simply by the way he arranges the seating.

The problems of the slow learner are similar to those faced by the working-class children identified by Bernstein (Stenhouse, 1975, 31) as having problems because of their 'restricted' language code, they too were unable to access the education system with its largely middle-class values and perceptions. Stenhouse (1975) extends this idea by suggesting that it is their 'perception of reality' which is different. The fundamental problem of working-class children may be the difference between the school culture and their everyday culture which Stenhouse feels the schools should attempt to bridge.

'A single undifferentiated prescriptive curriculum cannot be expected to meet the needs of so many individuals, each of whom is unique in terms of his own senses and perceptions, his own memories, cupidities and needs and may well be the reason for much of the failure in education.' (Kaufman, 1971, 193)

A second view adopts a discipline-centred approach (Bruner, 1960), with knowledge gained being regarded as worthwhile, generalisable to other future situations, intellectually stimulating and forming a coherent whole. Bruner is concerned that the 'educated' man should understand his world sufficiently to form the basis for satisfying his curiosity and preparing him for being able to make plans of action, but he emphasises the changing nature of knowledge. Schwab (cited in Stenhouse, 1975) urged the need to teach pupils 'the significance of this ephemeral character of knowledge' so they did not regard it as a statement of permanent truth.

Curriculum planning on the basis of separate subject departments is not likely to encourage change which will only be forthcoming when whole school staffs work together in a concerted effort to meet the needs of the pupils (Mann, 1983).

An extreme subject-centred view regards education as a 'personal confrontation between teacher and pupil, at the end of which a lesson has been well and truly learnt and that there is positive value in insisting on hard work and high standards' (Hewitson, 1969). Lessons probably would be learnt, but would they have anything to do with the accepted picture of education?

The subject-centred approach over-emphasises examinations which themselves inhibit curriculum change, (Cornwall, 1983; Mann, 1983), so schools should accept that 'examinations should follow curriculum and not determine it', (Norwood Report, 1943), by working to minimise their impact.

The subject-based orientation of the curriculum is defended on the grounds that to adopt a more integrated approach would be to move back towards the organisation of the all-age schools where head teachers had unrivalled power (Musgrove,1975). Musgrove bases his argument on the premise that diversification and differentiation are essential features of modern society and he accepts the Durkheimian view that division of labour generates the interdependence from which there can be a coming together to establish objectives. Organisation along subject lines confronts the head teacher with several power bases and this reduces much of his power to act autocratically.

A weakness of Musgrove's position seems to be that he chooses to ignore the fact that subject specialisms can lead to insularity possibly more than they encourage co-operation.

Two distinct types of curriculum organisation were identified by Bernstein (1971) when examined against the school's value system and organisational pattern. The 'collection' type retained various elements as discrete and isolated units i.e. subjects or disciplines, and the 'integrated' type was typified by the more open relation between elements. The strength of the boundaries around subjects was assessed using the concept of 'classification' and the degree of teacher or pupil control over the selection and pacing of work was referred to as the strength of 'frame'.

Hamilton's (1973) evaluation of the Scottish Integrated

Science project revealed strong classification which prevented successful integration, but Stenhouse (1975) suggests that even when integrated units are created they can themselves become new 'collection' types. Perhaps this has happened to some extent with SCISP which has created its own subject-like boundary around itself.

The hierarchical organisation of knowledge in any collection code allows access to knowledge to be controlled so that only a chosen few ever reach the stage where the full mystery is revealed (Bernstein, 1971).

Teacher control of access to knowledge may be expressed in other ways:

'With complex integrated curricula, team-teaching often appears to lead to tight framing; teachers facing uncertainties of open-endedness without a firm role close down on possibilities and obtain security and power by teaching pupils what questions can be put at any particular time (Stenhouse, 1975, 50-51).

The presentation of curriculum matters in two documents produced by H.M.I.: 'Curriculum 11-16' and 'Aspects of Secondary Education in England' tends to emphasise the dominance of the subject approach, though they do consider wider curricular issues, but the general tone is prescriptive in terms of the needs of society.

E. The Child-Centred Curriculum.

Dewey (1910) rejected the subject-centred model of curriculum because its emphasis upon order and structure denied individuality:

'The child is simply the immature being who is to be matured; he is the superficial being who is to be deepened; his is narrow experience which is to be widened. It is his to receive, to accept. His part is fulfilled when he is ductile and docile.' (Dewey,1910,12)

How does Dewey see child development?

'His development, his growth, is the ideal. It also furnishes the standard. To the growth of the child all studies are subservient; they are instruments valued as they serve the needs of growth. Personality, character, is more than subject-matter. Not knowledge or information, but self-realization is the goal (Dewey,1910,12).

Dewey presents us with an ideal which continues to re-appear from time to time in education as it did in the late 1960's and early 1970's. Kaufman (1971) pursues this theme of individual dignity and worth when he suggests that too often children are projected as behavioural machines.

The child-centred curriculum aims to set the child on a voyage of self-discovery through self-directed activity pursuing individual interests at his own pace. The teacher acts as a facilitator in small group or individual learning situations. He shares in forming problems and hypotheses, provides access to resources and experiences of all kinds, may give direct exposition, but does not undermine individual autonomy in inquiry and problem solving.

This was the basis of Plowden (1967) which rejected the notion of knowledge being chopped into subjects because the curriculum should enable the child to understand the world on his own terms by constructing his own reality.

Critics, including Peters (1969) were able to mount a considerable campaign against the proposals which, simply put, suggested that such a 'laissez-faire' attitude towards education would not serve the personal or intellectual development of the child and leave the teacher with a very tenuous and unsatisfactory role. Demands upon teachers would be excessive in terms of attending to individual demands and preparation of materials as well as demanding a highly flexible working environment supported by a huge data and resource base.

Highly-motivated children from supportive homes might succeed in self-directed learning, but children from less-fortunate or culturally impoverished homes might suffer from a lack of support and limited access to knowledge, a situation which would not occur in the subject-based approach. (This latter point is perhaps wishful thinking in view of some homework tasks set by some subject teachers).

Discovery learning may be exciting and motivating, but is not particularly cost effective nor is it genuine discovery since that depends upon a base of previous knowledge. (Shipman, 1972)

F. The Process Model of Curriculum Development.

In the search for a coherent model for curriculum development which would take into consideration the complexities of school and classroom life Stenhouse proposed the use of 'principles of procedure' in his 'process model'.. (Stenhouse,1975). In seeking an alternative to the means-ends or objectives model Stenhouse turned to the ideas of Peters(1966) for a basis for the selection of content which must be 'worthwhile' and 'must involve knowledge and understanding and some kind of cognitive perspectives which are not inert.'(Peters cited in Stenhouse,1975)

'In the humanities curriculum one selects for adolescents those topics which are of enduring human interest because of their importance in the human situation.' (Stenhouse in Hooper,1971,338-339) It is the intrinsic value of different forms of knowledge which make them valuable, not their value as a means to objectives. The contribution which activities such as science, history, literary appreciation and poetry can make are valued because of the contribution they make in illuminating other aspects of life. The key procedures, concepts and criteria of these forms of knowledge become the focus of joint speculation for both the teacher and pupils in the classroom and provide the key to achieving understanding. (Stenhouse,1975,85)

Such an approach to learning increases the opportunities for reflective and critical thought which are regarded by Stenhouse as necessary for the development of autonomous and independent thinking. Indeed reflective theory was the basis for Dewey's (1933) democratic ethic of education which rejected the idea that specific beliefs and ideas could be instilled into children since the suppression of knowledge is contrary to democratic ideals.

Bruner (1966) explained that the course 'Man:A Course of Study' cast the teacher in the role not of an expert, but of joint learner and emphasised the discovery and inquiry approach to the work.

The Humanities Curriculum Project tried to establish procedures for achieving pupil understanding. It was accepted that understanding could only be deepened through the interaction of the participants, but the Project also rejected any attempt at objective judgement e.g. examinations, and aimed for self-assessment: any examinations which were taken must not be seen as tha 'raison d'etre' for the course.

The process model demands teachers of a very high quality capable of helping pupils to achieve understanding and develop criteria of judgement, but too often teachers' chief concern appears to be with survival and they do not have the opportunities for professional development.

'In a system where curriculum decisions are seen as resting with the individual school, the school becomes the focus of curriculum development and a process of continuous organic development becomes possible. On this assumption every school should have a broad development plan. From year to year the curriculum will be modified as part of a continuous process of adjustment and improvement.' (Stenhouse, 1975, 123)

G. Curriculum Development through Evaluation.

This interest in the wider picture of curriculum development was accepted by Harlen(1973) who perceived teachers' assessments and classroom observations as far richer sources of information than test results which reflect only short-term changes in pupils' behaviour.

The link between curriculum development and evaluation was made by Cronbach:

'Evaluation is a fundamental part of curriculum development not an appendage. Its job is to collect facts the course developer can and will use to do a better job, and facts from which a deeper understanding of the educational process will emerge.'(Cronbach, 1975)

MacDonald (in Stenhouse, 1975) favoured a holistic approach to evaluation and like Cronbach (1975) he believed that evaluation was an aid to decision-making though he did not see that as part of the evaluator's role. Cronbach also envisaged evaluation playing a central role in accountability.

MacDonald was concerned to provide information to a wide audience and evaluation should attempt to represent the interests of many by providing an exchange of information between groups on the basis of a 'right to know'. This was the central feature of 'democratic' evaluation (Simons in McCormick et al,, 1981. MacDonald and Walker, 1974).

In adopting an anthropological or naturalistic approach Parlett and Hamilton (1972) expressed their concern over previous evaluation methodology:

'Their aim (unfulfilled) of achieving fully 'objective methods' has led to studies that are artificial and restricted in scope. We argue that such evaluations are inadequate for elucidating the complex problem areas they confront and as a result provide little effective input to the decision-making process' (Parlett and Hamilton,1972,1).

Using naturalistic methodology 'the records grow quickly and rather chaotically. If noted faithfully they will reflect the muddle and messiness of everyday life. However ultimately, one becomes conscious of certain "themes".' (Woods,1977,17)

'Evaluators adopting an illuminative style are likened to ethnogaphers immersing themselves in the milieu of the innovation in order to identify significant issues and phenomena and relating those to the expectations, perceptions and experiences of the various participants and other interested groups.'(Boud et al,1985)

It is the emergence of themes or significant issues which lead to a 'progressive focussing' (Nisbet,1974; Dearden and Laurillard,1977) upon them as the central features of the research. The difficulty appears to be in deciding how sharply the focussing should go: concentrating upon the minute detail might mean that the general picture is lost, on the other hand by taking a broad holistic approach the research may be so general that it reveals nothing of the complexity which is the make-up of classroom life and therefore it serves no purpose in helping to build a theory.

Stake (1967) adopts a wide view of evaluation in seeking to understand the complexities of classroom life. Doyle identifies three major dimensions which make up this complexity: multi-dimensionality, simultaneity and unpredictability of events. (Doyle cited in Tamir,1985)

Parlett and Hamilton's work abandoned measurement in favour of intensive study of the total programme: its rationale and evolution, its operations, achievements and difficulties, all of which are viewed in the context of the school or 'learning milieu' which is defined as 'the social,psychological and material environment in which students and teachers work together.' (Parlett and Hamilton,1972,11)

The uniqueness of each setting was stressed and they emphasised that the evaluator must remember that the 'learning milieu' also includes the prominent personalities, accidents of history, feuds, in fact all of those things which together give it this stamp of individuality. (Parlett in McCormick,1981)

Weiss and Rein suggest that evaluation should be concerned with describing the unfolding form of the experimental intervention, the reactions of individuals and instiutions subjected to its impact and consequences, so far as they can be learned by 'interview' and observation of these individuals and institutions. It would lean towards the use of methodology emphasizing interview and observation, though it would not be restricted to them. But it would be much more concerned with learning than with measuring. (Weiss and Rein cited in Stenhouse,1975)

The other major concept which Parlett and Hamilton employ is the 'instructional system' which refers to the formalized plans or statements upon which the instiution operates,i.e. aims and objectives, statements about organisational structures etc. In other words the fabric upon which learning is founded; but the evaluator must remember that it is not immutable and may undergo major changes in each learning situation as it is applied by teachers in their classroom encounters. (Parlett and Hamilton,1972)

Pedagogic research is eclectic and pragmatic as it seeks improvements and solutions to practical problems,(Bassey,1983), through observation, interviews, questionnaires and analysis of documents and background information, including quantitative data.(Nisbet,1974) The value of collecting data from a number of different sources and employing a variety of techniques is that this facilitates the process of validation through a process of 'triangualation'. As Adelman (1981) points out however triangulation involves evaluations of the actions of an actor in a role, not an evaluation of the person:

'...the most any evaluation, whatever its methodology can provide is evidence in pursuit of truth...it can only constitute a stage in a more or less continuous educational debate.' (Adelman and Alexander, 1982)

Kushner and Norris (1980) suggest that the validity of naturalistic research is achieved when participants have agreed, in open dialogue, what constitutes a truthful account of the school.

'We measured the programme at perhaps its point of greatest strength - that's what I mean by being fair....Where the programme did turn out badly we reported it. Through familiarity with the programme we also knew where the weakest points lay.... That's what I mean by being honest.' (House, 1972)

If the researcher is to be successful he must gain the confidence and co-operation of individuals which to a large extent may depend on his ability to assure them of confidentiality, avoid being seen as a tool of the administration and also realising that his presence will have a profound effect on the situation (Parlett, 1975; Straton in Tamir, 1985).

Naturalistic evaluation should produce reports which are rich in description and intelligent analysis, which are easily read, illuminate issues and promote discussion (Jenkins et al, 1981), though many have not been accepted when written, possibly because they do not make recommendations.

A separate strand of naturalistic methodology adopted the concept of 'curriculum criticism' which viewed the curriculum as an art object which could be understood by using the methods of literary criticism (Mann, Willis, Eisner and Jenkins). It received some support from Stenhouse (1975) but was vigourously attacked by Gibson (1981) because of the rather grandiose and omniscient literary style of its supporters.

In disagreeing with naturalistic methodology Henderson (1979) argues that it is too time consuming, too impersonal and requiring expertise - he suggests that if evaluation is to be a normal feature of institutional life then it should take place naturally during and after meetings. If this does happen then it may tend to be non-structured, non-systematic and often highly subjective with little attempt to analyse the classroom in anything other than a superficial way.

An alternative to the qualitative-naturalistic-descriptive methodology or social anthropology paradigm (Parlett, 1975) is to use a quantitative-scientific-summative methodology or agricultural paradigm (Parlett, 1975) which follows a pre-determined experimental design and accords more with the behavioural objectives model of curriculum being concerned with measuring end results which may be used to pursue accountability.

Parsons (in Lacey and Lawton, 1981) supports measurement programmes located in discipline-based, policy-orientated research as the only true method of providing information for decision-makers. Methods which concentrate on school organisation and teaching do not show sufficient interest in pupils' development and Parsons accuses the 'new wave' evaluators of 'conceptual impoverishment'.

Nevo (1983) advises that the evaluator should select the methodology which best suits his purpose rather than adopting a closed mind.

In looking for reasons for the growth in interest in evaluation and particularly school self-evaluation Simons (in Lacey and Lawton, 1981) suggests that schools might have reacted to the setting-up of the Assessment of Performance Unit. By becoming involved themselves they could determine the criteria. However Simons does make the point that evaluation should precede curriculum change and not follow it. A further incentive may have been that it was seen as enhancing the professional image of the teacher. This is certainly one of the benefits expressed by Simons to which she adds the improved educational performance of the school, though she does not see this in terms of accountability.

Case-study reports should not be conclusive, but should accurately reflect the opinions of the participants, but it must be accepted that there will be value judgement in what to include and what to leave out of reports. (Simons cited in Safari, 1974)

Emphasis is placed upon the need to present data by using the subjects' own words as they provide important insights into how they define their world (Spector,1984. Nisbet,1974):

'Thus a major segment of a qualitative report should be devoted to descriptions of the school world the subjects live in, as they see it. Two appropriate procedures employed to gather data are open-ended interviews and participant-observation.' (Spector,1984)

Wood (cited in Adelman,1981) warned of the danger of interviews, which might create situations which were ideal for exaggeration, misrepresentation, lies and melodrama; these must be identified and regarded as data rather than information. Simons (in Adelman,1981) makes the point that interviews should be conversations not inquisitions. The major difficulty for the interviewer is to control his own part in the conversation in that he must allow issues to emerge and be explored by the interviewee, but he must also have the skill to elicit deeper answers when they seem to be in danger of being lost. Throughout the interview he must be conscious of his own needs, but avoid the trap of too much personal involvement by verbal or non-verbal gestures which might lead the interviewee in the way he wants them to go.

Stenhouse (1978) draws a distinction between interview-based case-study and participant observation as he perceives it in that, in the former, the interviewer is seeking observations from the participants (usually by audio-recording) and in the latter the interviewers observations (ethnographic style) are recorded, perhaps long-hand, although he may use interviews as an extension to his evidence. In each case, the aim according to Stenhouse is not 'telling it as it is', but rather 'telling it as it feels to be in it' - a phenomenological experience.

The role of the researcher is to come to understand the interpretation which participants put on their actions, in addition to having his own interpretation. To some extent this demands that the researcher assumes some of the thinking of the participant without becoming totally involved and losing objectivity - he resides somewhere between the two. (Wilson cited in Stenhouse,1978)

Stenhouse reveals his own preference for interview-based research on the grounds that it is less susceptible to accusations of bias and distortion. (Stenhouse,1980)

For all its imperfections participant observation is, according to Delamont, a much more fruitful and revealing process than any other, (Delamont,1975) including the American tradition of interaction-analysis with its check lists of categories. (Stubbs and Delamont,1976)

# CHAPTER II

# THE CONTEXT OF THE PRESENT STUDY

## THE CONTEXT

The school exists to provide secondary education for one of the larger Dales in North Yorkshire. It was established on the 1st September 1971 by the amalgamation of a County Modern School (founded 1959) and a small Grammar School (founded 1601).

Since November 1978 the school has been a single-site 11-18 mixed comprehensive school. Previous to that it occupied the sites of the two schools which were situated some 13 miles apart. Provision, until September 1983, was on a four-form entry catering for a maximum of 120 pupils in each year group, but since that date falling rolls have reduced the intake forcing the school to adopt a three-form pattern of entry.

Most of the pupils live in small villages or isolated hamlets in the hills where many of their parents run small hill farms. At busy times of the year such as lambing or haytime, pupils are often required by their parents to stay away from school to help with the work. This can be a source of tension between the school and the home and applies almost equally to boys and girls.

There are no major industries in the area so that employment outside agriculture is usually found in small businesses, such as shops, garages, small builders, banks, solicitors offices, estate agents, cafes and restaurants. There are two cheese-making dairies and some development of light industry is taking place.

Tourism is a growing feature of the economy of the area and many people have extended their homes to provide bed-and breakfast accomodation, but young people, in common with those in other similar beauty spots, face a difficult task in finding reasonably priced housing when they want to get married. As a consequence many have had to move out of the area as more and more cottages are turned into holiday homes by people from large local conurbations.

The enormous size of the school catchment area means that most pupils are transported to school. A significant number of pupils need to take a taxi from their homes before making a connection with a school coach and others travel on public-service buses. The bulk of the pupils arrive at school between 8.45 a.m. and 9.00 a.m. for a 9.10 a.m. start and leave again at 3.45 p.m.

The majority of pupils have lunch in school though these numbers have fallen sharply following the industrial action by teachers, many pupils finding that they prefer to eat down in the town.

The 'bus ing' problem places a constraint upon the extent of extra-curricular activity at the end of the school day, though parents do try to organise transport for their children if they are involved in sports fixtures.

The Report of the inspection of the school by H.M.Inspectors in October 1983 states:

'The school is attractively sited on the edge of town. The main premises comprise a 2/3 storey building (1959) with craft block and workshop together with a two storey block(1978), providing additional laboratories, a remedial base and general classrooms. The area health office occupies a wing of the main building and there is a small open air swimming pool on the site. The hard playing areas and field are of generous size, and include a school farm of approximately four acres.'

The buildings are generally well-cared for, but the architecture does not lend itself to a warm welcoming atmosphere as it tends to be mostly long featureless corridors without the benefit of suitable display areas. However, with the aid of mobile display units different departments have attempted to enhance the appearance of the rather bleak entrance to the main building.

Projected figures released by the LEA in May 1981 reveal the downward trend in entry , indeed it appears that they might be rather too optimistic since they do not reveal the numbers of pupils whose parents choose to send them elsewhere.

| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|
| January Intake (Previous September) | 100 | 110 | 90 | 85 | 85 | 80 | 65 | 60 | 60 |
| Total Main School | 530 | 540 | 510 | 500 | 480 | 460 | 410 | 385 | 365 |
| Total Sixth | 45 | 45 | 50 | 45 | 45 | 45 | 45 | 40 | 35 |
| Total on Roll | 575 | 585 | 560 | 545 | 525 | 505 | 455 | 425 | 400 |

On entry to the school pupils are placed in one of four Houses, largely to serve as the basis for competitive sports.

Form tutors are allocated and usually follow the same group for two years when there is a change of tutor for the next three years. Each yeargroup has a member of staff designated Head of Year who is responsible for pastoral and academic progress.

A programme of Social and Personal Education operates throughout the school, the time between the start of school and first lesson (approximately 25 minutes) being used for this purpose. Since September 1984 the fourth and fifth years have also had a Social Education programme as part of the compulsory curriculum. This change effectively reduced the number of subjects which could be taken to examination level from nine to eight. The whole of the Social Education programme is directed by the Deputy Head (Pastoral) in conjunction with the five Heads of Year who each lead a team of form tutors.

The school prospectus states: 'Pupils entering the school aged 11-12 follow for Years 1 and 2, a common course providing a balanced general education. The subjects studied are Mathematics, English, Humanities, French, Science, Religious Education and Physical Education, Art/Practical subjects. Special remedial education is provided for some pupils by withdrawal from regular classes'.

The only major changes in the 3rd Year curriculum are the introduction of specialist History and Geography to replace Humanities and the introduction of Spanish as a second foreign language for the more-able pupils: this is at the expense of one art/practical option and one period of either P.E. or Music.

Teaching in the First Year is in mixed-ability groups, but by the Second Year pupils are sometimes being grouped by ability in subject sets.

In the Third Year there is a mixed system with some subjects setting by ability, but others work on a banding system, however with the advent of falling rolls this is becoming less easy to organise with three teaching groups.

Fourth Year curriculum gives a certain degree of choice though there is generally firm guidance for the more-able pupils. Everyone takes Mathematics, English, Science (8 periods), P.E. and Games, Religious Education and Social Education. In addition everyone is expected to take one of History, Geography or Religious Education,one Art/Practical subject with two other optional subjects filling the remainder of the time which includes French and Spanish. A similar pattern exists for the Fifth Year.

The school has a small Sixth Form. A number of pupils return each year for a one-year course following a package of six courses which lead usually to CEE examinations. The subjects in the package are: English, Mathematics, Economics, Science, Geography and Art/Practical. Reasons for returning for one year in the sixth are usually that the individual wishes to improve exam qualifications or because there is a feeling that the extra year at school will bring greater confidence, maturity and self-awareness. Traditional sixth form students are offered a range of A level courses: Art and Ceramics, Mathematics, English, French, Spanish, Physics, Chemistry, Biology, History, Geography and Fashion and Fabrics. In addition other subjects may be provided if there is a demand. It is not unusual for A level groups to consist of single students particularly in Physics, Chemistry and Modern languages, but the Headmaster maintains that this is reasonable since the local authority made a commitment to sixth form studies when the school was re-organised and therefore ought to give preferential staffing. In practice the sixth form is quite heavily subsidised by staffing from main school provision.

The section of the prospectus on public examinations policy states:

'The most able pupils in the Fifth Year will be expected to sit the GCE or 16+ examinations provided by the Joint Matriculation Board or 16+ consortium in those subjects. A very small number of pupils in the Fifth Year (including of course those who leave at Easter) will not sit any public examinations at all, by agreement between parents, the pupils and the school'.

The remaining pupils take a mixture of O level, 16+ and CSE examinations. HMI expressed some concern that the examination demands made on the less-academic might be too great.

Homework is regarded as a formal requirement by the school, with younger pupils receiving two subjects a day and a subsequent increase over the following years. A system of homework diaries is used to check how much homework is being done by pupils since parents are expected to sign when each piece of work has been completed. The system is open to abuse since parents tend to sign in blocks of time without checking. Tutors are expected to spot this during their regular diary checks reporting any problems to the Deputy Head (Curriculum) and this includes reporting those subject areas which do not regularly set homeworks.

The school has a policy of uniform for all pupils below the Sixth form and by and large it is worn with some minor variations in shade of colour. The exception to the clothing rule is outdoor wear where 'anything goes' seems to be the rule. Uniform is justified in the prospectus:

'The wearing of a uniform helps to encourage pupils to take a pride in their own appearance and gives them a feeling of identity with the school. It also prevents any feeling of inequality between children'.

The school claims to have need of only a few basic rules for conduct and discipline which are presented to the pupils in the form of 'Notes for the Guidance of Pupils' in the School prospectus. The rules fall under three broad headings: Attendance, Clothing and Equipment, and Conduct and Discipline. Punishments may include lunchtime detention, written work or loss of privilege (though these are not specified) at the discretion of a member of staff. Use of the cane is restricted to the Headmaster though that does not include the caning of girls. Sending pupils home and expulsions are the most severe punishments used by the school and during the period of observation three boys were sent home, one of whom was subsequently expelled following a meeting of a sub-committee of the Governing Body. Few other examples of serious breaches of rules are recorded.

Full School assemblies are held in the hall on three mornings each week, singing does not feature and pupils are generally passive except on the few occasions when other pupils are involved.

ORGANISATION

The senior management team comprises, the Headmaster, Deputy Head (Curriculum), Deputy Head (Pastoral) and the Senior Master who is responsible for the day to day running of the school. This year the management group has begun to have regular meetings after school one evening each week with other 'ad hoc' meetings taking place during the week.

The school is organised on a subject basis though three areas, Science, Humanities and Art/Practical each have a Head of Department who might be regarded as a Head of Faculty. In fact the Heads of Subjects within the Humanities and Art/Practical areas exercise almost complete autonomy. HMI commented that there was an obvious need for a clear policy for staff development when promotions and new job opportunities were diminishing.

There are heads of six major departments, Mathematics, English, Modern Languages, Humanities, Science and Art/Practical. Below these in the hierarchical structure come the heads of individual subjects: Music, CDT, History, Lower School Humanities, Domestic Science and Special Needs.

Departments have been given a high degree of self-determination by the Headmaster so that by and large they function as independent units and sometimes appear to guard their 'territory' rather jealously in terms of staffing,rooms, resources (including capitation) and time. As a consequence there is little obvious inter-departmental co-operation in terms of curricular aims and objectives, so that a significant degree of overlap and duplication occurs which was noted by HMI in their report. Heads of Departments strongly defend their individual power bases as witnessed during observations when there were discussions about the need for staffing reductions as a consequence of falling rolls.

Within departments there is a good deal of emphasis placed upon academic achievement through the external examination system, indeed there is only one course in the fourth and fifth years which is non-examination and that is Applied Physical Science. Few activities and events occur outside the normal subject teaching pattern which usually takes the form of one teacher working in a 'closed' classroom.

The pastoral system which has developed in a rather haphazard fashion over recent years is largely separate from the academic structure because it has grown out of the enthusiasum of some of the younger members of staff and has not included the senior Heads of Departments to any great extent. Although most staff have some pastoral responsibilities, usually as form tutors, an uneasy peace exists between the academic and the pastoral systems and some members of staff are openly opposed to the idea of social education since it is seen to be outside the normal teaching responsibilities.

The staffing of the school is Headmaster plus thirty full-time and three part-time teachers. The age structure of the staff is quite high with about half being over forty years of age. Several teachers taught at the two schools before re-organisation, indeed the Head of Science began teaching in the Modern School in 1959. About half of the staff have been in the school since re-organisation making it very stable in terms of staff turnover.

Commenting on the structure of staff consultation and curricular discussion HMI wrote:

'One element is a steering committee, composed of senior staff and a member of each department, which meets weekly and sends topics for discussion to a full staff meeting (held monthly) or a fortnightly heads of departments meeting or a meeting of heads of years also held fortnightly'.

The overall aim of the school is stated as being:

'To provide a balanced and consistent educational environment within which, as part of a happy working community, the young people of (the Dale) become prepared for a purposeful and fulfilled adult life in the 20th/21st century western society they are to enter and in which the adult members feel that they are making a worthwhile contribution. In preparing pupils for adult life it is recognised that there is a need to inculcate awareness of other peoples and cultures and our interdependence within them'.

The detailed pastoral aims (See Appendix A) reveal a concern for the development of the individual within a caring community emphasising the need to develop personal qualities, including self-respect which will enable each person to take his/her place in the wider community by being able to establish 'appropriate relationships, contacts and means of communication'.

There is an emphasis on the development of skills in the curricular aims which will permit the individual to function as an autonomous, self-assured and decisive person, capable of assessing people and situations, able to communicate easily in a variety of ways and with a life-long interest in learning.

The problem with this list, as with other such lists of aims, is that it gives no description of how it might be possible to assess whether there has been any success in achieving the objectives. Different teachers will engage in different activities in the their attempts to achieve the same things, but the problem lies in evaluating what has been done.

The list does present a picture of what ends are considered to be worthwhile by the school and as such they represent the value judgements of a particular group of teachers about the desirable outcomes of a secondary education. It would be necessary to investigate the objectives and activities of the different subject departments to understand how the actions being taken were designed to meet these aims.

'Aims are abstracted from the concrete situation; they do not pinpoint any particular objectives; they simply point to certain criteria whereby any chosen objectives should be evaluated.' (PRING,1972,87)

# CHAPTER III

# THE SCIENCE DEPARTMENT

## THE SCIENCE DEPARTMENT

The science department, the largest department in the school, has a full-time staff of five male teachers and it receives some part-time help from the female Deputy Head and the Head of Girls' Physical Education.

The staff has been very stable over the last fourteen years with the only changes occurring in the teacher of Physics, the last change being in 1980.

The specialist teaching commitment of the various members of the department are as follows:

| | |
|---|---|
| Head of Department | -Biology, SCISP* and the New Nuffield Combined Science Project. |
| Chemist | -Chemistry, SCISP and Nuffield Combined Science. |
| Physicist | -Physics, General Science, Applied Physical Science and New Nuffield Combined Science. |
| Biologist | -Biology, SCISP and Nuffield Combined Science. |
| Agriculturalist | -Agriculture, SCISP, General Science and Nuffield Combined Science. |
| Deputy Head | -Human Biology, General Science and Nuffield Combined Science. |
| Head of Girls' PE | -Human Biology. |

* Schools Council Integrated Science Project.

There is a bias towards biological sciences in the qualifications of the members of the department and HMI made the following comment in their report:

'Qualifications and training are mainly on the biological side, but all members of the department are involved in teaching science across the main subjects and are able to do so with few difficulties and with commitment and enthusiasum'.

Staffing of the department is completed by two female technicians who are also long-serving members of staff.

The programme of courses in the academic year 1984/85 was:

FIRST YEAR -New Nuffield Combined Science (Trial)

SECOND YEAR -Nuffield Combined Science - Modified original

THIRD YEAR -Foundation year of SCISP - Building Blocks

FOURTH YEAR -SCISP or General Science (Based on Nuffield Secondary Science) plus one of three options: Agriculture, Human Biology and Applied Physical Science (non-exam)

FIFTH YEAR -As for Fourth Year

ONE-YEAR SIXTH-Environmental Science

SIXTH FORM -Biology, Physics and Chemistry

EXAMINATIONS

| | |
|---|---|
| Associated Examining Board | - O level SCISP A and B |
| YHREB CSE | - Integrated Science A and B Mode 3 |
| | - General Science Mode 3 |
| | - Agriculture Mode 3 |
| | - Human Biology Mode 1 |
| Joint Matriculation Board | - Environmental Science (AO Level) |
| Joint Matriculation Board A Level Examinations | - Biology |
| | - Chemistry |
| | - Physics |

LABORATORIES

| | |
|---|---|
| MAIN BUILDING: | 2 general junior laboratories ( one is the base for Agriculture) |
| DALTON BUILDING: | 3 specialist laboratories, 2 of which were specifically designed for the SCISP course |
| OTHER BUILDINGS: | Large greenhouse |
| | Large farm building |

The teaching commitment of the department members changes from year to year, but this year because of the introduction of the New Nuffield Combined Science course, the Head of Department and the teacher of physics have taken responsibility for all first year science. There are three mixed-ability groups and the Head of Department teaches two of them.

The second year has four mixed-ability teaching groups taught by three teachers including the Deputy Head who teaches two groups. The third year also has four groups, but these are broadly banded to give two roughly parallel 'top' sets and two 'lower' sets. The teaching is covered by two members of the department who have shared this foundation year for SCISP for many years - one is the biologist and the other the teacher responsible for agriculture.

The SCISP course in the fourth and fifth years has been taught by the Head of Department and the chemist since it was introduced. The policy of the department is to make the two integrated science sets as large as possible to give as many pupils as possible the benefits of this type of work. There is very little choice given to pupils about this course because they are selected for it towards the end of the third year and very few ever challenge the decision by asking to take one of the other courses; the recommendation made to parents seems to be taken by them as final.

For the most part the science timetable operates on double periods of 70 minutes (4 periods in the morning divided by a break and four periods without a break in the afternoon) which assists with organising practical lessons during the morning, but the afternoon presents the technicians with problems on occasion.

Teaching in the department is organised according to weekly 'schedules' which are prepared for the different courses by different members of staff and comprise a broad outline of the work for each lesson with details of experiments, apparatus, films to be shown and details of homework. The technicians have copies of these schedules and they use these in conjunction with their own card-index system to prepare for each lesson. If members of staff wish to deviate from the schedule or add something they must notify the technician well in advance.

The 'schedule' is a central feature of the work of the department and one which might appear to be restricting to the individual teacher, but staff felt that within the framework there was opportunity for individual presentation and a degree of flexibility about the pace of work, though in practice teachers did not appear to do this unilaterally. On several occasions during the period of observation the schedule of work was telescoped and compressed to fit into a single session in order to make up for time lost through bad weather or industrial action by teachers.

Practical work is usually organised so that pupils work in small groups of two, three or four which requires a great deal of preparation and organisation on the part of the technicians to set-up the labs before each leson. Pupils are trained from the start of the first year to be efficient in handling equipment and assisting the technicians in clearing away, otherwise the task would be impossible in the time available.

The Head of Department sees his role as allowing the departmental staff a good deal of influence over decision-making though he did point out that if a decision had to be made quickly he would make it himself and justify it later.

The system of consultation seemed to work because the staff spoke very supportively of the Head of Department and were enthusiastic about the fortnightly departmental meetings he organised. These meetings were notable, it was claimed, for not being overburdened by procedural niceties such as the reading of minutes because it was felt that decisions which were taken were sufficiently well-communicated to the department. There was always a tight agenda which would be discussed in an efficient, but thorough fashion with everyone having the chance to air their views. It seemed that in this respect, the department was close to achieving one of its aims: to work together in a corporate, integrated and consistent fashion.

There was ample evidence of mutual support particularly when teachers were dealing with topics outside their own specialism: even after so many years of working together as a team this feature of their relationships was still highly valued.

Assessment is given high priority by the department: regular tests are conducted with all pupils, detailed notes of individual progress are maintained by each teacher and there is frequent formal and informal exchange of information between teachers. A new system of profile reporting is being developed to meet the assessment requirements of the new combined science course.

Discipline and safety in the laboratories are given very high priority. The majority of pupils appear to have accepted the code of behaviour laid down for them, but there was one aspect of safety which was flagrently disregarded, particularly by girls, and that was chewing in the laboratories. Pupils are not allowed to enter labs without a member of staff and up to the fourth year they are expected to stand by their benches until the teacher greets them and allows them to be seated. This measure of control is thought to create an atmosphere in which lessons can begin, though it did not appear to operate universally.

There is a detailed marking policy laid down following departmental discussion which stresses that measurement should assess the individual against his own standards, encourage initiative, conscientiousness and self-discipline. Written work is assessed according to content and presentation rather than grammar and spelling, but emphasis is placed on the quality of summaries and conclusions which result from laboratory investigations.

There was some evidence that this policy was not working in the way it was stated since many exercise books contained incomplete descriptions of experimental work and few had the sort of comments which might have been expected of staff who were actively implementing such a policy.

In general the department gives a low priority to the setting of homework since so much teacher energy and time is expended on maintaining adequate assessment procedures. It is accepted that the examination groups require homework, if for no other reason than it is a valuable exercise in initiative and self-discipline.

It is difficult to imagine the department being able to function in the way it does without the assistance of the two lab technicians who have to work extremely hard to service the department's needs. They have both become highly trained and knowledgeable over the years and they not only organise and set-out equipment for practical work, but they also include the following in their list of responsibilities: make and develop small pieces of eqipment, repair and maintain equipment, control and ordering of stock, order and set-up films, check and service laboratories, type and duplicate hand-outs and test papers, assist with care of livestock and farm secretarial and accounting work.

The allocation of two technicians to five laboratories in a small school could be regarded as generous, but this must be seen against the perspective of the high departmental involvement in practical non-didactic teaching and its commitment to innovatory ideas in science education. It is rather surprising that the technicians manage to find 'spare' time in which to help other areas of the school, but attempts to make further demands are being firmly resisted.

The watchwords of the department appear to be: efficiency, organisation and discipline.

The development of the department since 1971 helps towards an understanding of the context of this study and a brief historical review appears in Appendix H.

# CHAPTER IV

# FIRST YEAR SCIENCE

## FIRST YEAR SCIENCE

### A - THE NEW NUFFIELD COMBINED SCIENCE PROJECT

Since the school was reorganised, pupils in the first and second years have followed the Nuffield Combined Science course being taught in mixed-ability groups, but in September 1984 the school became a trial school for the new course which is a product of the Nuffield-Chelsea Curriculum Trust.

Whether this involvement was due to dissatisfaction with the existing course or whether it was something which the Head of Department had decided for the department was a question raised in conversation with two members of the department:

BET. What about policy. If you take the new Nuffield Combined Science, becoming a trial school as an example. Was that discussed as a department or was that a decision that John decided to take?

M. No, he brought it to us.

D. He brought it to us. We were already looking at the combined science and saying, "We're going to have to do something".

M. We knew that first and second year work had to be re-structured.

D. Yes.

M. I mean we'd been sort of, planning it for a while, we were going to write our own course.

BET. Based upon...Why?...Could we just digress about why you thought that it needed to be updated.

M. I don't... It's just..There were so many bits to it that we'd fallen out with over the years... It didn't flow like it used to do...

D. No.

M. ...the Nuffield course...Originally the Nuffield Combined Science was good, then we modified it ourselves over the years. Then we got this new modification, this big input from...I think it's just called Combined Science, but it wasn't Nuffield, it was a re-write. That was about five or six years ago, and really the attraction of that was it was published in a book, two books, and we were - at the time we had two non-scientists teaching first and second year and it was a real help to them to have, to be able to go to the books rather than experiments...And all the time, right from the beginning, I can remember, we've all muttered haven't we?

D. Mm!

M. From simple things like mis-spelt words right up to big things like misconceptions, and we've said all along that we'll wear these out and then re-write it ourselves because we can do a better job than that ...I think we'd got to the point about a year ago, John saying, "We've got to make a decision about starting this new course", and suddenly, out of the blue, this Nuffield re-write came up and did we want to go.

He was willing to take on the discussion bit, travelling to London and all that, and we said, "Yes, certainly, anything", because when I came here SCISP was at that stage. We were a trial school for SCISP and never looked back, so there was no doubt in my mind that it was worth a go, even if it was only from the point of view of getting material for nothing.

D. Yes, and a chance to feed back-in your ideas.

M. Yes. In other words a chance to influence the course.

From these comments it may be seen that the department is continuously evaluating what it is doing by means of regular curriculum meetings, making changes and adjustments as they seem appropriate. These changes occur in all courses, but particularly in SCISP and Combined Science where the department has used materials from both the trials versions and the final versions of the courses because some parts suited their approach rather better than others. Similarly the department has written and developed sections which it is claimed suited their children and the environment in which the school is situated - "We've got the kids innate knowledge which we've got to use".

Having undertaken the new Nuffield course so readily did the department consider the change which would be required in their approach to the teaching, or would the new scheme be adapted to fit the existing working framework?

Research conducted by Allsop and Collins (1982) revealed that in the many schools which had adopted similar curriculum packages for this age group, the teaching had become stereotyped and packaged to fit in neatly into the normal timetabled time, so that project work of a problem-solving nature had been a casualty and most of the other work was so organised that there was an answer towards which pupils were inevitably guided.

Certainly on the basis of observations the work appeared to be being organised on very similar lines to work in other year groups.

The guide for the course explains that so far as pupils are concerned there are four major parts to their learning:

Reading

Discussions

Activities

Preparation of a book

Each of these categories will be related to the observations of the researcher.

1. READING

Reading is dealt with more fully in Chapter VI, but it is worth making the point here that the teachers had made a decision that the readers would only be used sparingly, but even then, as the field notes reveal, the pupils found great difficulty in coping with the set reading tasks:

A lesson on Invisible Inks.

The teacher read the instructions from the booklet, amplifying points as he went along. At one point he stopped to show the group a tripod which he thought would be new to them, but the group pointed out that they had used one in his absence.

Most of the group followed the instructions in the booklet, but several spent the time looking around the room.

A lesson entitled,"Scientists can be wishful thinkers too". The class had been asked to write a story linking what scientists do with the account about the scientific study of Mars in the Focus reader:

'When the class was asked whether they were sure about what they had to do, they certainly didn't look confident and eventually one boy said that he wasn't. When the teacher enquired about which part was unclear, the boy replied, "The start". The teacher asked whether he meant the beginning, which the boy confirmed - it was suggested that perhaps if he read the passage it might become clearer.

Many of the group seemed hesitant, reluctant or unable to make a start and the teacher, perhaps mistaking their mood, pointed out to them that science is much more than just doing things, and that was why they had not had equipment out that week.

BOY Do you have to.....

T. Read it first.

(Then the teacher went off to talk to a Research student from York who was also observing the group.)

The group got down to reading the Focus booklet quietly. Alice asked a question about the booklet which was not overheard, but shortly afterwards the teacher asked whether anyone was having difficulty reading.

T. Be honest (No response).

As the class completed the reading there was some quiet muttering. Joanne and Angela looked quite lost and even frightened, not seeming to know what to do, others had expressions of boredom on their faces and there was increased fiddling with earrings among the girls.

A conversation with Craig:

BET. Do you understand what you are doing?

CRAIG. I think so.

BET. What is it about?

CRAIG About Mars and a scientist who looked through a telescope, and he saw some lines that he thought were canals.

BET. Why did he think they were canals?

CRAIG. Don't know.

BET. How did he know they were not rivers?

CRAIG. Rivers are bigger

BET. Are they?

CRAIG. I think so.

Later in the lesson the notes continued:

Angela and Joanne confessed to being confused. They admitted to not being able to read the booklet, but were reluctant to admit this publicly. Asked whether they thought anyone could understand the work they suggested that the "brainy ones" would. On pressing a little further the "brainy ones" were identified as, those who get "goods" on their books.

A further note towards the end of the lesson:

Checking the work of the group failed to reveal anyone who had linked their work with the text in the Focus booklet - most had simply written about Mars and its canals, something which was merely used to illustrate a point about how scientists work. (The teacher would not allow the books to be taken home so that work could be completed, in fact there was no obligation for pupils to do so.)

2. DISCUSSION

Pupils were constantly being urged to talk about their work whether they were gathered round the front or working on practical activities at their own benches.

An extract from notes of a lesson on Senses:

Discussion was encouraged among the groups. It was emphasised that containers must be held in the palm of the hand and not in the fingers as some had begun to do.

Discussion there certainly was and not a little disagreement as views and opinions were exchanged, but gradually lists were formed as a consensus emerged - infact the lists on the different tables were very similar.

The curricular aim of the teachers was to stimulate discussion and debate about the validity of using the senses in scientific inquiry in the hope that it would reveal to the pupils the fallibility of this method and would highlight the need for more accurate and non-subjective methods in the search for truth. In practice this distinction was not brought out during this lesson, but may have been subsequently.

One boy holding two containers on the palms of his hands with eyes closed said to his partner," I reckon they're both the same" - the partner swopped the containers over which brought a different response - " No. That's a bit heavier."(Boy indicates his left hand.) "No. They're both the same."

Later in the lesson:

'So the group collected their balances and began to weigh the containers - the reaction to the results was quite surprising and created disbelief - it rapidly became apparent that the reading for each container was the same which caused several of the groups to approach the teacher to tell him that the balances were either broken or stuck on one reading. After pointing out that he did not think there was anything wrong with the balances, the teacher asked the class to recheck their results. When identical readings were produced the group began to realise that their senses had been fooled.'

This particular lesson had been presented as exciting by the Head of Department which it certainly was because of the way the pupils were allowed to explore their own senses and were encouraged to share their experiences with others - the teacher was treated as just another person to share the learning experience.

There was a marked contrast in other lessons when the teacher assumed the role of the expert behind the demonstration bench - then the talk tended to be a monologue with the teacher having difficulty in getting more than short answers to his questions. The children appeared to expect that they were there to listen and watch: the large group situation seemed to inhibit their natural enthusiasum.

This tendency was seen most clearly during a lesson about the work of scientists which was a review of some of the ideas the group had looked at over the first few weeks of the course. This lesson highlighted the difficulties which have been built into the course - not only was the expected reading far too difficult, but the conceptual reasoning which was expected of the pupils would have probably daunted much older children.

The teacher faithfully followed the lesson outline prepared by the project and attempted with enthusiasum to encourage the pupils to think and to talk, but to no avail.

An extract from notes taken during the lesson perhaps reveal something of the difficulty of this topic: 'The teacher began by writing the heading, "Scientists observe" on the blackboard and asked what scientists do with their observations.

The class was asked to quickly jot down some thoughts on this topic, but looking round the class many of the faces had "lost" expressions, those who were writing being the exception. It was noticeable that those who were not able to write anything were anxiously trying to see what someone else had written seeking inspiration. The writers usually guarded their "knowledge" by shielding their exercise books with their arms.

Walking round the room, the teacher urged the class to deeper thought, when nothing appeared to be coming out: several heads were resting on hands almost in resignation.'

The entire lesson of almost seventy minutes was conducted in similar manner to the obvious distress of many of the pupils. Considering the project is designed to emphasise skills and processes, this particular part of the course seemed to be rather inappropriate and possibly counter-productive in terms of its de-motivating effect on the children.

During a conversation this matter came up when the head of department raised the issue of presenting courses at too high a level when he referred to the new project (See also Chapter VII Girls in Science):

T. This new course for the 11 to 13's you can still see that the way the group are presenting this course that they're presenting this course to show off science at its best to a minority of about 20 per cent, and yet they've had all this experience of combined science.

BET. They're after the elite.

T. Yes.

BET. It's sad isn't it. And how do they react to those sort of comments when you send them feedback or when you go to the meetings?

T. Well I mean, they smile and they still say, "Well you've got to strike a balance. You must look after the people who are going to make progress in science". But the thing about this course, it's about the very things that everybody's capable of doing - skills and processes, but they're still bringing in the academic slant, the wording...I'll give you the next two copies of this next term's work and you'll see what I mean. You've only to look through with the experience you've got in evaluation and so on, you'll see what I'm talking about and the amount of work they expect them to do - the new ideas...

BET. That struck me, the amount of work was phenomenal.

T. The new ideas. I've just had a word with (mathematics teacher) about 'scattergrams' - it's research. You only do scattergrams for a purpose. You don't learn scattergrams as a matter of course - it's an artefact - but they can't leave it alone. It's very worrying.

3. ACTIVITIES

Observation of the activities which first year groups were engaged in revealed a wide range of skills and processes, from lighting of bunsen burners, using electric scales, heating glass rod to form glass beads, discovering the mass of an unknown object, testing a variety of senses, investigating the properties of varicus chemicals for use as invisible inks and a wide range of measuring and recording skills.

The enthusiasum with which pupils worked showed that they were enjoying what they were doing and their ability to record data in an orderly and coherent way showed a thoughtful and careful scientific approach to their studies. Note-taking during lessons was not a prominent feature of the work, most pupils seemed to rely upon their memories when it came to writing-up.

During the second half of one lesson on invisible inks, the field-notes reveal something of the way the pupils tackled what could have been fairly hazardous work involving the use of ammonia:

'The group, showing all the signs of horses waiting for the "off" exitedly returned to their places to get started. Initially there was some confusion about which message was to be placed inside the box and Jonathon was not sure what to write with until the teacher told him that the brush might be best. The group seemed to be conscious of the need for careful handling of equipment and the need to cork the ammonia test tube after use. There were no accidents or evidence of mishandling of equipment during the lesson.'

The new project was clearly encouraging good laboratory practice and was developing skills and confidence very rapidly in these first year pupils, though one wonders how effective such a course would be if the teaching staff were not supported by highly trained technical assistants who could be given the responsibility for pre-testing the practical activities and organising all the materials used during the lesson.

4. PREPARATION OF A BOOK

It was noted that the work in the pupils exercise books varied in the quality of presentation and some of it was so brief that the teachers had noted that more detail was required. The work in the exercise books did not seem, in general, to reflect the same enthusiasum as the practical work. It is of course much less exciting to write about something than to be involved in practical work, but it might be that lack of time available in lessons to complete all of the work connected with a lesson meant that pupils were doing this at home when the experience had begun to fade and where the teacher was not available to help.

The lessons as a whole seemed to follow the same pattern as science lessons for other years in that they were being forced to fit the seventy minutes. Quite often this did not work and pupils were unable to complete their practical work because they had to clear away. Discussion and reflection on what had been achieved did not occur in any of the lessons observed.

This problem of shortage of time was particularly noticeable during the lesson involving 'massing' when pupils were not able to confirm their calculations because the materials they had been using were cleared away.

If pupils are to be able to reach conclusions and then reflect upon what they have learned with their teachers and their peers, they must have sufficient time. It seems likely that the benefits of this course will only come from a re-appraisal and re-organisation of the teaching materials to allow teachers the time to assess the success of their teaching through an evaluative process with the pupils towards the end of each session.

The lessons were conducted in a friendly atmosphere with the teacher acting as a facilitator in a child-centred environment and obtaining an enthusiastic response and a high degree of commitment from the pupils.

'Friendliness, when successfully operated as a classroom strategy by teachers, allowed a subtle mode of control which shrouded the institutional disparities of power between staff and pupil and was particularly useful in the context of the open classroom where the teachers sought to minimise the appearance of authoritarian teaching styles' (Dennscombe, 1980, 61).

The first year science curriculum is integrated with none of the traditional boundaries associated with Bernstein's 'collection' type, but it has strong 'frame' since the pace and content of the work are firmly directed by the teacher.

In the selection of content there are marked similarities with the strong boundaries associated with the 'collection' type in that that there are no obvious moves to broaden the subject outside the direct orbit of the science department even though content may well overlap with other subject disciplines. So although the lessons are conducted in a relaxed atmosphere with pupils being allowed a good deal of personal freedom and responsibility it is still firmly teacher-controlled and directed.

## B- A SURVEY OF ATTITUDES AND PERCEPTIONS OF SCIENCE AMONGST FIRST AND SECOND YEAR PUPILS

This science survey (See Appendix E) was designed to try to discover whether pupils at the lower end of the school had any particular ideas about science and whether they had stereotyped images of scientists. Several writers (Kelly, 1981. Smail,1984) have suggested that pupils may reach secondary school with preconceived ideas about science and scientists and that these could be an important factor in why girls in particular may not pursue science in large numbers when they get higher up the school, because they identify it as a masculine domain.

The first question on the survey asked for a brief written description of a scientist and the results of evidence of gender differentiation in their answers is given in Table 1.(See following page.) Analysis of pupil responses was concerned with obvious references to gender by the use of nouns such as 'man' or 'woman', 'male' or 'female' or pronouns such as 'he' or 'she'.

The figures in the table seem to suggest that either the belief that children arrive at secondary school with pre-conceived ideas is not particularly strong in this school or it might be that the nature of the course is encouraging children to see that scientists may be of either sex.

Table 1.DESCRIPTION OF SCIENTISTS SURVEY RESULTS

| DESCRIPTION | | MALE | FEMALE | NEUTRAL/BOTH | N/A |
|---|---|---|---|---|---|
| FIRST | GIRLS | 23.7 | 0 | 73.7 | 2.6 |
| YEAR | BOYS | 46.9 | 0 | 53.1 | 0 |
| % OF TOTAL SURVEYED | | 34.3 | 0 | 64.3 | 1.4 |
| TOTAL IN SURVEY 70 OF 76 IN YEAR GROUP | | | | | |
| SECOND | GIRLS | 15.8 | 0 | 81.6 | 2.6 |
| YEAR | BOYS | 25.0 | 0 | 75.0 | 0 |
| % OF TOTAL SURVEYED | | 20.9 | 0 | 77.9 | 1.2 |

TOTAL IN SURVEY 86 OF 92 IN YEAR GROUP

First year boys are almost equally divided between those who perceive scientists as being male and those who describe them in a neutral way or as being of either sex. The figures for girls show that almost three quarters do not regard the sex of a scientist as being an important characteristic.

The figures for the second year show that almost 82 per cent of girls describe scientists in ways which do not indicate sex stereotyping of scientists: the comparative figure for boys being 75 per cent in the survey. These results only give a general indication of the way in which young people perceive scientists and it is not possible to say to what extent the teaching in the department is responsible. It may well be that there has been a gradual change in the way society projects the role of women in science since the advent of equal opportunities legislation. What the results do suggest is that it is quite possible that if girls do not choose to take science when they get further up the school it is not due to sex stereotyping in the first two years.

Other aspects of the work of scientists contained in the responses to this question reveal a wide variety of ideas about the work of scientists amongst the pupils:

Do experiments to explain things

Talk about things

Help find things out

Observe scientific things

Test chemicals

Do tests

How things work

Make discoveries

Make recordings of what they found out

To find out different ways of doing things

Explores

Find out what animals die of

Invent

Tries to find out about the world we live in

Tries to make things safer

Cures diseases

Tries to prove things

In summary these seem to form perhaps three major categories identified by pupils:

investigation, experimentation and explanation, and the whole of this seems to be concerned to help to improve the quality of life.

The second question on the survey asked the pupils to name as many scientists as they could. Perhaps naturally, many pupils in the first year wrote the names of their science teachers, which was a reasonable response to the phrasing of the question, but ignoring these answers the names most frequently mentioned were: Newton, Galileo, Bell, Pasteur and Lumiere; the only female scientist mentioned being Marie Curie. It would have been very surprising if many more female scientists had been mentioned since the whole argument about female representation in science is based upon the fact that so few have achieved prominence in a male dominated occupation.

The two readers for the Nuffield Combined Science course "Probe" and "Focus" do show a real attempt to associate female scientists with advances in science through the use of textual and photographic material which shows females and males involved in a variety of scientific tasks and the females in the photographs are clearly labelled as scientists. It is clear that the course team has made a conscious effort to include topics which can show females involved in research possibly due to the public concern about the low numbers of able-girls opting for science courses. Even so the materials chosen have a strong masculine orientation: machines and instruments for measuring abound, and there is little to indicate that there might be a human side to science which might be more attractive to girls.

In answering the second question about a third of first year pupils mentioned only male scientists, about 16 per cent mentioned both male and female scientists, 31 per cent named teachers only and 20 per cent did not answer. The last two sets of figures may be disappointing to the teachers since there is a good deal about the work of different scientists during the first term of the course.

Second year pupils showed a different pattern of response with 79 per cent naming male scientists, only one pupil named a female scientist and almost 20 per cent named only teachers.

Question 3 asked pupils to name a scientific topic on which they would chose to write given the choice. The answers were many and varied, but by producing broad categories it was possible to make a comparison between the responses of girls and boys. The topics may, to some extent, reflect the type of work which was being done at the time in the department as this would be fresh in the pupils' minds. Perhaps the most interesting feature of Table 2 is that so many girls have chosen to write about the skills and processes of science, which are the focal point for the teaching emphasis of the course. Equally interesting is the fact that many of the boys chose biological topics in preference to those on space and the universe, which do not feature as prominantly as they might have done a few years ago.

| FIRST YEAR - GIRLS (38) | % |
|---|---|
| Experiments, discoveries, observation | 42.1 |
| Human Biology and biological topics | 21.5 |
| Chemistry | 10.5 |
| Scientists at work | 7.9 |
| Space and the Universe | 7.9 |
| No answer | 7.9 |
| Electricity | 2.6 |

| FIRST YEAR - BOYS (32) | |
|---|---|
| Engines and mechanical science | 21.9 |
| Human Biology and biological topics | 21.9 |
| Chemistry | 21.9 |
| Space and the universe | 12.5 |
| Bunsen burners | 9.4 |
| Other topics | 6.3 |
| No answer | 6.3 |

Table 2. PREFERED TOPICS FOR WRITING IN SCIENCE - 1ST YEAR

It must be remembered that these questions were asked after only a few weeks of science teaching and the current or recent topic probably had some effect on the choices.

| SECOND YEAR - GIRLS (38) | % |
|---|---|
| Human Biology and biological topics | 34.2 |
| Chemistry | 18.4 |
| Space and the universe | 15.8 |
| Electricity | 13.2 |
| Historical topics | 7.9 |
| Geology | 5.3 |
| Others/No answer | 5.3 |

| SECOND YEAR - BOYS (48) | |
|---|---|
| Space and the universe | 31.3 |
| Chemistry | 20.8 |
| Human Biology and biological topics | 16.7 |
| Historical topics | 12.5 |
| Electricity | 10.4 |
| Others/No answer | 8.3 |

Table 3.PREFERED TOPICS FOR WRITING IN SCIENCE - 2ND YEAR

The results of the second year responses to the same question are quite different in some respects perhaps reflecting the nature of the change in course and the different approach and materials being used with the first year.(See Table 3.)

The responses of the girls are possibly what one might expect them to be with emphasis upon biological aspects of science and the boys interest in space and the universe is perhaps predictable, but the low interest in topics related to electricity in boys of this age is perhaps a little surprising, indeed they show less interest in it than the girls.

The final question on the survey was far more difficult to interpret because pupils were able to give open unstructured responses which were difficult to assess in terms of the pupils' attitudes to science.

Analysis of all the responses generated two lists, one of positive words or statements and a similar list of negative ones from which it was possible to establish a total score of positive and negative statements for each year group.

Positive statements included: good, enjoy, fun, like it, exciting and like experiments.

Negative statements included: boring, hard, useless, not like, not understand, don't like writing.

First year girls made 53 positive statements and 29 negative, but first year boys made only 36 positive statements and 25 negative ones.

These results perhaps suggest that girls enjoy the new Nuffield course rather more than the boys, but much more research would be needed to confirm this hypothesis.

The figures in the second year reveal that the girls made 42 positive statements and 51 negative, but in this case the boys made 72 positive statements and 42 negative.

Since there were different numbers of pupils in each category it was decided to take the number of positive and negative statements and express them as percentages of the total number of statements made by each sex. These calculations revealed the following percentages of positive statements.

| | | |
|---|---|---|
| FIRST YEAR | GIRLS | 64.6% |
| | BOYS | 59.0% |
| SECOND YEAR | GIRLS | 45.2% |
| | BOYS | 63.2% |

These figures again seem to indicate a growing interest in science among the girls of the first year - figures for the boys in both years are more similar and perhaps do not reflect any significant change in attitude towards science.

Although it is very early in the life of the new course it may be that the results of the survey reveal that girls are showing an increased interest and motivation because emphasis is not being placed upon facts, but rather on the skills and processes which form the accepted pattern of the way scientists work.

C- Mixed-ability Teaching in Science.

Mixed-ability teaching in science clearly presents a challenge, as it does in any subject area, but the language, the conceptual difficulty and the demands upon practical skills in the form of motor co-ordination possibly make such grouping especially problematical, as this conversation seems to confirm:

BET. Looking at mixed-ability, how do you or the department try to deal with kids who are above-average ability or..and those who have learning difficulties?

T. With difficulty really. Partly because of the group size and time and so on. We try to get round and help and push the rest - the more able - and help the less able. I mean there are no separate worksheets as such, which might be a good idea, but then you've got to decide who's going to get the special worksheets and who's going to get the top worksheets. I try and set extra tasks for those who are getting further on, but I think the best way to do that is to go round and tell them, otherwise the others think, "What on earth?". I don't think you can do it in a book as such because the others think,"Oh! I'm missing that bit out" - but it's difficult.

BET. They feel that they're being deprived if they're not getting the same jobs to do.

T. Mm. The interesting bits. But the first year, they often do it themselves. If you set them something, the brighter ones do it to a higher standard and more detail so it takes them longer in some ways and as long as they're conscientious about it - it is easy for them to say,"Oh! I don't need to bother", because everyone else tends to bring them down a bit - a difficult problem.

Clearly such an approach to mixed-ability teaching demands teachers who not only know their pupils very well in terms of their intellectual abilities, but it also demands tremendous stamina to respond to the multiplicity of requests for help which might arise in the course of a lesson. To accept such a method is to have made a decision involving the weighing of advantages and disadvantages.

The Headmaster made the following comment about mixed-ability teaching:

Head. There is loss to the least-able, because if you are to go at anything like a reasonable pace and the child really has difficulty in taking in written instructions, for example, then that child isn't getting what is ideally designed for them. I don't really see that it's very easy with reasonably large classes to get around the problem.

He also mentioned the possibility of differentiated worksheets, but pointed out that this would at least double the preparation work though he added that it might be done over a period of years. He presented a second possible solution:

HEAD. The other side, the other way of tackling it is the mixed group of children where each practical group doing a particular experiment contains children of a range of abilities in which case, as we all know, the strong help the weak, and to some extent, as we are taught by research, the boys hog the manipulation and the girls stand back and record.

(This last point did not appear to fit this present research in that in some situations the girls were not only equal, but they sometimes dominated the work.)

Another member of the department admitted that mixed-ability teaching in the lower school is very hard work during the lesson, but it is possible providing the teacher has the lesson well-prepared and is well-versed on the theme of the lesson. He explained how he approached such a lesson:

T. I start them all off at the same level, this is - we're talking about first and second years anyway - therefore I suppose you could read into that, that we start them off at the lower level, otherwise, if you don't start them off at a lower level the special -needs-type-child would be left right at the beginning of the lesson.

So we set off fairly low level and get the thing rolling, whatever it is, whatever the lesson involves. More often than not they'll all be doing, all the groups in the room will be doing, the same practical

work and then your job is to get round them - to get round those nine or twelve, however many groups it is - I cheat, I go to the quick groups, the brightest ones, a minute - two minutes with them...
"Right you know what you're doing, you know what's expected. I want it done in this way and I want you to end up with that, that and that. And the idea is to answer the question."
And there might be two groups or three groups like that. The middle groups, the middle-band-type child, you need to spend a bit more time with and you end up - you might have gone to two or three of these middle-type groups, dodging back to the top groups - and you end up with these lower-type kids which usually gravitate together. Three on a bench, I mean, if you've got three really low-ability kids together you can spend a bit of time. Now we're talking about ten minutes of your time there, ten minutes out of seventy.

This teacher's solution to his problems is similar to the one given by Smith, who was faced with a group of boys who were unable to retain verbal instructions or read written instructions adequately.

'Each child really needs individual attention and the only way that that can be done is by spending the entire lesson going round and round each working area' (Smith, 1983).

The method which these teachers have adopted by an

intuitive process is described by Harlen(1977) as an "iterative process" of gradually changing the learning environment to meet individual pupil needs. This 'matching' process takes the form of a loop in which data is gathered about the pupil, this is then used to inform decisions about the best teaching strategies to adopt to optimise the learning environment and finally the pupil interacts with this new environment. The whole process then begins again.
Harlen points out that this cycle occurs simultaneously for all pupils in the group and therefore the various loops may not be obvious to the outside observer. Indeed it may be that to some extent they occur in a teacher's subconscious until the teacher is asked to justify them. It is then, a continuous assessment and adjustment process which is being carried out for each child in the group.
Each of the teachers interviewed was adopting a slightly different approach to devising and adapting activities in the classroom to suit the individual characteristics of the pupils. To do so however demands that the teacher has a great deal of information about each pupil because variations can have a significant effect on achievement. (Harlen,1977) Indeed, using evidence provided by Brown (ibid), Harlen points out that 'very little of the variation in attitudes to science of thirteen- year-old pupils was accounted for by the chaacteristics of the science course or class, whilst about half was ascribed to characteristics of the pupils which were present when the

pupils entered school'. (Harlen,1977,112)

If this is indeed the case then it might confound the hypothesis that the new Nuffield Combined Science course is having an effect on girls' attitudes to science. It might be that the attitudes and beliefs which these children held about science and scientists were already present when they entered the school. In order to check this it would be necessary to question pupils before they leave the primary schools. Any changes in attitude which do occur after the pupils join the secondary school may of course be related to quite separate variables within the school.

What does it mean to cater for individual variations?

'Since each pupil is unique, it is unlikely that identical sets of experiences are equally profitable to all, and thus there will be differences, sometimes large, sometimes only slight, between the activities of pupils. What this individual catering does NOT mean, is that the pupils will be working alone....In fact, no assumptions are made about class organization beyond the essential provision of flexibility and opportunity for the teacher to have individual contact with each pupil; this could be within the context of large or small group working, and does not preclude occasional whole class discussions nor private study' (Harlen,1977,113).

Research into mixed-ability teaching (Frost,1978, Plewes,1981) produced results which suggest that there may well be social advantages, but at the same time the academic performance of all but the least-able is seriously affected. Plewes also found that most pupils preferred to be taught in sets because there was a uniformity of work and pace. Teachers also benefitted from setting or streaming as the pressure of work was greatly reduced.

However, Sands (1979) reporting similar research is not in total agreement with these findings. She does not accept that mixed-ability teaching is very time-consuming and demanding on teachers. She confirms the social advantages in terms of friendship and working relationships,( teachers accepted the political and sócial idealism implicit in this method). The gains to pupils were reported in terms of the advantage to late-developers, increased incentive to work and succeed in pupils, the enjoyment of self-pacing and the growth of independence in pupils. Sands did report that often the teaching was based on the traditional whole-class method ' with little concession to mixed-ability except to pitch the lesson at the middle ability range of children'.(Sands,1979,617). Teachers had to move round from group to group giving individual instructions and there are problems of stretching the more-able in these circumstances.

It was clear from conversations with the staff in the department that they believed there were advantages and disadvantages to mixed-ability teaching: one teacher explained what he saw as the advantages:

T. I think, first of all, with not trying to get information in really we're getting skills and so on which means that they're learning in - often you get less-mentally-able that are manipulatively able so that helps and you'd lose that. And often the less-able come up with some good ideas when they are talking verbally.

BET. Do you think that's because of the more practical approach to...

T. I think so and sometimes they're freer to think because they haven't grasped anything so they come up with these outlandish ideas which often have a good idea embedded in them if you can winkle it out and I think that helps the others see possibilities and see that although they are different they are still worth listening to. I think that's important socially as well.

This particular attitude towards children with learning difficulties seemed to accord well with the general aims of the school, especially those which stressed the worth and value of each individual. There was however some doubt amongst the members of the department whether they were able to realise the potential of the most-able pupils using these teaching methods.

'Approaches to teaching which are sensitive to differences between individuals, aim to provide the conditions which are most conducive to successful learning in all pupils. It has been argued that, when these conditions prevail, then not only are cognitive goals achieved more readily, but the experience of success and the atmosphere of mutual help promote the development of positive attitudes...'(Harlen,1977,129)

Inculcating pupils into the ways of working in science depends upon a successful programme for developing a variety of skills in basic scientific techniques, developing awareness of the interaction of science and society through technological development, developing images of scientists and the ways in which they work and developing understanding of basic ideas and patterns in science. But to achieve this it is necessary for a programme of language development which introduces pupils to scientific vocabulary and helps them to mediate between their everyday language and this specialist language since they may not easily exist side-by-side. The next chapter looks in some detail at the problems posed by scientific language in schools and then analyses data collected in the school from the point of view of language development.

# CHAPTER V

# LANGUAGE AND SCIENCE

# LANGUAGE AND SCIENCE

'The limits of my language means the limits of my world' (Wittgenstein).

## A-INTRODUCTION

One of the major features of science teaching and learning which emerged during observations and interviews was the problem of understanding.

Pupils frequently commented that they did not understand what the teacher was talking about: they could not understand the long words used in science and they were not always sure of the purpose of what they were doing. Similarly teachers commented about pupils' lack of understanding and tended to blame inattention and poor concentration span.

Reading did not feature in the work of the department nearly as much as might have been expected since many of the textbooks were regarded as too difficult. An analysis of content and readability of some science textbooks used by the department is to be found in Chapter VI.

Tape transcripts are used to analyse the use of language in the classroom to discover how it was used to convey meaning or to construct meaning.

Before the detailed analysis of language in the department a review of some of the literature investigates the difficulties which the science teacher and the science student face in dealing with the language of the laboratory.

B-REVIEW OF THE LITERATURE

The quality of the language which the child brings to the learning situation is generally the product of the range of opportunities which he has had for developing language useage. (Flower,1966)

The Bullock Report (1974,51) clearly identifies the home environment as the major influence upon language development and a home which is not rich in language opportunities can lead to children being 'linguistically deprived' (Bernstein,1970).

If the home provides many opportunities for the child to use and to hear language then his language store should develop. Listening to and being involved in conversations, reading and being read to, creates the sort of language environment which helps the child to acquire a wide range of language skills.

There are homes in which education is not valued and language may be restricted to the bare essentials. Flower suggests that such an environment can present schools with major problems.

'We can only begin to resolve this dilemma by deliberately widening the range of situations in which language - spoken and written - will be important, and introducing the student into those situations in which he will come readily to appreciate the inadequacy of his restricted language.'(Flower,1966,56)

Language is one of the ways in which we represent the world to ourselves and through it we construct meaning:
'All our knowledge of the world, in commonsense as well as in scientific thinking, involves constructs, i.e., a set of abstractions, generalisations, formalisations, idealizations, specific to the respective level of thought organisation.... This does not mean that, in daily life or in science, we are unable to grasp the reality of the world. It just means that we grasp merely certain aspects of it, namely those which are relevant to us carrying on our business of living or from the point of view of a body of accepted rules of procedure or thinking called the method of science.' (Schutz,1972,10)
Whorf (1956) suggests that the structure of a person's language largely determines how he views the world and the construction which he places upon reality: his behaviour is also affected by it to a considerable extent.
It may be that, to a lesser extent, children and their teachers are using very different languages and patterns of thinking and therefore could be constructing very different meanings from each other. A socially determined barrier may be preventing adequate communications.(Flower,1966)
One of the major problems of academic disciplines is the terminology which is involved; this is particularly the case in the sciences where so many expressions have to be mastered. Indeed Evans (1974) suggests that secondary school pupils who study science may meet as many new words

as they would in learning a foreign language, but there is the added problem created by the unfamiliarity of the context and the conceptual difficulty involved.

These difficulties often result in the inability of people in adult life to receive information about science in an intelligible form by whatever medium: Flood (1963) identifies a lack of a suitable vocabulary, through which to present science, as the major problem.

'Because of its clarity, precision and constancy, the language of science is cold, plain and forthright. No warmth of human emotion, no grace of literary decoration, no touch of humour, no shared euphemism, no eloquence is found in its composition. It is, and it is likely to remain, a language within a language, serving no more than its own purpose; yet as science more thoroughly permeates our daily lives, more and more men and women come to read and write a language of the laboratory.' (Savary,1960)

It is this very precision,clarity and economy of words which some scientists believe gives strength to scientific language (Flower,1966) and the Royal Society felt that with good teaching and common sense it should present no difficulties in schools and colleges. (Henn,1966)

Bibby (1974) criticises the sort of language used in science teaching and science reporting. He criticises scientific journals for their use of 'obscure and otiose gobbledygook, characterised by an apparently compulsive use of the third person passive, and almost universal phobia with illuminating imagery and an endemic tendency to verbal flatulence'.(Bibby,1974,15)

It may be that scientific writers have something to learn from many modern writers, such as Hemingway, Greene, Orwell and many others, who use a very economical style in their writing, but are able to convey deep meaning and emotion by the careful use of single words. (Flower,1966)

Flower goes on to suggest that scientific writing must lie somewhere on the continuum between poetry; compact and irreducible, and scientific prose, which is built-up in a sequential manner, if it is to have meaning for its various audiences.

The problem which the scientist faces, when speaking to a lay audience, is that if he seeks accuracy, clarity and conciseness he may find that each conflicts with the others. In being concise he may not be either accurate or clear; in striving for accuracy he may need to introduce so many qualifications that meaning becomes unclear, and in seeking clarity he may lose accuracy.(Flower,1966)

Clarity and accuracy may sometimes be achieved by providing definitions, but as Hayakawa points out, definitions which remain on the same level of abstraction may be largely meaningless:

'People often believe, having defined a word, that some kind of understanding has been established, ignoring the fact that the words in the definition conceal even more serious confusions and ambiguities than the word defined.'

(Hayakawa,1952,172)

The problem of definitions of facts and concepts is dealt with in the context of the present research later in the chapter.

Flood also highlights this gap which exists between the scientist and the common man in that in modern society we have 'a community which is dependent upon science, but whose members are singularly ignorant of science.' (Flood,1963)

It has long been held that the ideal language for science was one which was free from ambiguity; each of its symbols having one referent and each referent represented by a unique symbol. Indeed for a time science almost achieved this when it only used the classical languages, but translation into modern European languages created problems: it is still an ideal which some scientists recommend. (Newton,1984)

The absence of this ideal language in the twentieth century has led to the difficulty that 'in physics, in biology, in psychology, and in other sciences we are coming up against the limits of description in the language of the phenomenon that we are observing.....Often we have to resort to metaphor or unsatisfactory analogy. The difficulty physicists have in describing the behaviour of certain particles arises from the actual structures of our language.'(Flower,1966,60-61)

It is interesting to note that Flower appeared to scorn the use of metaphor and analogy yet he and other writers recommend their extensive use in our attempts to create the meaning attached to science concepts:

'Our language...cannot tell us what sub-microscopic phenomenon such as an electron is. It can only provide analogies which enable us to describe certain problems.'(Flower,1966,61)

Wellington (1983) believes that the Bullock Report (1974) which led to a general focussing on language might well have resulted in a greater emphasis upon 'learning by talking' in science. But Wellington goes on to point out that though many scientific words may be relatively simple to understand, because they refer to objects or entities, and some concepts such as 'inertia' may be understood from experience, there are large areas of scientific knowledge which are unobservable and outside experience. The problem here is to try to create a mental image by which to give the concept meaning.Wellington suggests that teachers should present new ideas to their pupils in the form of a game designed to create meaning.

Wellington's 'game' with the meanings of scientific words does not extend to the pupils creating their own meanings since this would eventually have to be rejected by the teacher in favour of the accepted meaning, which would probably result in the whole exercise being regarded as a waste of time or a confidence trick.

In creating meaning it should be remembered that language is public and therefore Wellington urges that meanings should be 'interpersonal', but not 'impersonal' - he seeks shared or common understanding or meaning and it is through the 'game' element that children are led towards this shared meaning.

It has been argued that schools should teach pupils the impersonal style of language use as one of the methods of presentation or modes of thinking. (Flower,1966) But it may well be that the dehumanising character of traditional scientific language and reporting is what causes the rejection of science by so many young people, particularly girls. (See Chapter VII).

It is believed that this impersonal style is related to the level of conceptual thinking:

'The adolescent will form and use a concept quite correctly in a concrete situation, but will find it strangely difficult to express that concept in words and the verbal definition will in most cases, be much narrower than might have been expected from the way in which he used the concept.' (Vygotsky,1962,79)

Flower makes four points about teaching laboratory language in relation to concept development:

1. a process of enrichment of concrete experience is needed before abstract thinking, and therefore impersonal writing, can be mastered

2. students must have reached the level of maturity required for abstract thinking and concept handling

3. student thinking on these lines must be accompanied by complementary progress in other modes of thinking or the ability to think conceptually is put at risk

4. verbal intelligence tests for selection should be avoided since students do develop at uneven rates and may be penalised unfairly.

'The world which the human mind knows and explores does not survive if it is emptied of thought. And thought does not survive without symbolic concepts. The symbol and the metaphor are as necessary to science as to poetry.'(Bronowski,1961)

So, in many respects words are inadequate for the purpose of science, but Evans(1974) highlights a further problem which our language presents to the pupil in school. There are many words which have exactly the same spelling, but which have entirely different meanings when used in science, indeed it may well be that within the different science disciplines a word can take on different meanings. Evans uses the word 'ether' as an example of a word which has a hypothetical meaning to physicists and another to the chemist. This is a common enough problem in everyday language, but scientists are adding to children's difficulties by using existing technical terms for new purposes, in effect giving two words.

Language is not clear and unambiguous because a variety of meanings can be created through language which presents us with the dilemma of trying to achieve understanding.

Language is essential 'without it we could not explore that environment to any extent. We could not transmit our findings to our fellows nor to our children. Yet we cannot be sure that it does not distort the external reality that we examine with its aid.' (Flower,1966,58)
For many children science language, either in a textbook or written on a blackboard, must, according to Wellington (1983), give rise to the sort of confusion which Alice experienced when she first read 'Jabberwocky' in Lewis Carroll's 'Through the Looking Glass'.
The number of scientific words and their multiple meanings present one problem, but Evans (1974) identifies a further problem in that a word which has a prefix or suffix added may change its meaning completely. It does not follow that knowledge of the root of the word will automatically present a child with a clue to the meaning of the new term. The idea that words should be capable of being understood by means of the word elements from which they are constructed is, in Evans view, a pipedream which can only be achieved to a limited extent. An additional complication arises from compound expressions formed from two or more words, and again these may or may not be comprehensible from their separate meanings.
Whilst science has taken many everyday words and used them for its own purposes, so the mass media are accused by Evans of taking technical terms such as 'environment' and 'lunar orbit' and using them in such a way that they have

become part of common parlance. It might be asked how children are expected to recognise the usage of words such as salt, pressure and fruit when they neither look nor sound technical. (Evans,1974).

Flood accused science education of being too narrowly academic and doing practically nothing to indicate the social and economic importance of science, both charges may now be rather unfair in view of curriculum changes which have occured over the last decade and the academic charge might only be valid because the language barrier prevented easy access for the majority. Whether this barrier was created deliberately to limit access to the mysteries of science to the few is open to debate.

It is very difficult for many people who are steeped in academic tradition and subject specialisation to modify their language use to suit an audience of lay people let alone children and this might be seen as a criticism of the training of teachers in that emphasis is placed upon academic excellence and pedagogical skills often come as something of an afterthought.

'But I know not how it comes to pass that professors in most arts and sciences are generally the worst qualified to explain their meaning to those who are not of their tribe...' Jonathon Swift, Letter to a Young Clergyman.

Language has a crucial role to play in the development of learning in science as Robertson points out:

'The science teacher can share particular ways of seeing with his pupils. I use share here, because I want to get away from a single notion of the direct transmission of knowledge from teacher to pupil. For if we agree that coming-to-know in language is the issue, then we must recognise that this is a process within each individual.' (Robertson,1977,137)

This review of the literature leads us to an analysis of the ways in which language usage and language development can help or hinder pupils as they seek to achieve understanding in science. The next section considers language and the development of understanding in science lessons and is drawn largely from data collected in 4th and 5th year lessons.

C-LANGUAGE AND UNDERSTANDING IN THE CLASSROOM

The literature review points to a number of convenient headings under which evidence collected in the school may be examined:

1. Teacher talk and understanding in science - will examine the complexity of teachers' language, the pace of work, and the amount of new information which pupils are expected to absorb.

2. Understanding and the pace and sequence of work - examines the problems which arise from the order in which topics are taught in the integrated course.

3. Language and control - considers the ways in which teacher language may restrict and control pupils' use of language.

4. Definitions of facts and concepts - a consideration of how to achieve understanding.

1. Teacher Talk and Understanding in Science.

The teacher's own speech is thought to be of the utmost importance in developing that of his pupils, but Barnes (1971) has illustrated the difficulties which children encounter in lessons where the teacher is trying to teach a difficult concept.(For an example of this see transcript of a lesson on the mole concept in Appendix C).

Pupils sometimes find the language which the teacher uses very difficult to understand because it is not pitched at their level of understanding:

A It's hard to sort of...(the teacher), sort of, explains the things, you know he tries to explain...it's the way, it's the language he sort of uses...we can't...it's not, sort of, our level if you know what I mean. There's sometimes he just writes things on the blackboard quickly, you know, and you're expected to know what it is and you can't, sort of, work it out.

B Sometimes he, like he has us all round and he explains 'summ and everybody says they don't know what the heck you're on about. He explains it again and you're still none the wiser.

Later in the same conversation:

B He ...As soon as he starts talking your mind just wanders 'cos...

A 'Cos you don't...'cos it's not going in, 'cos you don't understand what he's on about, so as soon as that stops going in you lose concentration and then well... (mumbles last few words).

The pupils were then asked whether this might be an automatic reaction when they were being taught by this particular teacher:

A We're not aware at the time that the shutters come down, you know. We're not...Oh! Right we don't understand this so why should we start working? You just...You realise that afterwards when you haven't got sort of, the results and things in your book, you realise that you mustn't have understood it and, sort of, haven't gone over it.

BET Do you ever go back to him on your own or during lessons or whenever and ask him for more help?

A Well sometimes he comes round during lessons and says, "Do you understand it?" and if you say no, he'll explain it and you, sort of, you just have enough time to remember how he's said it and write it down in your book. That's sort of...

BET But do you really understand it when he does that?

A At the time yes, but when I sort of, look back at my book I don't.

The difficulty presented by the sophisticated language in SCISP was described by one of the teachers:

> 'Sometimes the original booklets, background books, the language is far too complicated. Equally if you go overboard that way you end up not teaching scientific language at all, so it's a question of not getting caught up with too much, "Leonard Sachisms" and equally at the same time developing a new language which they can communicate in with other scientists and understand what's in the newspapers and all the rest of it."

There was evidence of teachers trying to leaven the language of science by the use of analogy which would allow entry to the ideas and concepts at a much easier level. In one lesson dealing with the heart the teacher used a motoring analogy to illustrate the difference between arteries which he described as similar to a motorway and capillaries which are similar to minor roads. (Lower-ability fourth year general science).

Another teacher helped two girls who were trying to understand the growth of bacteria on jelly plates by likening the white strands of mould to frost patterns on a window During the same lesson when the class was inspecting slides of bacteria under microscopes the teacher used the analogy of a large crowd viewed from above: the people appear as a mass except perhaps for a few individuals who may possibly be identifiable on the edge (Third year girls, slow learners).

From a fifth year lesson on colour (See Appendix C for full transcript) the teacher was trying to get over the idea that white light can be dismantled into its component colours and can then be put back together again:

"Now many Americans have dismantled old English buildings and taken them out to America and rebuilt them again - not as replicas, but as the identical thing apart, perhaps, from a few modern innovations like new modern cement and so on. If we break down, we can build up - we've seen this with some chemical reactions..."

A group of pupils expressed concern about the amount of time which was spent with the teacher talking to the group which left little time for doing experiments, recording, clearing away and considering what had been done:

X I don't feel he makes himself...sometimes I don't feel he makes himself clear and he's said something and I think, you know, I've been listening and I think, well what on earth am I supposed to do and I just can't think what I'm...

(It is interesting to note this girl's change of mind at the beginning when she adds the word 'sometimes' to qualify her remarks. This was a notable feature of many conversations in that pupils were reluctant to appear to be too critical of their teachers,they would almost invariably find some other good feature to counteract or qualify what they had said.)

Y I find that when he's talking, he'll talk absolutely everything about the subject which isn't anything to do with what we're going to be doing. Sort of, he tells you everything about it which isn't...

Z He talks around it and not sort of in it, yes..

Y Yes. And the final thing will be a quick flip, that's what you're supposed to do, get on with it. So he's not really told you it in complete detail. I don't know what he's talking about. He was going on about, you know, sort of, the eye - he can tell you all about it, but when he's supposed to tell you all about what you're going to have to do, he's very quick at it. That's when you don't understand it 'cos you're taking in all the rest of it thinking, "Ah! I'll have to remember this", and you just don't need it at all.

This extract throws a rather different light on understanding in that it is not necessarily concerned with language difficulty, but with the difficulty of coping with the mass of information which an enthusiastic teacher can put across in a very short short space of time. Here the girls were unable to sift out the essential from the non-essential.

There is also a false assumption amongst girls that the boys understand the work all the time:

A. And they always understand it, you can tell, you know they understand it more than us when they sit on a different table. (This meant when boys and girls occupied the same table.)

BET. Does that help, if you're working at the same table and you know that they understand? Are they in a position to explain to you what's going on or don't you bother to ask?

B. Yes. Well they can...

A. And also you can, sort of, follow their ideas, what's gone on.

BET. So you find that helpful to you?

BOTH. Yeh!

A. I never really thought about that, but it would be a good idea.

BET. To have boys and girls together?

B. (First word lost)...they always know what they're doing in experiments, we don't.

The boys have a different perspective:

N. I think that he tends to - he tends to, sort of, like look to the, look to the brainier people like (Boy's name). You know he, sort of like leaves us out a bit, he tends to get them into, you know, he gets them...

M. He doesn't do it much, explaining to people on their own really. He...When we go round the front bench he explains everything to us and then we go back to do the work and he doesn't really come round to explain everything to people individually who don't understand it all that much. I mean, he does sometimes, but that's probably because he doesn't have time really.

BET. So the point you were making was that if he's explaining something or asking questions he concentrates on people like (Boy's name).

N. Yes, he concentrates on (Boy's name).

M. He concentrates on people who will understand it easier.

N. Yes,well I think (Boy's name) knows most of his...most of the work anyway so I think that he should concentrate on us lot.

The problem expressed by these boys in grasping new concepts and searching for understanding demands that the teacher uses each individual's experiences and ideas therefore:

'It is what pupils do following up the presentation that realises its value and this is best achieved by the teacher's interaction with the individuals and small groups.' (D.E.S.,1975b,191)

Such intervention demands skil ful use of questions by the teacher if the development he brings about is to be the product of the pupil's own thinking.

A little later in the conversation a boy made a similar point to that made by the girls:

L. '...last year in the fourth year he spent a lot of time, sometimes he spent more than one lesson round the front bench, you know, talking, talking, you know going through it and then he'd maybe leave, say 25 minutes at the end of the lesson for us to do an experiment and if we didn't finish you know, he was always annoyed. So I think he should spend a little less time explaining around the front and then go around individually...'

The value of the practical work and the problem of the teacher exposition was put in this way:

'If you're doing an experiment you learn it a lot more than, sort of like, a person tells you 'cos you can see what's happening, whereas when he tells you he drags it out longer and so he then muddles words up. You know, he says something different the second time, it totally confuses you kind of thing.'

This remark and others of a similar type seem to throw into question the familiar teaching practice of repeating information in a number of different ways to stimulate understanding.

The flexibility to be able to repeat, extend and alter information in various ways is one of the greatest advantages which the Bullock committee felt the spoken word had over the written word, but these children found that it only added to their difficulties. (DES, 1975b, 144)

2. Understanding and the Pace and Sequence of Work.

Another problem which pupils identified on a number of occasions was that they were unable to understand the sequence of work which perhaps contributed to their overall lack of understanding and confusion:

A. And also that the lesson, sort of, doesn't relate, you know like we have four lessons in a week don't we...

B. We do one thing....(interrupting)

A. ...and some of them are just totally different, you know, and then about two weeks later we go back to something we've been doing.

B. And then you go onto 'summat' else and then you go back to it later on and then you do something that you haven't done for months.

This is not an easy line of argument to follow, but basically the complaint seems to be that when the group appears to be in the middle of a topic the teacher switches to something else, which may or may not have been introduced before. In either case it may be a number of weeks before the group returns to the original topic. Though the teacher may have a perfectly valid reason for the topic changes in the context of the integrated course, the reasons do not seem to be apparent or obvious to the pupils.

Another girl explained it this way:

'It's not very good, I don't think. I don't like the course at all. I don't like the way it jumps from day to day ....Like one day it will do eyes and then the next day it will do magnets and then another day it will do something different, so you've got a whole jummbled-up book. I don't like it at all.'

The boys also took up the theme of the sequence of work:

M. We, sort of, do one experiment that's separate then we do another one, find out that, we don't, sort of, join them in and string them together 'cos...we don't sort of go through the lesson and sort of develop the patterns and concepts. We, sort of, do separate things each lesson more or less.

BET. I see. Yes.

L. We could...sometimes we could do four totally different topics in one week, you know, that aren't connected in any way.

N. Yes, if you connected them together, like if you ...one day we'll do something about electricity, you know, and all that and then we'll do something that's totally different that's to do with the body. If he'd connected them all together you'd sort of like understand it better, if they all formed-up in a group. You know he always brought them into line starting with the first things first then something and then when he finished that go on to something to do with electricity.

L. Then you do a couple of days work on the body and then you go back to electricity and you've completely forgotten it.

This conversation is also very difficult to follow as it jumps from what the boy believes is happening to what he thinks should happen and then back again without warning, but essentially it is the same point made by the girls, that the way in which the work is presented is very confusing because they are unable to see a coherent patern to it.

Later the boys went on to suggest that separate exercise books for the separate science disciplines would help and even suggested separate specialist teachers to teach the different topics would enable them to keep track of where the work was going. The point of separating the work into different exercise books was also made by two groups of girls in separate conversations.

D-THE ROLES OF DISCUSSION AND PUPIL TALK

One teacher in the department explained that he held very useful group discussions around one of the pupils' benches, but this was only made possible by that fact that the group was a small one of twenty.He felt that holding such sessions on their 'territory' was important if they were to be encouraged to come up with ideas which could be tested - but group size was a crucial factor.

BET. Do you think that's why you don't see that much discussion, because groups are too big?

T. I'm absolutely certain because I started with my fifth year group, 27 in that group, and they couldn't handle it. They might think I couldn't handle it - we couldn't handle it, there were too many of us. And with the best will in the world at that age you're always going to get some who are more forthcoming with their answers or they will steal the limelight and that's alright for ten minutes, but after you've been doing it for half a term or two or three weeks even, the ones who have been on the fringe have dropped back, lost their interest, they've started looking for something else to do, so the whole thing dissolves...disintegrates.

For this particular teacher the answer was quite simple, revert to old-fashioned teaching methods:

T. I went back to a more structured approach. What I do quite often with them is to bring them round the front bench. Now it's a totally different thing from a group discussion round their benches, because I'm up on the platform - right old-fashioned stuff - give them their instructions, tell them where whatever they're going to use is, go and do the experiment and come back - that's not quite the same.

BET. Teacher controlled.

T. That's right. It works and they, funnily enough, prefer it. I feel that they're being controlled - kids do like to be controlled occasionally and with a group of 27 that's been the most effective way of getting through the syllabus.

(This may have revealed that content is more important than process in the final analysis.)

The Bullock report suggests an alternative approach to discussion:

'For "exploratory talk" to succeed it must be as informal and relaxed as possible and this is most likely to occur in small groups and in a well organised and controlled classroom..."class discussion" cannot be had simply on demand; it must be built up on work in small groups, and continue to be supported by it.'(DES,1975,190)

Discussion in the classroom often seemed to be identified as those occasions when the group were gathered together around the front bench as the teacher explained something - the participation of the pupils being generally restricted to short answers, usually one word, with no apparent attempt at this stage to asses pupils' level of understanding in depth.

'...brevity of answers is a likely feature where dialogue is being used simply to transmit information.' (DES1975b,142)

The reason for this in a secondary school is that the teacher usually concentrates on a step by step presentation of the work and tends to use questions of a closed type. (DES 1975b,142)

After one such session which lasted about 25 minutes the teacher said,"We have spent rather a long time discussing that" during which time observation had revealed the following pupil behaviour:

Some inattention in boys especially two, both new to school

Giving one word answers

Some chattering and inattention among those farthest away from table - girls farthest away

Nick tends to grin and play under the eye of the teacher

Julie losing interest as is Catherine

Nick playing again - several looking around the room

Girls kicking each other or grinning at each other

Graham head down on front bench eyes closed - increasing restlessness - good deal of chattering.

One teacher made the following comments about accepting one word answers in lessons after being given field notes and transcripts to read:

'Yes. The one that was more disquieting was the one involving the transcript of the class conversation in so far that one felt one was always answering what they, the pupils, answered, but there again that can be useful particularly if some members of the class are not hearing and it keeps the argument going.

There is a sense as well in that a transcript loses a lot of the reality of the situation, it's a consequence very often of the punctuation: the need for going over things again and again doesn't really ring true, and equally, odd sentences may not even make sense because of the way that they've been adjusted as they appear on the script'.

Extract from the transcript of this conversation

T. ...there was a noticeable comment that some of the questions were answered by one word; well sometimes that can be deliberate to try and keep the pace going.

BET. Yes.

T. Equally, sometimes the teacher will answer anyway to maintain the argument, sometimes because he may have chosen the wrong question and to get himself out of it, or else to keep the pace. There's always the question with a group, if they come in and if they're not as settled as they might be that one can wait an interminable amount of time. Sometimes if there's quite a lot to do you can try, rather like a car in a skid - there's a choice of either braking heavily or trying to steer yourself out of it - and sometimes one can get sufficient stimulus going that in fact the excitement is then brought to use.

Other times you find it best to actually put the dampers on and there is obviously a restriction, or, one feels there is, when there are people in with you, because you feel much more under stress to try to keep things going rather than spend half a lesson or whatever reading the riot act'.

This latter comment highlighted the point made by Parlett (1975) and Straton (in Tamir, 1985) about researcher presence having a profound effect. It was clear from this comment and this particular teacher's desire to talk about problems within his classroom that being observed had been quite stressful even though he had been told that he was not being judged as a person, as any comments would be related to events in the classroom.

Within a school science department there are ample opportunities for developing pupils' language through 'talk, clear, concise writing, accurate recording of information, vocabulary extension and reading for both information and pleasure.' (DES, 1979, 191)

Talk is an important feature of the laboratories in the school whether pupils are working on practical experiments or working on a written assignment and departmental policy was explained in the following way:

M. We try to encourage them to discuss amongst... in what you might call group situations - "the table" - because they've got to get in the way of using each other. I think it's important for kids of mixed-ability to bounce ideas off each other and I think I see my role in that situation as being...allowing the brighter ones a bit more rein to try and gee the others up, you know to keep them in touch - but we don't....

I presume in your observations you've noticed there's a heck of a lot of talking going on amongst themselves.

BET. Yes.

M. And it's not all...it's not 100 per cent science...

BET. No.

M. ...but you've got to...there's a...you've got to try and work out where the main theme of the lesson's been lost, then you've got to stop them.

I mean (the Head of Department) has constantly drummed into us that you've got to allow a lot of freedom in this discussion type thing rather than keep them rigid.

There was indeed a great deal of talk, but the bulk of it appeared to be directed towards pupils exchanging information about what they had been doing or were going to be doing, discussing pop records, talking of girl friends or boy friends, making jokes or just generally 'mucking about'.

The following extract was recorded with a fifth year group who were dissecting sheep' eyes (See Appendix C for full transcript).

S. Get off. Oh! Will you behave. Oh! Stop it.

(Another girl was trying to make her hold the eye)

R. Press that in.

E. I'm not touching that.

S. I'm moving.

R. (Holding the eye) Hello! I'm watching you.

E. I don't like the eyelid it's horrible...What are you supposed to do to it (girl's name)?

Teacher The stuff that looks like meat is muscle. (to the whole group)

K. The stuff that looks like what? (No answer)

Teacher Can you make some kind of a drawing to show what you've discovered on the outside of the eyeball that might be important.(Again to the whole group)

K. What did you say? (Still no answer)

S. (Teacher's name) I'm not touching it, you can't make me, now get off.

R. I can't get his eye out.

E. Ugh! You horrible person...That protects...

R. Get it touched Bez...(comment not transcribable)

S. Swimming today girls...(lightheartedly) That's probably why she (another girl in group) missed it she doesn't like games.

BOY Bez...she's just touched that thing at the back.

R. How do you make his eyeball come out?

BOY Ugh! You rive it out.

R. It's looking at me.

The lesson was filled with a great deal of activity, a lot of learning through observation and discovery, but there was not a great deal to suggest overt language development in the pupil exchanges.

'There is obviously great value in providing opportunities for children simply to talk freely and informally on whatever interests them, and nothing we say should be taken as detracting from this. But although such talk may serve many useful purposes it will not necessarily develop the children's ability to use language as an instrument of learning.' (DES, 1975b)

E-LANGUAGE AND CONTROL

Teachers are able to control the use of language by pupils by the way they frame their own questions and also perhaps by intonation or non-verbal gestures such as smiling, frowning or nodding.

Sinclair (cited in DES, 1975b) describes how 'what may appear at first sight to be an alternation of two kinds of discourse, the question from the teacher and the answer from a pupil, is in fact very often an exchange containing three kinds of discourse: Question (teacher), answer (pupil), and evaluation (teacher). 'Evaluation', in plainer terms is the teacher's verdict on the pupil's answer.' (DES, 1975b, 142)

Interwoven into the language, will be elements of control which may serve to distract the attention of the pupils away from the main thread of the argument.

The following extract (See Appendix C2 for full version), highlights some of these points and also gives a useful example of the complexity of the language which pupils face in science lessons: the theme is Molar Mass.

During this part of the lesson it was noticeable that only a small percentage of the class was directly involved in the interaction with the teacher, of those who were, the majority were able-boys who competed with each other for the teacher's attention:

T. ...and which substances have reacted together.
Now so far we've had two ways in which we can arrive at how many moles we use. One of these of course is to take the substance, like a piece of magnesium ribbon and do what?
(Teacher appears to indicate that this knowledge is known to everyone, but he gives them a lead into the answer which seems to effectively limit the options.)

BOY. Weigh it.

T. Weigh it. (Repeats the answer to reinforce it.) Having weighed it, what kind of thing should I weigh it in, Julie?
(The named person may not have been paying attention, but the teacher gives a clue to the answer he expects by the wording of the question.)
(Julie's answer was not audible on the tape, but was presumably correct since the teacher goes on.)
I need then to be able to find out how many moles I've actually got in that piece of magnesium ribbon,

so I need to know something else. What else do I need to know?

GIRL. How many things there are in the...

T. No! (Interrupting and rejecting the girl's answer the teacher does not invite her to explain more clearly what she means, he goes on to repeat his question.) What else do I need to know? (Gives a clue) I've got the mass in grams of the piece of magnesium ribbon.

BOY. Atomic weight. (sic)

T. Atomic weight. (sic) Well done. (Repeats answer and having evaluated the answer he gives praise.) I need to know the mass then...Don't talk... (Control)...of a mole of that particular element. (The control may have distracted sufficiently for the pupils to lose the sense of the point the teacher was making.)

In the case of magnesium remember (Recall) this was 24, we did an experiment on it. (The teacher might have tried to obtain this from the pupils, but chose not to do so.) 24g then was one mole of magnesium ribbon. I've only got, less than that...I have in fact...Mrs.C. (Technician) weighed this out for me...I've only got in fact, 0.05g, so to convert that into moles, I have to do what? ...(Pause, but no response so teacher provides more stimulus) I know the mass of one mole, how do

I find how many moles then I've got left...
(Long pause with no response so the teacher goes back to the basic facts)...If I had 24g how many moles would I have?

GIRL. One

T. One mole (No encouragement this time.) How did I work that out? (Does not wait for an answer before going on to give the clue.) I divided...

BOY 24 by 24

T. 24 into 24 (Accepts the boy's answer) The mass of one mole into the mass I'd got. (Supplies the formula.) If I'd had 48g, how many moles would I have then? (Checking understanding.)

VOICES Two.

T. Two moles. If I've only got 0.05g, how then do I find how many moles I've got?

BOY Point-0-five...

T. Over 24 (Answers the main part of the question himself.) So that would tell me how many moles. That's one way. That was the way we learned first. The next way when we were trying to find moles and the ratio of moles, was using a solution and we were not dealing then with just single substances, elements or compounds, but they were in water. To find how many moles I had then I had to look at what it said on the bottle. In this case it says, 0.1M. What does 0.1M mean, Roger?

R. Point-one-O (Does not seem to understand the question or perhaps wasn't concentrating - several other voices try to help out.)

T. And what does that actually mean?

BOY. Tenth of a litre. (Several other voices.) In a litre. (Is this part of trying to guess what the teacher has in mind?)

T. A tenth of a mole dissolved in water. (Supplies the answer himself.)

The transcript reveals very little evidence of efforts to extend pupils' ability to verbalise and reveal in their own words the meaning which they attach to the knowledge the teacher is imparting. Opportunities to use previous knowledge are not used as a means to creating a climate which is receptive to the new ideas and it seems that the teacher's chief concern is with transmitting new information, therefore he dominates the classroom talk.

The earlier transcript (See Appendix C1) similarly reveals a predominance of teacher talk and though this is perhaps to be expected in such a lesson there are probably many opportunities which would allow pupils to talk about what they see and to make suggestions and decisions if the teacher had been taking a less obvious role in directing the learning.

Throughout the period of observation only one teacher was observed discussing pupils' written work in class: bookwork seemed to have a low priority as an aid to developing language skills; departmental policy seemed to be aimed towards self-motivation and self-discipline in written work. Some work was clearly of a very high standard of presentation, but some was of a lower quality and quantity even within groups which were of a homogeneous ability level.

F-DEFINITIONS OF FACTS AND CONCEPTS

The department was aware of the problem of language in science and spent a considerable amount of time some years ago compiling a set of definition sheets for the three year groups taking the SCISP course. In total there are almost nine and a half sides of closely typed A4 paper and a small sample taken from a fourth year sheet shows how difficult it is to create definitions which pupils will be able to understand without too much difficulty.

| | | |
|---|---|---|
| 1. | Alkali metal | A Group IA element which reacts with water to give an alkaline solution. |
| 2. | Allotropes | Physically different solid forms of the same chemical element. |
| 3. | Analysis | The 'breakdown' of information to find out about the components of a material or a solution. |
| 4. | Artery | A blood vessel carrying blood away from the heart. |
| 5. | Avogadro No. | The number of particles in one mole of specified particles. |

6. Adaptation — Modification in structure or behaviour of an organism resulting in a better chance of survival in an adverse or changing environment.

7. Blood — A fluid transporting tissue consisting of separate and independent cells in a liquid plasma.

8. Breathing — The physical process of gaseous exchange in organisms.

9. Capillary — A very small bore tube or a fine blood vessel.

Endean and George (1982) in their research involving a group of able children reported that it was essential that the teacher must have the ability to explain new concepts in readiliy accessible 'everyday language' using 'everyday examples'. The students themselves repeatedly emphasised the importance of discussion and learning with students of their own level of intelligence and interest.

There must be some doubt about whether small comprehensive schools are able to create the sort of learning environment in which the most-able pupils are able to discover and explore their own potential.

The Head of Department was very concerned that many people in science education were ignoring the evidence about the problems of teaching science which have been published by the various project groups, the A.P.U. and the Secondary Science Curriculum Review:

'It's so obvious there that kids are struggling. It's so obvious from what we're doing in our assessments, (New Nuffield Combined Science) the kids are struggling; not just the dim ones, but the bright ones as well; they're all in the same boat when you get down to brass tacks, because we're in a very fundamental difficult area of study that's difficult for everybody.

The so-called 'bright' ones have just been the ones who have been quick-witted, been blessed with high IQ and have got a very good memory, being able to put two and two together and to learn facts, string facts together, but we've never got down to really questioning their basic understanding of what they're doing.'

CONCLUSION

The emphasis in the working of the department is on knowledge associated with the processes of science and the content of the courses is directed towards those topics which will allow pupils to develop the ability to apply their knowlege across a wide range of situations. In this respect the department is working along the lines of the process model of curriculum which stresses what might be called 'cognitive objectives'.

The pupils however did not appear to have understood the basic thinking behind the course since their conversations often centred around an apparent need for a body of facts which could be regurgitated for examination purposes. It may be that this block in understanding what the teachers are trying to do is preventing them from developing their skills as fully as they might.

The topics chosen for study are intended to illuminate other aspects of scientific investigation, which, when seen together generate 'patterns' for speculation by the pupils and teachers. Reflective and critical thought leading to autonomous and independent thinking are at the heart of the process model of curriculum and appear to be central to the SCISP philosophy. However this important learning element was often missing from the lessons observed because there was insufficient time for discussion and the exchange of ideas after practical work had been done. In these circumstances it is perhaps not surprising that pupils had come to believe that the factual content of the lesson was what was important.

The tightness of the work schedule did not seem to leave any room for the exploration of the unexpected or the interesting, so that access to knowledge was being tightly controlled by the teachers.

The question of whether the pupils have reached the stage of development which allows them to handle the concepts of the course is outside the scope of this study, but it would be a possible avenue for future research particularly as many pupils stressed the importance of demonstrations rather than verbal explanations in helping them to achieve understanding. The use of analogy is one way which is used by the department to try to create understanding within the pupils' own frames of experience.

The evidence of observation did not point to any structured approach to the development of language within the department and without language it is difficult to see how pupils could achieve real understanding. In the absence of understanding it would be natural to fall back on rote learning of facts, leaving only a partial awareness of the general principles. This type of thinking was evident in conversations with a group of pupils who said that they found difficulty in remembering the details of experiments: they were looking for facts to remember rather than ideas and principles which could be used in problem-solving.

It is these misunderstandings of the underlying nature of the course which perhaps point to the need for some sort of dialogue by which teachers and pupils might discuss their different perceptions of the course and through coversation develop more effective teaching and learning strategies.

# CHAPTER VI

# TEXTBOOK ANALYSIS

## TEXTBOOK ANALYSIS

### A - ANALYSIS FOR SEX BIAS AND CONTENT

One of the reasons which is often given for girls not responding positively to science teaching is the bias which is exhibited in science textbooks. It is claimed by many that sex stereotyping is revealed in the way that science is portrayed as a masculine activity. Text is often heavily male orientated and the photographs which are used, usually show men in active roles and women being rather passive and submissive, often in 'traditional' female roles. (Taylor, 1979)

The Schools Council Integrated Science Project readers 'Patterns' accompany the course workbooks and provide additional information. The series was published for the Schools Council by Longman and Penguin Books, and comprises twenty four separate readers and these books were used in the search for sex bias.

A random selection of fifteen of the readers was taken from the department bookshelves for analysis of content. It is interesting to note that two of the books in the series (See Appendix D) use the word 'man' in their titles which may be regarded by some as an indication of sexism.

The analysis was concerned with:

(a) photographic material - looking at the type of photographs used to ascertain whether they could possibly convey the impression to girls that science is a masculine or male dominated activity.

(b) text - looking at the number of instances that men and women were specifically mentioned by name.

(c) the book covers - this being the point at which readers gain a first impression of the content of the book.

a) Photographic Evidence

Most of the photographs used in the books seemed to show men and boys doing things traditionally associated with men and women doing things traditionally associated with women. For example, males are seen in football crowds or playing football, playing computer chess, soldiers patrolling in a jungle, working on an oil drill, climbing about on a climbing frame, playing darts in a pub, conducting meetings, working on power lines wearing hard hats, gathered together at a protest meeting and rescuing people from floods by boat. In photographs which might be seen as directly linked to science and technology there are photographs of men using a laser cutter, erecting a kite aerial, operating a wireless, working on a holograph image and operating machinery.

By contrast, females are depicted shopping, serving a meal to an elderly person, taking food from a microwave, pruning a tree, suckling a baby, talking with neighbours at the door of a house in a high rise block, doing laundry, checking-in passengers at an airport and reading to a child. Only two photographs were found which showed women doing anything which could be linked to scientific work: a female using a laser in eye surgery and nurses working in an intensive care unit, though each of these might equally be seen as women in the traditional 'caring' role.

Although the books are designed to provide information across a wide range of topics they do not generally portray the sexes in anything other than their traditional roles; males are dominant, aggressive, enjoying dangerous and exciting lives whereas women are caring, nurturing and rather submissive.

The photographs in the books are clearly intended to be linked to the subject matter, but one wonders whether perhaps there is a hidden message which is conveyed to both male and female readers about what is expected of them by society. Certainly there is little in the books to provide a message for girls that science is as interesting, exciting and appropriate for them as it is for boys.

b) Textual Evidence

In the readers analysed there were 103 references to men by name, though not all were scientists and there were 6 references to women by name. This is not too surprising since women have perhaps been under represented in science over the years. However there may once again be a hidden message which suggests to girls that science and scientific work has little to do with them and perhaps subconsciously they dissociate themselves from the idea of scientific careers.

Perhaps teachers have to be aware of these possibilities and make a deliberate effort to point out that although women have not had the opportunity to participate fully in science in the past there is no reason why this should be the case now.

c) Book Covers

The covers of the books fell into two distinct categories when analysed, neutral and masculine. Eight of the covers were neutral in design and were attractive to look at, one other which depicted children playing could also be considered neutral. However six covers were strongly masculine depicting: a miners' rally, a motor racing scene, a male pop singer, a male pole vaulter and a male cyclist.

It might well be that first impressions of a book have an important influence upon the way the readers perceive the content and the way they view their own position in relation to the subject. Certainly there are strong feminist lobbies who condemn this over-emphasis upon the masculine domination of science education and who regard such a portrayal of science in terms of male power, dominance and competitive spirit as one of the chief reasons why so few girls want to be seriously involved with the physical sciences in particular.

B - ANALYSIS FOR CONTENT

The next area of investigation involved trying to get some idea of the different skills which pupils require if they are to access information in science textbooks.

Method

The method of analysis involved counting the total number of pages in the books, excluding title page, contents page and index, and then counting the number of pages on which a particular category of information occurred. This number was then calculated as a percentage of the total number of pages and represented on a graph. (See Appendix D) It should be noted that where a particular category appeared more than once on a page it was counted as a single occurence.

Text as a category was taken as an extended piece of continuous writing rather than including notes on diagrams or headings on maps for example. Photographs, the content of which might need to be interpreted, were differentiated from static photographs such as portraits.

As might be expected the major category was text and it may be seen from the graphs of the new Nuffield Combined Science course texts that only in Activities Book 2 is this less than 100 per cent. Diagrams form a second major category and it is noticeable that as the pupil progresses from Activities Book 1 to Book 2 there is a decrease in the presentation of information in photographic form and a marked increase in the use of more schematic forms such as diagrams, tables, scales and maps.

Cartoons feature prominently in both books, but many do not seem to serve any useful purpose other than providing some entertainment. For the most part the information contained could probably have been put across in different ways.

C - READABILITY OF NUFFIELD COMBINED SCIENCE TEXTS (Trial Version)

Bearing in mind that these were trial materials which will hopefully be improved before final publication a few comments seem to be in order. The text is printed in a type face which is not easy to read because it is small with little space between the words. Some children in first year classes had considerable difficulty in distinguishing one word from another. As the reading ages in one of the groups ranged from approximately 7.0 to 15.0 it is clear that to produce adequate material to span the range is virtually impossible unless there were supplementary materials available for more-able pupils.

In general the books are written in a friendly manner but an example from Activities 1 highlights some of the problems faced by pupils. On page 4 the pupils are presented with the following:

Puzzle Investigations. Get together with some of your friends and discuss these puzzles. When you have some ideas for solving the puzzles, talk about them with your teacher. You may be able to try them out.

1. If you held a balloon filled with hydrogen gas on a string you would feel the balloon pulling gently upwards. If you held a balloon filled

> with air from your lungs you would feel it pressing gently downwards. How could you find out which was greater - the downward push of the air balloon or the upward pull of the hydrogen balloon?
> Suppose someone gave you another balloon full of a mysterious gas. What could you find out about its push or pull? We think you would have to make sure that all the balloons are the same size. Why do you think we say that?

First of all the pupil is presented with a considerable reading task in trying to discover what he is expected to do. There are three initial sentences which give two different sets of instructions and a promise of what might happen in the future, but does this depend upon the outcome of their conversation with the teacher? Are they only allowed 'to try them' if they get the 'right' answers?
Next the pupil is faced with a series of statements which talk about balloons 'pressing' downwards and 'pulling' upwards which seems to be fairly easy to grasp, but then he is asked to make a considerable conceptual leap to consider which 'was greater' - what does 'greater' mean? It could mean 'larger', 'bigger', 'wider', 'longer' - depending upon the child's vocabulary, but the reader is expected to

retain this concept whilst completing the complex sentence to discover that it involves a comparison between the air balloon and the hydrogen balloon.

This presents the poor reader with considerable difficulty in trying to achieve understanding. He hasn't been given all the information he requires until he goes on to read the third paragraph which points out that the balloons must be identical in size. But even that fact is not revealed until the pupil has been presented with yet another challenge concerning a balloon filled with a mysterious gas.

It seems to be assumed that the pupil will read the whole of the passage about balloons and will not take the natural course which is to consider each answer immediately the question has been posed.

It may well be that this reading task would be more difficult for many pupils than the science problem it deals with. In the hands of inexperienced teachers, who simply left pupils to work on this section by themselves, this work could be totally misunderstood by many: in fact the two teachers observed went through the passage step by step to try to ensure understanding.

The layout of the books is confusing since there is no set pattern to the arrangement of text: some must be read in the conventional left to right fashion from the top to the bottom of the page, but other sections are set out in two vertical blocks on the page. However, to add to the confusion, the reader may be required to jump between columns without any indication of this in the text.

To test pupils' ability to cope with this arrangement of text a group of first year pupils of mixed abilities was asked to read the section on Senses 2 in the Activities Book 1 Pages 16-17 (See Appendix D) which appeared to be particularly confusing in this respect. Each pupil was instructed to read the page as though they were going to do the experiment. After reading the first block they were asked whether they understood what was expected of them - one of the five said he would not be able to do the work because he did not understand what he had read; a second boy said that he would need to read it again but the three girls were all able to explain what they had to do. On being invited to continue reading the instructions they all continued straight down the left-hand block of type without realising that the remaining instructions were in fact at the top of the right-hand block. A senior member of staff was tested using the same text and with the same instructions and made the same mistake.

This experiment though perhaps rather simplistic does seem to indicate that the task of reading this book would be too complicated for many of the children in this school without very detailed instructions from the teacher. There must be a strong case for arguing that even though these were trial materials they ought to be as close as possible to the finished product if they are to provide useful feedback to the project developers. Clarke (cited in Gilliland,1972) claimed that factors such as design and colour are important in deciding suitability of materials, particularly for disadvantaged children.

'Although based on subjective judgements the conclusions do reflect the importance which format and production are thought to play in provoking interest in a book.' (Gilliland,1972,26)

Reviewing the first two Activities books in this series it is evident that the writers have aimed their work at the top end of the ability range, not only because of the complexity of the reading tasks, but also because of the rate at which skills and vocabulary are introduced and developed: listing, sorting, classifying, note-making, comparing, distinguishing and observing, all within the first three weeks.

Read (cited in Gilliland,1972) concluded that discrepancies between the frequencies of sentence patterns in speech and print were so marked that this might add to reading difficulty. It may be that this is especially so when children, fresh from primary school, are faced with science texts for the first time.

In addition to the Activities books there are accompanying Readers which seemed to be even more complicated and sophisticated in their language, in fact, because of this, the two teachers concerned decided to use these books very selectively and not in the way they were directed by the

Teachers Guide for the course: instead of using them as background material their use became a whole group activity under the guidance of the teacher.

The readability of both the Activities I book and the Focus and Probe readers was checked using the computer program Textgrader. (See Appendix D for full details.) Samples of 100 words were taken at six points in each book and these were analysed producing the following information on reading ease:

Analysis of 6 passages from Activities 1
Nuffield Science 11 to 13
Secondary Material:
Flesch :12.54 Years
Fry :X = 6.27; Y = 134.95
Average Age level: 12+

Analysis of 6 passages from FOCUS
Nuffield Science 11 to 13
Secondary Material:
Flesch : 14.52 Years
Fry : X = 5.16; Y = 141.54
Average Age level: 13+

Analysis of 5 passages from PROBE
Nuffield Science 11 to 13
Secondary Material
Flesch : 13.46 Years

Fry : X = 6.75; Y = 144.33

Average Age level: 13

The seriousness of the problem faced by teachers using these books may be judged when the reading ages of the 1985/86 first year pupils are studied: out of 76 pupils there are 20 pupils with reading ages below 9.5 years and several are below 7.0 years. ( Further consideration of readability is included later in the chapter.)

The following extract gives some indication of how concerned the teachers were that the new course might not live up to expectations:

T. For the first and second year, we thought the Nuffield scheme would be the answer, but it isn't going to be.

BET. You don't think that's going to be the answer?

T. Well I think the reading age of that must be way up.

BET. I haven't checked that. You mean in the Readers?

T. The Readers and the instructions. They just don't understand it.

BET. You think it would be worth doing a check on that?

T. Yes, it wouldn't hurt.

BET. I'll do that I think.

T. Because it's very difficult for them to understand I seldom leave them by themselves to read it. I do sometimes just to see what they get out of it, but I often read through and explain it as we go through. It may be better when we get to the final version, I mean we've said that at their (the feedback meetings with the project team) meetings, but at the moment it doesn't look as though it's going to be that easy for them (the pupils).....I don't think there's an answer for mixed-ability that we get right from...Catherine she's got a reading age of about six to Jason who must be about fifteen. I mean what do you do? You've got to push one and help the other.

BET. You can't, you'd spend all your time re-writing things wouldn't you.

T. Yes. In the first two years I try to make most of it verbal and then back it up with...which again is a problem, because the people who need to back it up are the people who can't read.

Gilliland (1972) also makes the point that children often have very different linguistic backgrounds (See Chapter I reference to Bernstein's 'restricted' language code) so that a passage which may be readable by one child may be very difficult or beyond another simply because it is outside their language experience.

'..a person with limited reading ability will soon become discouraged if he is given texts which are beyond his comprehension.' (Gilliland,1972)

A concluding thought on these texts would be that a great deal more thought might be given to the style in which they are written if they are to be made accessible to most children. At present there seems to be little in the

Activities books which cannot be put over more effectively by the teacher and the Readers are so detailed and written in such difficult language that most pupils find them impossible to cope with.

The cartoons in the text appear to be an attempt to encourage pupils and to make them see science as fun, but the teachers believe that such additions only make the books more confusing and act as distractors. The comment was made that the Focus Reader was more concerned with 'name dropping' than making serious scientific points and the teacher felt that better examples could have been found to illustrate the ideas.

The analysis of SCISP Patterns textbooks (See Appendix D) reveals that they are also heavily oriented towards providing information in the form of complex text. Each section of a book is written in the form of an investigation with problems being clearly delineated by a black triangle at the beginning and end of the sentence. Optional work is marked by a clear triangle. The whole SCISP course is based around the search for patterns and a symbol is printed in the left-hand margin to indicate the presence of a pattern.

The language level in the books is sophisticated as the following example shows:

'Moving charges give an explanation of an electric current. The charged objects which move are called charge carriers. A continuous transfer of charge is an electric current.

So whenever you meet an electric current ( that is, whenever something conducts electricity) you are entitled to ask questions about what charges are moving. Sometimes these questions may not be very easy to answer.

The charge in Investigation 8.5 is transferred in distinct 'chunks' one each time the ball hits the second plate. This raises the question of whether charge exists in 'chunks' of a certain size, or whether it exists as a continuous 'fluid'. Benjamin Franklin thought in terms of an electric fluid and imagined glass as acquiring an extra amount of this fluid when it was positively charged' (Hall et al, 1973,125).

Analysis of 5 passages from SCISP Building Blocks

Secondary Material:

Flesch : 16.1 Years

Fry : X = 4.93; Y = 150.69

Average Age level :15+

The two scales used by the Textgrader readability computer program analyse the same information, the average number of words in a sentence and the average number of syllables per 100 words. Interpretation of the results of any readability scale must be approached with care because as Graham (1978) points out not all long words are equally difficult, indeed some may be quite well known, but these formulae treat them all equally. Similarly some short words may be very difficult in terms of their conceptual complexity, but again they will all be treated equally. It is often thought that sentence length is a good indicator of reading difficulty, but this must be related to grammatical complexity. The computer program used does not give any assessment of interest or comprehension skills, the detailed study of which was outside the scope of this study.

Graham (1978) identified a number of additional factors which may affect the readability of text: print size, vocabulary and content and style. Gilliland (1972) and Johnson (1979) suggest that interest and motivation are also very important and it is the teacher's task to try to match the reader and the text. Klare (cited in Gilliland, 1972) examined the disposition or attitude to reading which he described as a 'set to learn' and found that a weak 'set to learn' was characterised by a mechanical or habitual approach to reading whereas a strong 'set to learn' showed more deliberate attack with a more regular eye fixation pattern.

'The 'set to learn' must be strong or the goal important if the individual is to raise his performance in reading by a significant amount.' (Gilliland, 1972, 24)

Johnson argued that since textbooks were not the sort of books which people would read given the choice, it was important to make the text simpler than the reader might be able to cope with as ease of reading might encourage them to continue rather than become discouraged by having to struggle with the book. Mobley (1980) makes the point that teachers often underestimate pupils' difficulties when selecting textbooks, possibly due to their own familiarity with the language and concepts.

'Building Blocks' is the first of four books which cover the SCISP course through from the third year of the secondary school to the end of the fifth year. It is designed to serve the needs of the O level pupil and the extract above gives some indication of the abstract nature of the language and the conceptual difficulty which the pupil faces when trying to understand such a passage. In a school which has very few genuine O level candidates, such a book is beyond the ability of most pupils even in the top set according to the staff who taught them.

A second extract also shows that the reader must be capable of highly abstract thinking in what Piaget refers to as the formal mode:

'There remains the question of whether the waves are transverse or longitudinal. The evidence for this is slightly indirect, but from it important deductions can be made about the structure of the interior of the Earth.

All materials are to some extent elastic, that is capable of being deformed reversibly. Elastic solids can be transformed in two ways: compression (which represents a change in volume) and shear (sideways movement of one part in relation to another, which represents a change of shape).' (Bauser et al, 1974,55)

This analysis of textbooks in the science department suggests that if the teacher wishes to use books he must be prepared to give high priority to the development of reading skills, a task which might be shared with the English department and the Special Needs department. In trying to find suitable textbooks for different ability groups in science the teacher is faced with the special problem which scientific language presents. Wellington (1983) explains that conventional measures of readability do not produce accurate results, because they conventionally rely upon such methods as counting syllables, sentence length and the number of polysyllabic words. Wellington points out that these methods are not able to take account of the major difficulty which is the 'opacity' of scientific language, by which he refers to the inaccessibility of meaning.

'We may say that the more unfamiliar the reader is with the individual words the less fluent his reading will be. This will be due in part to the difficulty the reader will have in word attack when faced with letter sequences of relatively low frequency.' (Gilliland,1972,50)

Many of the polysllyabic words in science may well be relatively easy to understand because, as in biology, they may simply be naming words. An apparently simple word such as 'mole' however represents a major intellectual challenge because it is arguably the most difficult concept to understand in chemistry, yet on a readability scale it would be no more difficult than any other simple four-letter word. Research into the readability of science textbooks by the use of traditional methods has shown biology texts with their preponderence of long words to be far more difficult than physics texts which appear to be easier with their use of short words such as 'work', 'energy' and 'mass'.

A readability check on a fifth year worksheet on Echo Location (See Appendix D) which was used with CSE pupils during one observation session was found to have a reading level on Flesch of 17.93 years and on Fry it was 16+ years for 2 passages of 100 words each. The worksheet may have been made more difficult and certainly more daunting, by the fact that it was typed using single spacing on A4 paper with very narrow margins. This meant that first impressions were of a mass of words, the two sheets being relieved only by two diagrams at the top of the second page. Reluctant readers would probably be somewhat overwhelmed by the sight of so much to read and certainly the group observed did not read it with any enthusiasum and many of them merely copied sections into their exercise books when asked to make notes.

Passages taken from a series of fourth year worksheets had an average reading level of 18.93 on Flesch and 17+ on Fry

(See Appendix D) which seemed to place them well beyond the reading ability of most pupils in the fourth year. Passages taken from fifth year worksheets, including those mentioned above had average reading levels of 16.51 years on Flesch and 15+ on Fry.

It will be noticed that the Fry results are consistently one year lower in the reading level produced by the formulae. Stokes (1978) sounds a note of caution in the use of these formulae since his research revealed that variations between them was unpredictable, even when used on the same passages, and he did not recommend them for the casual purpose of trying to select suitable texts for use in schools.

Accepting that this is not a comprehensive study of readability of science texts this research does suggest that many children may be expected to have difficulty in coping with reading in science or being reluctant to read for a variety of reasons:

- the strangeness of the new language in comparison with everyday speech
- the amount of new words to be learned
- inappropriate design and presentation of textbooks
- the conceptual difficulty and opacity of the language
- lack of interest or poor motivation
- inappropriate choice of texts for the reading levels of the pupils
- the gender bias of many science texts

Bearing these points in mind we can look at evidence of girls' attitudes towards science in this school which has compulsory science for all for the first five years: this is against the backdrop of increased interest in lack of female involvement in science over recent years.

# CHAPTER VII

# GIRLS IN SCIENCE - SOME PERSPECTIVES

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### INTRODUCTION

It was stated earlier (See Chapter II) that the curriculum of the school is undifferentiated in terms of girls and boys, generally this was correct, but there are some courses which, though ostensibly open to all pupils, are in practice single-sex.

The practical subjects have traditionally been associated with single-sex groups in the school: the few boys who were permitted to take Home Economics being the exceptions to the rule. But even when the boys were allowed to take the subject, it was not until the 4th year when girls had already gained three years experience. So regardless of ability boys were placed in a lower-ability set and were not really taken seriously in terms of what was normally expected of girls: the assumption by staff seemed to be that the choice was for recreation and not for serious study. The only significant change in recent years has been that all pupils in the first two years experience all practical subjects, but again this has been in single-sex groups on the grounds that boys and girls cannot be taught in the same way. When choices are made by pupils at the beginning of the third year it is assumed that they will not choose non-traditional courses and when they do teachers are not really organised to meet their individual needs.

The Child Care course has only had one boy in the last ten years, perhaps because it is linked with the Home Economics and Needlecraft department, and it may be that the teachers 'advertise' the course to girls, but not to boys. It may be that the course is perceived as being concerned with 'motherhood' and not 'parenthood'.

In the science department, Applied Physical Science has only been chosen by one girl since its inception in 1978.Girls who were asked about this course were not inclined to take it because it was seen as being concerned with masculine-type activities like stripping down car or motor- cycle engines. Similarly the human biology course, which only attracts girls, is seen by the Headmaster as something for the non-academic girls to do.

Agriculture is regarded in a different light and a number of girls are accepted for this course each year (perhaps 25% of the group), but the reasons for this difference in attitude may be found in the fact that it is quite common for women to work on the family farms in the Dale, indeed it is often a necessity. The involvement of men in the running of the home or the rearing of children is less common, indeed many men are said not to concern themselves with their children's education leaving that to their wives.

These and other 'messages' which the pupils receive from the 'hidden curriculum' may reinforce gender stereotyping.The school system of punishment allows for the caning of boys, but not girls and though such occurences may be rare they say something about the different attitudes people have about boys and girls.

The staffing of the school is predominantly male: only two senior posts, one deputy and one senior head of department are held by women. The only female teacher in the science department teaches general science and human biology both of which are regarded by pupils as being inferior to integrated science and this may say something to them about the status of women in science.

It was against this background that during the initial stages of observation in the school it became clear from conversations with staff and from a review of previous research that girls present major problems to science departments, or to be more accurate a certain type of girl presents problems.

The girls mentioned were not usually amongst the most-able academically, though some were, but they had enough ability to make staff feel that they were capable of achieving success and learning a great deal of science. These girls tended to be extrovert in character and formed themselves into small groups of articulate and somewhat anti-establishment and anti-authority persuasion. One group of fifth-year girls had apparently been identified as early as the second year as being a potential problem to the department but it had failed to find a solution.

An attempt was made to discover something about the girls' attitudes towards science with particular emphasis upon those who appeared to be most rebellious in the department.

REACTION TO PRACTICAL WORK

Girls dislike of practical work is often expressed with reference to experiments which appear to be repeating the same thing, because they do not seem to get anywhere, this particularly applies to chemistry experiments which involve mixing chemicals in test tubes and observing the reaction.

A. When we do them (experiments), they're like, like that one we did the other day, it took up a whole lesson waiting for them things to react in the test tubes...

B. Oh! Yes.

A. ...and in the end it didn't work - wasted a whole lesson on it.

B. Enzymes and things.

A. And spitting in test tubes.

BET. Yes.

A. And it just didn't work in the end, so that was just a wasted lesson.

BET. So what have...what do you do then? Does he give you the results that you should have got?

B. No, it's just forgotten about and you do your next lesson's work.

BET. Oh! So do you know what you were supposed to find?

A. No.

B. No, not really.

BET. I see.

One girl in particular saw a major difference between males and females in their reactions to repetitive experiments. She said that boys were prepared to go through the same experiment over and over again, but girls are satisfied if something works once and she could not understand the male fascination with such experiments - "making bigger and louder noises". She further illustrated this point by describing the way boys will take their bicycles to pieces at home, not necessarily because they are broken, but because they enjoy it. Girls, on the other hand, are reluctant to take anything to pieces in case they break it in the process - the philosophy seemed to be that if it worked why interfere with it.

Another girl identified this emphasis on practical work at home and school as being the main reason why boys enjoyed practical work more than girls. The girls said that whilst boys were involved in this practical activity girls were likely to be found playing with dolls and "making them better". This was described as the "maternal instinct": the dolls were regarded as small children.

"If I'd taken the trouble to take something to bits I wouldn't want to put it back again, what was the point of taking it to bits in the first place?"

Although the opinions expressed by the girls do not show any real appreciation of scientific methodology it is worth pointing out that they were very intelligent girls who were expected to do well in external examinations, and yet they could not really appreciate what science really involved even after five years teaching. Paradoxically these same girls did think very deeply about science particularly about its impact upon society.

'The fact that it's harmful to humanity perhaps gets me more than the fact that it's going to be...I think men are always looking for something that's going to make life easier for people, women perhaps are saying, you know, what's it going to do, how's it going to harm people? OK, so it's going to help people in the end, but how many people are going to get trodden underfoot in the process?'

A further example of the conflict between personal feelings and scientific methodology:

'I think perhaps that science where you're not leaving well alone, you're taking things to pieces is something that's pulling inside me saying, "Just leave it how it is."
Science is saying, "No, you've got to look further."
And I'm saying, "Why?"'

DIFFERENTIATION OF SCIENCE ATTITUDES BETWEEN BOYS AND GIRLS

A considerable body of literature exists which is related to the differences in scientific achievement of boys and girls and which seems to increase in favour of boys with increasing age. (Erikson and Erikson, 1984)

(See Appendix G Examination Results analysis which reflects this view)

The explanations which have been offered for these differences fall mainly into two broad interpretations: biological and sociological. Delamont (1980) argues that many of the male and female differences which are believed to be biological in origin are in fact the result of the culture in which children develop.

The biological interpretation usually centres around the notion of spatial abilities which are often linked directly to science achievement particularly in the physical sciences. It is reported that this factor gives males an advantage in the study of science. (Gray, 1981)

The development of spatial ability is usually linked with the degree to which individuals use the right or left hemispheres of the brain for spatial processing, (Erikson and Erikson, 1984), but there has been no substantive evidence to support this. (McGee cited in Erikson and Erikson, 1984).

Erikson and Erikson (1984) also cite Sherman who suggests that the functioning of the different hemispheres of the brain was the result of cultural and social upbringing rather than being genetic. He believed that it is the way boys and girls are taught to act which leaves the female at a disadvantage in the processing of spatial tasks.

'Let it be said from the outset that there infact appears to be no convincing evidence that performance differences in relation to spatial, motor and linguistic skills (all important in the study of science) exhibited by boys and girls relate to genetic or biological factors. All the indications are that sex differences in these skills relate to attitudes and perceptions developed in the child rather than innately determined.' (Blin-Stoyle,1983,226)

These visual-spatial skills which girls appear not to develop as fully as boys are described by Lisa Serbin as 'the ability to perform mental rotations of visual stimulii, to metally transform two-dimensional forms into three dimensions, or to complete or dissect complex visual stimulii' (Serbin cited in Marland,1983).

If environmental pressures do exist which shape the way children develop they may well begin in the home with the pressure to conform to certain sex stereotypes. Women are often portrayed in the media and in children's literature as being somewhat passive and submissive.

'Women occupy the supportive and expressive roles in society, men the innovative and instrumental ones.' (Kelly,1981)

This line of argument also extends into the masculine image of science and scientists which is presented by films, books and the media. Physical sciences are identified as masculine, but biological sciences, which may be viewed are 'nurturant' may be seen to be more suitable for girls.(Kelly,1981)

This point was made by one of the teachers during a conversation about his approach to teaching girls in the lower school:

T. I try to teach equally, but it's difficult because they've got different ideas, They have preconceived ideas about what they like and what science is and how they should react to science. So you tend to push the girls a bit more for what they've...

BET. They come with preconceived ideas?

T. Yes I think so.

BET. From home presumably and primary school.

T. Yes. School,Television. I mean, I still think we're fighting a battle and we're losing still. I think even perhaps more so because television just shows, nearly all the time,scientists are male or masculine women and we've got to do something about that.(See results of survey of first year pupils in Chapter IV)
They (parents) come at parents' evenings and say that it's not a girls' subject - even though they're doing well. It's often the ones who are doing well saying, "We're very surprised, we didn't expect girls to be interested in it".

This response by the teacher was interesting as it threw the results of the first year survey into sharp relief, as that had revealed a considerable depth of interest in science, and it also seemed to indicate that far from having stereotyped views about science the girls were very open- minded.(See also Appendix E).

Children's toys are important in this socialisation process.

'Boys alleged interest in "how things work" is fostered by mechanical and constructional toys where girls are given dolls.' (Smith,1977,302)

Sherman (cited in Erikson and Erikson, 1984) suggests that differential access of girls to mechanical toys such as Meccano and to blocks and models may well mean that they do not develop the spatial skills which such play encourages. Boys may be expected to do better on topics 'such as electricity, chemical reactions and mechanical objects like motors' which may develop from their greater interest in science-related books and media topics. (Erikson and Erikson,1984).

The following comments were made by girls:

'I don't like the experiments where you put this acid in a test tube and another acid, put a piece of stone in it and see it explode and write what it's done. I don't like that, I find it a dead end job, sort of thing.'

'I don't like doing circuits.'

'...it's more like a girls' subject isn't it (biology), I mean, I know we're supposed to be equal now, but it's more interesting. Like I always think it's more for boys what we do, you know, about, sort of, about electric motors and things like that.'

'We find chemistry the hardest.'

Research into deficits in visual-spatial problem-solving and low rates of play with 'masculine' toys does suggest that girls may well be disadvantaged by patterns of early childhood play (Connor,Serbin and Schackman,1977; Connor, Schackman and Serbin,1978).

One of the problems is that the emphasis in remedial education in this country has been on reading, which mainly helps the boys, surprisingly little has been done in remedial mathematics. (Marland,1983) Equally neglected is curricular provision for girls in three-dimensional work particularly with resistant materials such as wood, metal and plastic.

'This lack of three-dimensional experience at the early stages may leave unharnessed the interest and energies of some children; they could thereby be at a disadvantage at a later stage in forming spatial concepts in mathematics and some basic notions in physical science.' (D.E.S.,1975,2-3)

There is a problem however in that many girls do have superior spatial ability compared to some of their male counterparts yet they drop physics whilst the boys continue with the subject. (Ormerod et al, 1979)

The counter argument to the sociological model is strengthened by the consistency of differences between the sexes in science achievement tests reported by Kelly (1981) following research in fourteen countries: it is very unlikely that environmental factors could be responsible since the cultures were so very different, which suggests that perhaps biological factors are responsible.

'Factors peculiar to a branch of science seemed to be of greater importance in producing sex differences than factors characteristic of the national culture or school system.' (Kelly,1981)

Kelly's hypothesis that schools present science in a way which is better suited to boys than girls argues for a change in the way girls are taught science otherwise the school may be simply reinforcing the pre-conceptions which girls have about science.

Arguments for single-sex schooling (D.E.S.,1975; Ormerod,1975) as a way of increasing girls' achievement have been countered by others who suggest that it does not make any difference. (Blin-Stoyle,1983)

A research project at Huddersfield Polytechnic (available from the Polytechnic) suggests that the barriers which girls are likely to meet are not intellectual or physical, but more likely to be social. Teachers have an important role towards these girls as information providers, but they are also quite likely to discourage girls from entering engineering.

Comments on entering scientific occupations:

'It would probably be useful when we got cars 'cos they think that lasses shouldn't do engineering or anything like that, but it's a male chauvinist attitude that is.'

'I mean they say that girls can go into engineering and things like that, but it's only the ...a very few who actually want to isn't it.'

This point was made by Brierley (1975) who said that whilst most countries now seek to provide equality of opportunity in an attempt to fully develop the talent which exists in the population it may be that there are some women who value the uniqueness of being a woman and who are quite content with homemaking and bringing up children.

'All this is essentially the evolutionary argument in real-life terms which recognises that the different parts men and women play in society are complementary, but equally valuable' (Brierley,1975,24) (See also Radcliffe – Richards,1980).

For a girl to deliberately choose to do a subject in which she will be the only girl demands a high degree of commitment as she may feel that she runs the risk of ridicule from the boys. How far these fears are justified is uncertain and it may be that the greatest pressure would be not to appear to be different from her peers.

One girl suggested that the reason why girls do not choose to do certain subjects was:

' because they're frightened if they choose it they're going to be the only one, 'cos if you've got a couple of lasses then you can sort of do it together and help each other'.

Another girl was rather more determined in her attitude:

'If you've got a strong enough will that you know you want to do that then you've just got to do it...'.

In an article in New Scientist, Catherine Manthorpe (1985) explains how feminists are now focusing on the question of scientific objectivity, rationality and its disinterestedness, asking whether this is linked to the dominant male stereotype which depicts the scientist as unemotional, rational, logical and detached.

There may be more than a hint of this in this extract from a conversation with a fifth year girl:

'I find science very boring, I've always found it boring ever since the first year. It doesn't seem to have any point to me. I don't know whether it's just because the fact are there and you just believe them. There are no 'ifs' nor 'buts' it's just, that's it, and you learn it and there are no arguments, because that's the way it is, and I don't know whether it was that that put me off a bit'.

Manthorpe (1985) cites examples of the way that dominant scientific minds, including Aristotle, have imposed a masculine perspective upon scientific thought without reference to female experience. What was regarded as scientific objectivity is being questioned as male ideology, which feminists claim excludes half of human experience.

Attitudes to science education or indeed to education in general are not easily measured, perhaps as has been suggested, this is because instruments for measuring have simply not been developed. (Ormerod et al,1979).

There seems to be a general consensus that girls prefer biology to both physics and chemistry, because it is not regarded as being as difficult, but it may be that biology and the way it is taught comes closest to the female perspective on life.

Teaching subjects in an integrated course does not seem to affect girls' attitudes since they still compartmentalise science topics. In this school which teaches integrated courses in the first three years and then only introduces non-integrated courses for the lower-ability pupils, many pupils still refer to science by its traditional labels of physics, chemistry and biology.

Physics and chemistry, as they are taught today, seem to be more difficult than other subjects, a fact which is confirmed by comparative studies conducted by the GCE examination boards and it appears that to achieve success in these subjects students have to be of significantly higher intelligence compared with students taking other subjects.

The difficulty is not only found in the vocabulary and the complexity of the concepts being used, but also includes the mathematical difficulties. It has been suggested that if these scientific concepts are forced upon young people too soon they may not only find them too difficult to handle, but that they may never be able to grasp them even at a more suitable age, when others who have not been 'force fed' do so much more readily. (Garforth et al, 1976; Furniss and Parsonage, 1977).

This point of too early exposure to highly abstract concepts is raised in the chapter on first year science in connection with the new Nuffield Combined Science. (See Chapter IV)

Many of the factors which militate against girls' participation in science in many schools do not apply in this school. Girls and boys have the same experience of science regardless of ability for the first three years and because the courses are integrated the content may be less easily identified as being 'overtly' masculine or feminine. At the crucial choice point towards the end of the third year the pupils who are judged by the staff to be capable of benefitting from the SCISP course are recommended to take the course and few able-pupils are ever allowed to 'opt-out' to take the General Science course with a second science option. In this sense there is positive discrimination in favour of girls taking science.
Because the school has adopted this policy of 'science for all' with a time allowance equal to one-fifth of the timetable, it has clearly signalled the importance which is attached to the subject. No one is able to opt for a 'soft' science or opt-out of science altogether in favour of a subject which might be seen as offering the chance of a higher grade.
Certainly the girls do not have to face the problem of being part of a small minority in a male dominated subject such as physics: this occurs at sixth form level, but then overall numbers are so small that it is of little significance.
Problems of 'hidden selection' (Ormerod et al,1979) do not occur to the same extent that they would if science was

part of a larger options pattern, nevertheless they do exist. As previously mentioned pupils are rarely allowed to opt for science at a level below that which is recommended by staff, and pupils who wish to take Agriculture are closely 'vetted' as to their reasons: desire for exam success is rejected, as is the belief that it will help career aspirations. The teacher-in-charge says, "The right reason is because they're interested in Agriculture. Full stop".

Two Integrated Science sets are always selected and usually tend to be rather large to accommodate all the pupils who, it is considered, will benefit from the course. It has been noticeable over recent years that the number of girls in the O level set has fallen, leaving it more male dominated whilst the CSE set shows a preponderence of girls. This might reflect a changing attitude towards science by the girls.

A group of fifth year girls revealed their philosophy of education during a conversation:

A. Your personality counts as well when you come to get a job.

B. Yes. People say if you've got a good personality, if you can sell yourself, if you can get into the interview and sell yourself then you can get the job. (This is not an area of high unemployment).

C. I mean, fair enough, I mean you've got to work, but I don't think you should just work. I mean especially like (Nickname) more than any of us, I mean to say when she goes for a job she can say, "Oh, well I've been in a hockey team as well",(county representative) she's got that behind her. I mean we can say we've been in the school hockey team.

BET. You see education as a lot more than just examination results.

A. It's everything that you do in school.

C. Oh! Yes, because you've got to stress some other things as well because like I'm not going to mention any names, but there are a few girls who you'll know, I mean, all they do is their school work, they won't play hockey because they think they should be spending that time on their school work.

B. (Comment about non-socialising not transcribable).

C. I think you're just as well to get a grade B in your things and have stuff like your hockey and...

B. Jobs...(This girl had a part-time job).

C. ...what you've done, than to get all grade A's.

A. You've still got to have a social life as well.

THE BOREDOM SYNDROME

Boredom was one of the chief complaints which pupils in the school, particularly girls, made against science during interviews and one which the teachers seem to have the greatest problem in tackling.

EXTRACT FROM 4TH YEAR LESSON FIELD NOTES - MOLECULAR STRUCTURES

'Around the room the groups, which contained boys, or boys and girls, seemed to be working with greater enthusiasum and exchange of ideas than the tables which had only girls. I went across to speak to (group of girls), who were playing with the equipment, but had bored dissatisfied looks on their faces. When questioned (two girls) were quite vocal in their condemnation of science as being "boring", "too much to remember","all those formulas" and "all those long names".

All four girls claimed that the homework which they had been given the previous lesson had proved to be beyond their understanding. They said that they could not relate the homework to what they had previously done in class.

(Two girls), who were the spokespersons for the group by now said it was a waste of time and that they would prefer to do something useful. On being asked what they thought was useful they suggested work on plants, animals and trees. Work which had been done on flowers and plants was not considered to fall into the approved category however...

At this point (the teacher) again returned to the rebellious group of girls, who claimed not to know what title to use or what they were supposed to be doing. (Hope this wasn't the influence of the observer). The girls then proceeded to bombard (the teacher) with questions about why they were doing this work, what value it had for them - "What is it going to learn us?"

(The teacher) valiantly tried to get a word in to explain the significance of the models, but was not getting through.

Obviously disturbed by the minor rebellion during the lesson (the teacher) called for the attention of the whole group and began to explain and justify the work. He explained how work on DNA had resulted in the award of the Nobel prize, such knowledge was central to a greater understanding of the nature of the cells in our bodies and could have profound effects on our ability to fight disease.

In the future the members of the group would have the right to vote and help make decisions and these should be informed decisions based on knowledge. Knowledge was not only needed by scientists.

At the end of the lesson (the teacher) again came up to me and re-stated the difficulty of putting across the relevance of the work to girls like Louise, who could not see any point to the work and were not motivated.'

The day after the same teacher again spoke on the same subject, but said that he thought that Andrea was the catalyst who stirred the others to discontent. He returned to the problems of the day before when he said the atmosphere had not been good and atmosphere was essential for a good lesson.

Some days later the following conversation took place with the same teacher:

BET. You mentioned something about girls the other day I think, didn't you? There was a point about girls.

T. Yes. I think there's a big problem motivating girls these days. I find there are some that are very keen, and when they are keen they'll go on and do very well indeed.

The notion of trying to bring in more aesthetic ideas is one that's often suggested.(T.E.S. 11.1.85). Our course hopefully, aims to do that, probably more than most.

Last summer when the present fifth year were writing their own reports, almost all the boys said they enjoyed science and were keen and it was one of their best subjects and all the rest of it. There were a number of girls who did admit to enjoying science, equally a largish number who claimed that it was "boring". The word "boring" is a very common one to their lips and in many lessons one can see them anything but bored, so it doesn't seem to be particularly painful.

BET. Mm. So you think this is just a...perhaps a peer group phenomenon, if you like, that they claim to be bored, but in actual fact it may not be true boredom...

T. I think there's a measure of true boredom in some circumstances, but equally, I think that the thing tends to mushroom and there's a tremendous amount

> that isn't, which is caught from a few people, rather more dominant people, as we've found in, for example, one of these lessons, then they can have quite a large effect and it's not always so easy to combat. I think that the big problem really in a group like the one that I have is the ability range. In the present 5th year, 18 out of 28 will be O level and about 10 or 11 CSE, so that even though it's a top group there's quite a wide range of ability and within that, keeping up the pressure for those that are going to get the exam is one priority and a very needful one considering other issues in the school, and also the needs of those particular kids. Equally, as in the newspaper I was showing you (T.E.S.11.1.85) too much rigour can lead to rigor mortis and so you're always trying to strike a balance.

It is interesting that in that conversation the teacher referred to "the exam" by which he was presumably referring to O level, but the whole group was expected to take some form of external examination which perhaps suggests something about the value which this teacher placed on O level as opposed to CSE. It was essential to maintain pressure on that group whilst considering the needs of others, does this interesting distinction mean that CSE pupils need not be placed under pressure? ( The topic of pressure on pupils is pursued later in the chapter.)

A further insight into "boredom" was obtained in conversation with two girls following a lesson which involved the collecting of data about collisions of trolleys. The point the girls seemed to be making was that because they had an intuitive awareness of what was going to happen the work was boring and rather pointless.
However, what might be equally important in creating what they call "boredom", but which may be frustration, was the fact that their group had been working with faulty equipment and had not been able to produce any results which could have been used to test their hypothesis. In the absence of this opportunity the exercise became a 'waste of time'.
A further perspective on practical work was offered by another girl:
'But somebody's done it before you haven't they, I mean and if you don't get the answer - oh, well - it's just copy it from the board, because this is how it's supposed to happen and this has happened because somebody else has found it out before you. You're the one who's done it wrong, you haven't got a new discovery or something like that'.
Behind these statements there seems to be a basic misunderstanding of the nature of integrated science education. This girl appears to believe that she is doing science in order to 'discover' something which has never been achieved before, if this did happen it would be very exciting, but Yager (1983) identifies the purpose of school

science as 'a conscious effort to help students to find links between their lives and the scientific phenomena around them'.

Unlike teachers of separate sciences the integrated science teacher is concerned to develop his pupils' general education and not simply transmit the subject. His intention should be to bring out the connections between different sciences, but in addition he seeks the link between school science and everyday life.(Sutton in Cohen,1977).This may result in a possible increase in pressure on the teacher since there is no longer the safety which was afforded by the old subjects and the old didactic teaching method which rarely made the connection between the subject and real life or pupil experiences.(Bernstein,1971)

Sutton (in Adey,1980) identifies two ends of a spectrum of emphasis in science education - at one end is the goal of producing more scientists and at the other is a goal to produce a more scientifically literate population which is capable of understanding scientific and technological developments.

'...individual pupils and parents have a strong interest in education geared to the first one, because it is a means of 'getting on' in life and perhaps getting a good job. Teachers necessarily respond to the resulting pressure upon them and this again leads to a concentration on the structure of the subject.' (Sutton in Adey,1980,120)

It is this pressure to excel at a subject which becomes increasingly abstract and apparently separated from real life which may cause pupils to turn away from science. Research has shown that there is a decline in interest in science the longer pupils stay at school except for those who are scientifically and technologically literate who show increased interest.

Yager and Penick(1983) are critical of the way in which the priority for most science courses appears to be to make them fit neatly into class periods, the school day and the shool year with little attempt to make use of the vast wealth of personal experience which every pupil brings to the class.

'We have failed to realize that the world itself is the real laboratory for science learning.'(Yager and Penick,1983,69)

The idea that pupils might be encouraged to bring everyday problem-solving strategies into the classroom as a way of improving science is suggested by Maskill and Wallis (1982) since:

'it seems more likely that people will think most efficiently when they are most familiar with the context of the problem in front of them'.(Maskill and Wallis,1982,553)

What may be being lost sight of in the case of the girls and also boys in this school is that 'hands-on' experience through experiments, field-trips and the like is that it is encouraging them 'to use their innate inquisitiveness to help explore; it's offering explanations for why events happen; it's testing to reach new understanding and it's repeating the whole process when new questions arise.'(Yager,1983,27)

'Meaningful' learning can only take place when the material makes sense and conforms to experience which puts it within the individual's grasp so that it may be integrated into what is already known rather than it being simply memorised. (McClelland,1982a; Summers, 1982) This basis of Ausubelian theory of learning suggests that principles and general ideas already known by the learner provide associations or anchorage points for further learning. (West and Fensham,1974).

McClelland believes that children are natural theory builders which must help them when tackling the concepts of a high level of abstraction which are the most useful in dealing with new situations. Although these concepts tend to be less easily forgotten (McClelland,1982b) it is not sufficient to simply provide definitions or a list of attributes, the concepts should be built up if the individual is to come to terms with the enormous amount of sensory data which he receives in the course of daily life. Ausubelian theory places great emphasis upon activity and the use of concrete examples, but whilst 'talk and chalk' is not advocated it is accepted that it is necessary that verbal and visual presentation must be present and complement each other.

'As the process continues the learner gradually moves from using the examples to give meaning to the key statements to using the statements to understand new examples.'(McClelland, 1982b,354)

A major problem which McClelland (1982b) identifies is that the teacher must be able to identify the relationship between his students' previous knowledge and the learning tasks he proposes on the basis of the concepts he wishes to develop. But the fact that each pupil has acquired his own individual 'science' through his own experiences and interpretations may result in a conflict between these 'alternative frameworks' and later school science. It is often very difficult to change these ideas (Summers,1982), so the notion of merely building on previous experience may be too simplistic since it may be necessary for major revisions before satisfactory new learning can take place. Whatever the previous experience of students however the implication is that teachers must explore their ideas and beliefs with them before further learning is attempted.

'If we confront the world with an empty head, then our experience will be deservedly meaningless. Experience does not give concepts meaning, if anything concepts give experience meaning'(Theobold,1968).

The belief that all meaning is 'socially constructed' (Young,1971) and that truth/falsity are merely 'institutionalised conventions' is challenged by Hodson (1982) who believes that there are features in society which provide order and stability and it is this which enables teachers to present pupils with truth and meaning in science.

'The most important aspect of current British reappraisals of language and learning is the assertion that language is not just a vehicle for transfer of meaning, but also a means of creating it.....he (the learner) has to recreate this meaning for himself and that requires an active use of language and reflection on his own experience, with the help of concepts offered by the teacher.'(Sutton in Adey,1980,122)

The point made earlier about the inadequacy of presenting pupils with concepts and definitions is worth repeating since this makes science very much like history,'a study of the results and products of past efforts.'(Yager,1983,26) This is also a common method in textbooks, but what is required is repeated use of vocabulary in context so that the learner may develop a new network of meanings which can be integrated with previous knowledge.

Commenting on the differences between experience of an integrated course and a separate science course Brown(1974) suggests that the former may provide the learner with less information, but he may well be able to relate the various bits of information that he has to each other. Brown uses Bernstein's idea that instead of 'states of knowledge' the emphasis is on 'ways of knowing'.It is perhaps this aspect of integrated science which pupils find most difficult to comprehend since they have traditionally associated learning with learning a lot of facts often by rote methods.

'School learning has (or should have) little concern with real objects, but with concepts derived from them at different levels of abstraction. Wheeled trolleys are accelerated and rats are dissected, not because we want children to be knowledgeable about trolleys or the intestines of rats, but because they may be used conveniently to exemplify more general ideas.'(McClelland,1982a,158)

The extract below suggests that pupils do believe that teachers are concerned that they learn about trolleys and they seem to have failed to grasp the fact that it is the underlying principles which are important..

EXTRACT FROM FIFTH YEAR LESSON FIELD NOTES

'As the lesson drew to a close it was clear that neither of the groups of girls was going to have a full set of results and (the teacher) said that they should try to "describe" the patterns they would expect to find, or, if possible, use the data which other people had managed to collect. The table of data had to be completed for the next lesson. Equipment was put away and the lesson "wound down" without a definite conclusion or any attempt to review what had been achieved.'

This lesson had not started until 11.08 - eight minutes after its scheduled time and much of the equipment had been faulty.

The following comments were made by pupils about the lesson:

BET. What about the sort of thing you were doing yesterday, with the trolleys and things,I mean?

A. That's boring.

BET. You don't like that?

A. No, not really.

BET. Why do you think it's boring?

A. Well, you know what's going to happen sort of thing.

BET. You know what's going to happen.

A. Yes. So there's not much point in doing it really.

BET. You mean you could get the results without actually ....or you could...

B. As it was we didn't end up with any results because the ticker thing hadn't been working, so we're non-wiser anyway because we haven't got any results.

BET. I see.

B. You see so...

A. I mean half the time we're spending watching experiments that don't work.

BET. Is that because of faulty equipment or lack of time or because you haven't been listening properly and haven't done the job in the way that he wanted it to be done, or it might be all three.

B. All three. Yes.(Laughs rather nervously).

A. Yes, but most of the time like, most of the class is talking, no-one really listens to him.

BET. No-one listens. Why is that?

B. 'Cos he just...You can't concentrate on it. You see as soon...you try...(interrupted).

A. He...As soon as he starts talking your mind just wanders 'cos...

B. 'Cos you don't, 'cos it's not going in, 'cos you don't understand what he's on about. So as soon as that stops going in you lose concentration and then well...(mumbles last few words).

GIRLS' DISAFFECTION WITH SCIENCE OTHER SIGNS?

A common feature of lessons observed during the research, particularly those with fourth and fifth year pupils, was that they usually began well after the scheduled time, often between five and ten minutes late, but sometimes longer.

The reason was usually the late arrival of pupils to lessons and for the most part they were girls, but they were rarely questioned about this in front of the whole group and only once was a member of staff observed having a word in private. Equally when pupils walked into a lesson late they were never seen to apologise or explain where they had been.

One of the teachers explained that he felt that when pupils arrived late he was faced with the choice between making a major issue out of it or allowing the lesson to continue so that the group did not lose the thread by having to start again.

A second member of the department made the following remarks about the problem of lateness:

'...at the end of the morning break it's difficult to get punctuality, I mean kids wander in and frequently the lesson doesn't start until 11.05,well 5 minutes is a long time in a double practical, so it's a difficult one. I can see arguments both ways.I can see that we're supposed to be getting them to discipline themselves into good habits, therefore we shouldn't be ushering them here and there; but on the other hand if we did, if we had a very strict regime whereby they were expected to be at their lessons by one minute after the bell, lined-up quietly outside the room, no matter where it was, then every lesson would start better. It would be...start with a better atmosphere. How far you could push that one I don't know.'

The situation was all the more surprising since the department made a point during the first four years of making classes stand by their benches on entering the lab and waiting until they were greeted by the teacher before being seated. This exercise in class control and discipline was being eroded by the fourth year when late arrivals seemed to go unchecked.

The following extract exemplifies the problem:

EXTRACT FROM FIELD NOTES AT BEGINNING OF FIFTH YEAR LESSON

'The lesson began at about 11.05 with (the teacher) attempting to explain that because of the nature of the work it was difficult to establish a focal point in the room. (The group was not settled).

The boys had been noisy on arrival in the lab and 8 of them were grouped together on the benches closest to the front. The girls occupied the benches farthest from the blackboard largely in two groups, this was a consequence of the nature of the work, but there was a clear sex-split in the seating arrangements.

(The teacher) began to explain that the work was concerned with "Chnges in motion" or movement from place to place, but he was interrupted by eight girls who arrived for the lesson at 11.08. It was noticeable that this went by without comment from (the teacher).

As (the teacher) continued, one table of girls continued to chat and giggle making a fairly loud noise, again this went unchecked. (A girl) unwrapped a sweet and proceeded to eat it, whilst another girl chewed what appeared to be gum, despite the eating ban in the labs.

(The teacher) continued with his talk, but again it was noticeable that the girls were passive or simply not taking any notice; (two girls) were quite happy chatting and smiling, whilst any questions which were put to the group were answered by the boys, usually one or two word answers. After an answer (the teacher) would repeat the answer and then expand upon it, there was no further questioning or probing of understanding.With the exception of one occasion when he asked the girls to pay attention and listen (the teacher) appeared to ignore them and not make any attempt to actively involve even those who were passively listening to him.'

EXAMINATION PRESSURE AND RESPONSE TO IT

When examination pressures begin to build up, one strategy appears to be to laugh and joke about it, particularly when parents begin to transfer their own worries to the girls by insisting that they should always be working.

The joking and laughing does not prevent the girls from worrying, but it helps to disguise it and is seen to help them to cope with the pressure: it certainly seems to be successful in convincing some teachers that the girls are "not bothered".

BET. The exams are obviously looming large in your thinking at the moment aren't they?

A. I get worried, I get very panicky just before exams, but once I'm in the exam I'm fine, I can get on with it, but when I'm thinking about it I panic.

B. I'm just like that. You get to the point where everybody's reminding us all the time. You come to school and you get told that your exams are there.

A. You can't get away from it though.

B. I go home and my mother tells me I should be working. I say, "I've only come down for a cup of coffee". "You should be upstairs doing homework."

BET. You're feeling the pressure?

C. Yes.

A. At the moment.

B. I've been having this earache since October. (NB. "earache" is a colloquial expression for constant nagging.)

A. Yes. I have.

B. "You should start revising."

A. (Deputy Head) was counting the days. My mother goes: "Well your brother got eight O levels, your cousin got ten". I mean God, she's really getting at me.

B. My mother keeps telling me I'm the brightest in the family.

A. "And your cousin got four A levels at "A" passes, and things like this. "You should be revising all over Christmas, you shouldn't be enjoying yourself." Ah! God she expects me to spend my whole life in my bedroom just working and working.
"You don't need your social life anymore. You should be working and working", and to a certain degree I can do that, but I can't do it all the time, I have to have some breaks.

C. During the week it's alright.

A. During the week, but not...

B. My mum and dad have been alright. I don't know, I've stayed in, you know, most of the time, I don't..., They never had to say, you know, "Go and do your homework", I've always gone up and done it, and when I get into it I'm alright. But my mum, she knew I was working, but she worried, she kept saying, "Are you doing it right?", this kind of thing 'cos she was worried. She worries more than me. She doesn't think I'm worried about them, I am, but I don't make a big thing out of it. I have a joke about it.

C. Yes, I'm like that.

BET. Yes, you can worry inside can't you. You can worry inside yourself.

C. Yes, I worry at night in bed, but like my mum, you know she'll sit there and I laugh at her and she'll say, "But (girl's name) it is very important", and I'll say, "Oh, yes. I know Mum", and I'll laugh, but I know it is, it's just that she goes on.

C. I mean you get it all at school and then you get it when you get home.

The pressures of examinations appear to build up during the fourth year when teachers are constantly reminding pupils that the time is running out and more and more effort is devoted to simply getting as much of the syllabus covered as possible. The pressure described by the girls applies equally to boys, but their reaction , in conversation, was rather more phlegmatic and matter of fact.

With this type of pressure being exerted by parents and teachers it is perhaps not surprising if the pupils believe that the solution lies in memorizing facts and are rather disappointed that much of the written work they do in science does not give them that type of information which can be memorized for use in examinations.

Although the department had not been specifically criticised by HMI over examination results, the fact that a general reference had been made seemed to have made some of the teachers very sensitive to the issue. Parents, on the other hand, were concerned that their children should succeed in their examinations, not apparently, because of any intrinsic worth which they saw in the subject, but because of its utilitarian value in terms of helping them to get a job or a place in the next stage of their education.

To ease the pressure which they felt in school, one group of girls explained how they would go off in a group at break or lunch times and do something to ease the tension. This also occurred when one of their friends was upset about something, they made a point of joking so that their friend would forget about it.

BET. Do you think the teachers are aware of the amount of worrying that you do?

A/C. No.

B. No. Not at all.

C. I think they say, "Oh, we've all been through it", and I think (girl's name) is right. I think they think we don't care because we kind of laugh at school, but I think if that's our way, you can't get rid of it, we laugh together. I think all of us are worried...

C. But you just don't want to show it.

B. ...but you just don't want to think...Like at break and dinnertime and that we just kind of act daft.

A. Whenever one of us is upset about something we always go on joking so they forget about it, no point in getting upset. "Right, we're going to go and do this", and do something stupid out side.

C. I mean why be miserable.

Pupils obviously enjoy being together in each other's company, but this friendship and companionship has a utilitarian purpose in that it helps them to keep the pressures of school work in perspective and provides a safety valve for their emotions. It protects, helps to increase self- image and is the basic requirement for beginning to cope. (Davies, 1980; Measor and Woods, 1982).

SOME THOUGHTS ON RELATIONSHIPS BETWEEN TEACHERS AND GIRLS IN SCIENCE

BET. Do you feel that you have a different relationship with the boys and girls and if so why and how does it manifest itself?

T. Well I try to be as unisex as possible. I also try not to favour any individual, I've always endeavoured never to favour anyone and I try not to favour the boys or the girls, treat them all alike. But nevertheless there are differences, but I don't conciously alter my approach, because I look at them as individuals a lot of the boys are 'girls'...(a few words lost on tape here)...a lot of the girls are quite 'boyish'. I tend to be slightly less tolerant with silliness in girls, which is rather different from what I call immature stupidity in boys.

AS. Why is that?

T. I don't really know. When they get to that age I just think they should have got over it actually because, going back to when the school-leaving age was a year younger, we somehow managed to get, seemed to get rid of a lot of that before they left school, we don't seem to be able to do it now.

I'm just intolerant to it really, I've got to fight this intolerance, it shouldn't be there, it just interferes with teaching at this stage.

AS. Do you feel..

T. Girls are silly because...I think they're vying with one another and... about sex escapades and that sort of thing and parties, they seem to have parties all the year round now. They're always more interested - certain groups are more interested- in their own silly selfish concerns rather than getting involved in the lesson. I'm very much aware of that. It niggles me.

AS. How does it manifest itself? In the combing of hair and things like that?

T. It varies. At certain times of the year it's rubbing 'lypsil' on their lips, that annoys me, that becomes more important, this daubing 'lypsil' on their lips, than anything else. And the boys, their silliness will show itself in prodding or proddling. I think on the boys..(a few words lost here)..they've got to mess about, make a joke out of things.

BET. Do you feel that's anything to do with insecurity or feeling of inadequacy or whatever?

T. I wouldn't have thougnt so...shouldn't be... don't know what it is...anyhow they're just personal niggles really which I've got to fight when I'm teaching that's all...

There was only one occasion during the observations when a teacher spoke harshly to a girl and it occurred during a lesson on the dissection of a sheep's eyeball. The group of girls were laughing and giggling quite excitedly:

T. Alright,alright, don't be silly... (girl's name) (the tone was sharp).

A. What? (Hurt tone)

T. Everytime I look round I see your grinning inane face. Now will you just settle down.

A. (Quietly) I'm just a happy person.

Later during the same lesson the teacher moves back to the same group of girls:

B. Don't squash his eyeball.

T. What's the matter? (Slight irritation)

A. Look don't. Will you leave it. (As teacher tries to help her.) No! I'll do it in my own time. (Note of panic in her voice - does not like handling the eye.)

T. What's that? Come here.Come here. (Girl has begun to move away). What's that? (Girl still protesting.)

A. Bottom of your eye.

C. That's your eyeball.

A. Oh! Your eyelid.

T. An eyelid.

A. I don't know how you can touch it.

T. What do you think that stuff is?

A. Is that like the retina?

T. No. That's...

A. Skin.

T. That stuff...Look at it...You've worked in the kitchen haven't you and you've seen stuff like that. (Would this have been said to a boy?)

A. Muscle...Skin...Fat.

T. What are those bits of..This stuff...Look.

A. Meat.

T. Yes, bits of fibrous meat...Look, you've seen it. What's meat? What's meat?

A. Flesh.

T. Flesh. What's flesh?

A. Part of the body.

T. It's muscle. Meat is muscle.

During this exchange the teacher was growing more impatient with the girl's inability to comprehend what he wanted her to see, possibly so much so that he missed the reply when she gave the answer he was searching for as she poured out a string of words she thought might be relevant.

The exchange ended when the teacher admitted defeat and supplied the answer himself.

Girls seem to be affected much more than boys by a change of teacher and also by the personality of the teacher who takes them: boys are much more inclined to accept it and make the best of it without too much complaining.

Once a poor relationship has been established between a girl and a teacher then it appears to be unusual for the situation to improve sufficiently for the girl to take full advantage of the subject. Similarly in tightly knit groups of girls it may be that if one of them does not get on with a particular teacher it may influence the way the other girls react to that teacher.

On one occasion a member of the department who had had problems with one particuar girl over an extended period had another confrontation during the showing of a film. The girl had been moved into a different teaching group, so that she and the teacher seldom met, but on this occasion the teacher was taking two groups to cover for an absent colleague.

Another girl explained how her relationship with one of the teachers had deteriorated:

"I started off good in the second and third year, I got (teacher's name) and then I went straight down...and we just clashed straight off and I started, my work started to go downhill and then he started to pick on me so I started to rebel back and not do any work and what I did was very little...

He seems to get on better with all the boys than perhaps he does with the girls. You see the thing is I'm not one of those people who can listen straight off and understand it. I can't understand it straight away if it's something like... motors. I mean that completely confuses me, so I ask him to explain it again and he gets a whizz on with me and "You're not listening to me. You're not doing this", so I just give over. And that's how it started, that's why I didn't work after that, because everytime I asked he used to get narked with me....

There have been times when I've really tried in science. I've listened to him and I've understood the work and I've got on and still he finds something to pick at me with. (Note of despair in her voice.) Like that day we were doing the eyes, I was trying to work then, he still found something to come over and complain to me about even though I wasn't doing anything."

The girl's friends were quick to point out what they saw as the injustice of some of the punishments which their friend received when they were themselves doing exactly the same things and went unpunished: such incidents might take place in lessons, but were equally likely at anytime about the school.

Similarly the girls felt that their group was often singled out for special treatment by the teacher:

"You see we can be in class, right, and there'll be our group talking, there'll be the boys (missing word) and there'll be the boys on the opposite side talking and them lot talking and the only group that gets flipping told off is us lot isn't it? It is. He always picks on our table for talking:

'You lot are talking'

'Well what about the lads?'

'They're not'.

He annoys me."

Staff were reported as acting differently to being asked to repeat what they had done. Often the reaction would depend upon the time of day. On Friday afternoon it would often result in the teacher getting in a "nark", whereas in the middle of the week it was quite likely that the teacher would repeat the information. Reaction also depended upon how often the same person asked for the same explanation - three or four times was usually regarded as too much, in which case the best thing to do was to pretend to understand it, "then they'd forget about you".

An alternative strategy was explained this way:

"Like it's best to say, 'Oh! So it's such and such", and kind of have a rough guess at it because if you say, 'What's ', you know, 'Could you just explain that again', you know he might get a rat on, because he thinks you haven't been listening".

In these situations the girls have worked out that a direct request for assistance is likely to result in a rebuke for not paying attention, so they modify the request by forming it in such a way that if they are wrong the teacher will tell them and will probably supply the right answer, but is less likely to be annoyed with them.

A good many of the girls' reactions to their teachers centre around the teachers' ability to make the work clear and understandable.(See Chapter VI Language and Science). But there are other important characteristics such as humour:

A. I started to like science when we had (teacher's name) because he made it a laugh and ,I don't know, he made it...you started listening because you know he kept making jokes and that, and it made it a lot more enjoyable, and then we had (different teacher) and I couldn't understand a word he was on about it, what he was on about.

B. He's boring though.

A. Yes. He's got a very droll voice, he doesn't put any expression in it, but I mean as I started getting better at it, I liked it more and you know, I mean, I get on alright with him.

There seems to be a contradiction here as the girl says that she could not understand the second teacher and yet her work began to improve. Does this mean that she made a conscious effort not to let the feelings she had about her teacher interfere with her using him as a learning resource?

Later the same group of girls made the following comments:

A. That's another thing, I wish he'd smile more, he's a bit...If he laughs we say, "Oh! You're smiling", you know.

(Laughter drowns out another comment.)

It's not very often. Like with some teachers it's better to...

B. I mean if he's more friendly towards you and we can be more friendly back...

A. We'll have a better relationship with him.

B. Yes.

C. I mean all he talks about is science, science, science all the time.

BET. So you've never actually been able to have a discussion about it and try to sort the whole problem out?

B. Never.

C. Never with ( teacher's name) because he's not the type is he?

B. Never..He feels..(several voices at once not transcribable).

C. He thinks we're there to understand it and get on with the work and if we don't we've had it.

The implication behind this conversation seems to be that the girls believe that there should be more to a relationship between a teacher and his pupils than a subject if it is to be successful. Humour is important as is the ability to relax and show some warmth of personality: single mindedness does not appear to be a quality thay appreciate or admire.

What comes out of this and preceding chapters suggests that curriculum development and evaluation involve very much more than subject content. To be successful in curriculum development teachers must be prepared to analyse every aspect of their work in the classroom and analysis of content may well form a very small percentage of the work involved in this task.

A certain amount of analysis can be achieved by the individual teacher on his own, but to be thorough there is probably a need for additional help which might come from a variety of sources. The teacher's task is too involved and too time consuming for the individual to attempt to do it alone - too much would be missed, not deliberately, but because it is familiar and may not be considered important. The experienced 'outside' observer using audio and video tape recordings would be able to catch these moments and feed them back as discussion points to illuminate current practice. This method can often reveal how what we think is happening may be quite wrong and not really what was intended at all.

# CHAPTER VIII

# DISCUSSION AND FINDINGS OF THE EVALUATION

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## FINDINGS OF THE EVALUATION

One of the most striking features of the science department is the level of commitment to the teaching of science expressed through corporate activity. If the department maintains a certain degree of isolation from the rest of the school staff it is because they have found that their job satisfaction is to be obtained within the department rather than in the wider school environment: the way they function as teachers also demands that they spend a lot of time together, formally and informally, planning and assessing both the work and the pupils.

These findings and thoughts are addressed primarily to the teachers in the department in the hope that they will not see them as being critical in any respect, since the task of this research was to describe and interpret their roles as actors, not to judge them as people or as teachers. It is hoped that these remarks will cause them to reflect upon what they are doing and perhaps they might gain fresh insights into their work.

It might be a useful exercise for the department to consider whether the courses it offers and the teaching methods used do in fact meet the needs of a comprehensive intake. It could be that when courses are built "downwards" from the most able they do not achieve as much as those which are initially developed to meet the needs of the least-able and are then extended upwards throughout the ability range.

FIRST YEAR SCIENCE - THE NEW NUFFIELD COMBINED SCIENCE PROJECT

As the project has been running for a very brief period and then only in its trial version it is perhaps too early to make anything other than general remarks, but there are features which are disturbing and which do merit some comment.

It would be a great pity if the course which has generated so much enthusiasum within the department and amongst pupils of all abilities was to become just another proving-ground for the science elite because of its tendency to high flown scientific language, and to some extent, 'gimmickry' instead of concentrating its efforts on teaching about the skills and processes of science, which is what young people probably need if they are to be motivated towards science.

Within the department there appears to be a range of views about pupils' previous experience. The Head of Department is very concerned that pupils may be taught "wrong" science and would therefore be better off without any science teaching since it is very difficult to "unlearn". Another member of the department was equally concerned that teachers should use the "innate" knowledge which the pupils brought to school. This issue is one which generates a great deal of discussion in science education and might well be addressed by the department to good effect.

'Get a child to observe carefully and describe clearly how a frog eats a worm or how a rubber ball bounces and you have given him some scientific education of much higher merit than if he had learned how to determine precisely the pH of a solution with a hydrogen electrode...'(Bibby,1974,20)

During the lessons observed, pupils had some opportunities to talk with each other and to a limited extent with their teachers about what they were doing, so to a degree they were using and developing their own thinking skills through the language of their everyday world, but this process was seriously threatened when they were confronted by the project readers.

When this occurred the pupils' attitude seemed to undergo a dramatic change: instead of the teacher being regarded as a guide and counsellor as he was during the practical lessons when pupils were able to respond through a shared learning experience, here the teacher resumed the traditional role of one who possesses all the skills and knowledge. The teacher was now asking very difficult questions in a language they could barely comprehend and he often seemed to be making reading demands which were beyond their ability level. The children often looked confused and not a little frightened.

The textbooks as was mentioned earlier, are written in a language which is way beyond the grasp of most of these

11-12 year old pupils and to make such texts such an integral part of the course design would not seem to do a great deal to serve the cause of science education. It must be remembered that these children have moved from small primary schools and have high expectations of the school science laboratory: expectations which, if they are met at this age may well lead to greater scientific interest later. As Bibby (1974) points out facts learned at school are mostly forgotten within a short space of time. What is the educational justification for the inclusion of any material? The only justification must be if it encourages and assists in the learning process and the development of cognitive skills. Some children would get little from these Combined Science texts in these terms:for many it would be the small amount which might be gleaned from looking at the pictures.

The teachers involved with the course were generally working very closely to the project brief, believing that this was the only way to give valid feedback, but they were acutely aware of the fact that most lessons were too crowded for satisfactory learning. The pace at which they were expected to cover the work left little opportunity for checking that instructions were fully understood or for allowing pupils to develop their own ideas through questions and answers during whole or small group sessions. The amount of work expected of pupils during practical lessons was unrealistic if they were to have time to record their findings, reflect on what they had achieved and try to reach some general conclusions. The most common feature of most of the lessons was that the reflection and the drawing of conclusions were ommitted because time had run out, so probably the most valuable part of the lesson was lost. It is doubtful whether work could be followed-up with the same effect during the next lesson because the immediacy of this shared experience had been lost and could not be effectively reinforced. Completing work at home does not seem to be a substitute for being part of a group which can share its experiences and draw upon the skill of the teacher. Perhaps a consequence of this lack of discussion was that the notebooks, regarded by the project as an important feature of the work, were not being as carefully and accurately written as perhaps they might have been if more time had been available for discussion about how to produce a report in clear and concise language.

The department had obviously geared its approach to the project to fit the style of working which they used with other yeargroups and which had evolved from the early use of Combined Science and SCISP courses. It may be that the approach which was suitable in the early 70's is not entirely suitable for the 80's: perhaps the methods forged from the innovation of SCISP have become the orthodoxy which needs to be re-examined and perhaps re-shaped to meet changing demands.

It might be useful for the department to reflect upon whether the teaching styles used encourage or inhibit pupil to the extent that they may be so concerned with gaining teacher approval that the true enjoyment and excitement of science is being lost.

'Systems that don't reflect upon and learn from their experiences die, or at least start going backwards' (Kushner and Logan, 1984).

A similar point is made by Waring (1979) who suggests that 'schools and the teachers within them gradually accomodate themselves to a state of equilibrium (which is possibly unique for each school and for each class and teacher) within the context of a relatively stable body of ideas about how and what to teach'.

Self-evaluation is a central feature of the work of the department as it goes about its normal work and as such it is never static therefore the Combined Science will not be simply accepted, but will be subjected to frequent change following the trial period. But this does not necessarily provide the impetus which the department perhaps needs to stand back and look at curriculum development in the way that Stenhouse (1975) envisaged when he suggested that it should include much more than the subject. He would include the responses which the various participants make towards it and their interactions with each other, so that the product of development and evaluation are part of the same process, always changing. It is unlikely that tests and assessments will provide deep insight into the way that mixed-ability groups respond to the course. A more thorough investigation of pupils' responses and their cognitive and affective development is needed if the evaluation is to rise above the stimulus/response type of assessment.

The attitudes of the junior pupils towards science seem to reveal little evidence of the bias or sex steriotyping which are so often reported. It will be interesting to see whether this changes as these pupils go through the adolescent period when science becomes more academic and more demanding.

LANGUAGE AND UNDERSTANDING

Many factors appear to affect pupils' ability to reach understanding in science and they talk about them in a number of ways.

There is feeling amongst both boys and girls that the way science lessons are structured prevents them from achieving full understanding. This point was borne out by observation which revealed that most practical work had to be rushed so that it was not possible for pupils to spend time with their peers analysing and recording their results. It may be that on some occasions the size of the groups is a contributory factor particularly when equipment and apparatus has to be shared, or when classes have to work in large groups.

Much of the recording and analysis has to be done at home, but this might lead to pupils drawing incorrect conclusions paricularly since there was little evidence of pupils making notes during lessons. A great deal of what was produced in exercise books must have relied upon memory. Equally working at home deprived the pupils of the opportunity to develop and organise their understanding through the medium of exchange of ideas with their peers in much the same way that this affected younger pupils.

The department places a great deal of emphasis and faith in the assessment tests as a method of diagnosing errors in pupils' thinking and they follow up with review lessons. Pupils did not express the same faith in this method because they claimed that anything missed or not understood during the lesson was a chance gone. This may well be seen as a somewhat dramatic reaction but no additions or alterations to pupils' notebooks were noted, and since so much of the work was incomplete it must have been difficult for them to revise effectively.

In the main textbooks are used very selectively by the department, simply because most of them, as has been shown, are far too difficult for a large number of pupils, even those in the top ability set, so reading them would add little of value to their studies.Readability studies have in fact revealed that many factors other than language difficulty can affect a pupil's disposition to reading and where motivation is high it is possible to read a a higher level than might normally be expected. The whole question of readability might be a fruitful one for the department to explore since the lack of science reading is a cause for serious concern, not only in relation to their academic progress, but because pupils are not able to develop the reading skills which are necessary to take full advantage of the vast wealth of information in books, journals and newspapers. One question which might well be addressed is whether the paucity of suitable textbook material is sufficient reason for restricting pupils' exposure to scientific language in this form. Clearly 'home-made' materials can be equally difficult as has been shown, but at least there is the chance to do something about altering the reading levels of worksheets to make them more accessible without making them inappropriate in the learning situation. The wide ability-span within many science groups suggests that attempts to solve the problems of access to the language of science whether in written or oral form is a matter of fundamental importance to the department.

The great value which many pupils place on practical work is that they are able to understand and grasp scientific ideas much more easily when they can see for themselves rather than by receiving a verbal explanation second-hand. However some boys expressed the view that practical lessons were so tightly structured that they really couldn't go wrong, so that there was a feeling that much of the excitement had been taken out of the work: the investigative aspect was further denied them by the knowledge that if they went wrong the answers would be provided on the blackboard or they would be invited to copy results obtained by other pupils. A complaint was made that often results appeared on the blackboard before they had had the opportunity to consider their own findings. This suggests that results may become the essential feature of the lessons rather than analysis of the procedures involved, discussion of what pupils have observed or what patterns are beginning to emerge. The searching for 'right' answers is more applicable to the objectives model of curriculum rather than one concerned with processes of knowing. The pupils do not seem to appreciate the changing nature of knowledge or the fact that they are not being taught permanent truths.

In order to create the extra time needed for practical work, pupils suggest that teachers spend less time in whole group explanations and devote more time and attention to individual and small group discussion as a way of helping those pupils who have difficulty grasping the purpose of the lesson. Whatever the circumstances however, it seems essential that teachers should encourage pupils to talk about their problems as a means to achieving comprehension and the teacher could carefully modify his own explanations by providing the pupil with everyday examples whenever possible. The use of analogy appeared to be useful in this respect.

Some pupils were very conscious of the need to be treated as individuals: they recognised that they were all different with different levels of ability and did not wish to be treated as one amorphous mass.

A group of boys explained how they relied on one of their friends to explain the work to them because he used language they could understand.

In their report on the science department HMI made the following comments:

'In most ways these programmes match the abilities and interests of pupils in the school. There is always value in reviewing regularly the courses, the suitability of the aims and objectives and the appropriateness of their content. In particular the teaching styles need to be carefully considered. Although thought has undoubtedly already gone into this, it was difficult to ascertain the main purpose of some lessons despite the careful preparation which had been carried out.'(Report of HMI Inspection of the School, 1984).

These critical comments about teaching styles in the department are not easy to interpret, but after a period of observation a view might be that there is a feeling of 'sameness', so that after a while there is a searching for the unexpected and the exciting. Perhaps it was this absence of the unusual, the unexpected or the challenging which prompted HMI to make their remarks.The programme of lessons is rich in variety: teacher exposition, teacher demonstration, use of films, small group practical work, use of a variety of worksheets and some use of textbook materials; but the spark which generates great enthusiasum and interest in science seems to be missing.

HMI made the comment that pupils were unduly passive and this was certainly a noticeable feature of some of the lessons observed and it is perhaps in this area of pupil involvement where the key to HMI remarks might be found. Pupils are not involved in designing experiments since all the schedules are carefully prepared by the staff and all the practical requirements are met beforehand by the technicians. If a topic generates some interest there does not seem to be a mechanism for extending the investigations outside the normal schedule, so perhaps it is spontaineity which is missing.

'To arrange a topic which meets the four conditions (for discussion - nature of the problem, status of group members, size of the group and motivation) almost inevitably means having different groups doing different things on open-ended and therefore different time-scales which is very difficult to reconcile with a strict timetable and whole-class progress through a tightly scheduled syllabus.' (McClelland, 1983, 131)

This somewhat surprising feature of pupil comment showed that so far as SCISP is concerned they do not seem to appreciate the rationale behind the course even when they are well into their fifth year which perhaps throws a question mark over the concept SCISP for all but the most-able.

It was the frequency with which topics changed, the sequence of work and the fact that pupils were often unable to recognise the links between the different sections which caused confusion and led to the desire for the separation of the course into sections clearly associated with the traditional sciences. Teachers might lay the blame for this on those parents who still talk in terms of separate sciences to their children, but by now the school should have been able to disseminate the message of SCISP widely enough to counter such views. The Head of Department certainly felt that, for a school which has so obviously shown that 'science for all' is a central policy, there has not been very much done by the management of the school to 'sell' the idea to the public at large. Perhaps the fact that the other departments in the school are so clearly 'labelled' in subject terms makes the task of a lone integrated department that much more difficult. It might be that more strenuous efforts to involve other departments in the work in science and for them to become involved outside their own area would help to show that boundaries may well be regarded as an artefact created in order to try to produce neat packages of knowledge. Certainly conversations with pupils revealed a strong tendency to refer to the separate sciences when they were discussing their work so the process of compartmentalisation appears to be firmly implanted in their minds. The suggestion that the cause is to be found in the way in which parents talk about science is perhaps too convenient and one must question the depth of understanding which is being and can be achieved by most pupils.

The problem of pupils' ability to access scientific language through lessons, textbooks and worksheets is recognised by the department, but as yet it does not seem to have assumed large enough proportions to become a matter of serious concern.

GIRLS IN SCIENCE

Evidence of some of the views expressed by girls during interviews , in pupil profiles and the questionnaire appears at first sight to indicate a gradual, but growing rejection of science, but this may not be an accurate reflection of their real feelings.

Though it is clear from the examination results (See Appendix G) that girls do not achieve the same level of success as boys, the reasons for this are far from easy to determine and as we have seen earlier it may not be a question of anything more than the fact that examination success is not given a high priority by many girls, or it may be towards a more fundamental level that the department might direct its attention.

When girls are critical of science and science teachers it often appears to be because they would like to see changes which would allow them to enjoy science more than they do at present. They claim to want to understand, but are often unable to do so because the language does not allow them to create meaning and they are not able to do this without talk: talk with each other and with the teacher. Talk does take place, indeed there is a good deal of it, but often much of it is not work related or it does not take place at the point where it is most needed, towards the end of the lesson, since most lessons end abruptly without a conclusion or time for summing-up what has been achieved. Without this time for analysis and reflective thought it is likely that pupils will fall back on rote learning of the concepts and definitions without really integrating them into their knowledge systems and without developing real understanding.

The point made by some pupils about the volume of information which teachers often include in their lessons was verified during observations. The central thread of lessons was difficult to follow and it might be that shorter and more precise explanations would create less difficulty providing an opportunity for subsequent expansion of the ideas.

The girls claim to learn best when they are 'doing' something in a practical sense, but the problems at present are this lack of time or the fact that for a variety of reasons experiments go wrong, which then makes the work 'boring'. Many girls seem not to have learnt that failure may be a useful part of the learning process; they have not grasped the basic idea that in scientific investigation it is sometimes necessary to repeat experiments if patterns are to be allowed to emerge. They have not recognised that this is not 'boring' but is an essential feature in the search for scientific truth. Equally it could be stated that without the loss of so much time at the beginning of lessons when the girls themselves are often late there might well be more time available for a more structured conclusion to lessons.

Although there were few signs of differentiation of treatment of girls during science lessons, and the fact that examples used in the teaching did not show evidence of sex-stereotyping, there still appeared to be a problem for some teachers in dealing with girls. Most of the disciplinary problems which arose involved groups of girls who clashed with some teachers on a regular basis and the staff showed considerable antagonism towards them in the privacy of the staffroom or the prep room. The staff did not seem to consider that a less confrontational approach might be beneficial to all concerned.

The feeling that girls have about wanting closer and friendlier relationships with teachers seems to be quite strong: they want understanding from their teachers even if they are not able to share with the boys the same degree of interest and excitement about some topics, but as much as anything they want warmth and humour in lessons to lighten the academic slog.

'Jokes can humanise a teacher, transforming him from an official to a person in the eye of the pupils. Humour is also an important means of communication with pupils who inhabit different cultures from that of the teacher. Only by the teacher accepting jokes and taunts from pupils, encouraging the comic, can he signal the acceptance of diverse cultures, in some of which joking is an essential feature of everyday life. This is one way in which school knowledge and everyday experience can be brought together and learning enhanced.' (Walker and Goodson cited in Woods and Hammersley, 1977)

Many girls express an interest in broader social and moral issues in science as well as a keen interest in the 'nurturant' aspects of biological science because such topics are seen to be 'real' problems which directly relate to people.

As one girl explained:

'The longer questions in the exam, where they don't actually refer to something you've done in class, but they take what you did and put it in a different situation, now I can crack on with them like a good 'un'....It's me alone on this paper not someone saying well this is how you do it on the board...'.

Several writers, in emphasising the differences between boys and girls, mention the value which girls place on communication and caring. Smail (1984) suggests that girls interpret the world through its effects on relationships which are developed and they do not abstract events from their context as readily.

In advocating a change in emphasis in science from 'analysis' towards 'caring', Smail is not suggesting the total abandonment of analysis in favour of pure description, but rather that 'the "science skeleton" should have more flesh on its bones so that synthesis of "male" and "female" characteristics is achieved' (Smail, 1984).

This caring attitude was exemplified by a girl who described how she had watched a television programme concerned with the effects of high-voltage electricity cables, which appear to be having serious effects on the health of people living in the vicinity. The girl had become quite incensed as she explained that there appeared to be some sort of official cover-up aimed at preventing the full story being revealed. In normal circumstances this girl, who is very intelligent, had no real interest in the science programme because she could not see where it was going, but these broader scientific issues were what she was concerned about.

If we accept that this may be true of many girls and if we note the findings of the questionnaire (See Appendix I) which shows that girls inclinations in science are towards the practical rather than the abstract-theoretical learning, then it may be that we can accept the Head of Department's assertion that:

'Probably the benefits of this kind of approach will not be shown in exam results, they'll be shown in them as people in about ten years time.'

There seems to be a dichotomy and conflict between the investigative/practical approach to science which the department adopts and the stronger theoretical and abstract context of the examinations and one wonders what would be the consequences of the department pursuing its natural inclinations more strongly by not giving so much emphasis to the abstract concepts and simply allowing the examinations to find their own position within the framework of science education. Such a move would demand great courage and conviction, but it might produce more young people with a love and enjoyment of science.

It might also be that a change in emphasis towards a more female orientated approach to science would help to reduce many of the department's difficulties with girls: declining interest in science after the third year, late arrival at lessons and the problem of girls forming themselves into small pockets of formenting disenchantment.

There seems to be some evidence that the practice of changing science teachers at the end of the third year has an effect on the girls' attitudes and it may be that this 'tradition' developed over the years has taken precedence over other educational considerations.

Associated with the preference for a more practical/non-theoretical approach to science, is the fact that there is a general belief that girls do not have the spatial ability with which boys seem to be endowed. Whether the reasons are biological or sociological is probably immaterial in terms of making an attempt to provide remedial help. There does seem to be a case for suggesting that there might be closer links with primary schools in an attempt to place greater importance upon the acquisition of skills associated with an enjoyment of science such as three-dimensional work and mechanical model-making.

## THE COMPLEXITIES OF CLASSROOM INTERACTION

'..a classroom is an environment...the way it is organised carries the burden of what people will learn from it' (Postman and Weingartner, 1971, 29).

There is a complex and continuous process of negotiation going on in the classroom as both pupils and teachers assess and judge the mood of the other before deciding on what course of action to take.

Teachers adapt their responses and behaviour according to the situation which confronts them during each lesson. However a more difficult phenomenon to explain is that of pupil-group behaviour in the classroom where there does not appear to be any premeditation. This type of behaviour is not easily understood since it can arise one day apparently spontaneously and yet another day the group will behave quite normally.

When teachers discussed their groups they often gave the impression that when behaviour did not conform to an accepted norm the whole group was involved, but the question which must be asked was whether it was in fact a whole group phenomenon or whether it was the influence of a powerful sub-group which was able to dominate the lesson and generate this feeling of apparent unity.

'We have studies of teacher strategies and of pupil strategies but nothing so far as I am aware on patterns of relationships between the two beyond the vague concept of negotiation' (Hammersley cited in Hull, 1985, 5).

At other times it is quite clear that one small group of pupils may behave quite separately from the rest of the group and teachers tend to imagine that without such pupils the working atmosphere would improve, but then it is not known whether their absence would simply allow another dominant group to emerge.

Certainly there were several occasions when the point was made that whole groups arrived at lessons in a very 'high' condition apparently because they had been released from another lesson which had generated great excitement so that the teacher faced with this situation had first to try to establish a working atmosphere.

This delicate process of negotiation could be affected by many factors. Bad weather, particularly when snow threatened, usually resulted in classes being unsettled because they were uncertain about whether they would get home. High winds seemed to have a very unsettling effect upon classes and tended to make them more noisy.

Over a period of weeks the department was involved in a long dispute with the Headmaster over the allocation of technician-time and on one occasion the Head of Department arrived twenty minutes late for his lesson and was clearly very angry - that particular lesson went very smoothly perhaps because the class was not prepared to risk a confrontation. On another occasion an unscheduled medical inspection disrupted a lesson as pupils were called out at intervals and then returned eager to tell everyone what had happened. Industrial action by teachers affected lunchtime supervision so that pupils were often in a more highly excited state than normal when school resumed and staff then had to spend time settling them to work.

Each time there is an unusual occurrence in the classroom, even something as simple as another teacher entering the room, the process of negotiation has to begin again. Each side has its own expectations of a lesson and work can only proceed in a satisfactory way when both agree on a state of equilibrium which will hold until something occurs which once again tips the balance. Teachers have their own ways of dealing with groups and in much the same way pupils establish methods by which they can deal with the teacher. One teacher admitted that one of his 'coping strategies' took the form of 'bending the rules' until he and the pupils had accepted a workable compromise. Of course there can be occasions when the teacher simply uses his position of authority to maintain order and his version of a suitable working atmosphere, but this is temporary because any attempt to sustain such a regime on a permanent basis would risk a permanent breakdown in relationships.

'The message is communicated quietly, insidiously, relentlessly and effectively through the role of the teacher, the role of the student, the rules of their verbal game, the rights that are assigned, the arrangements made for communication, the 'doings' that are praised or censured'(Postman and Weingartner, 1971, 33).

An element in this negotiation between pupil and teacher could come from the use of the profile report, if it was seen as a point of contact. (See Appendix F) Pupils could express their feelings about the course and the teacher could express opinions about the pupil's reactions to it, but there should perhaps be a point where the two meet to discuss what each has written so that it forms part of a two-way learning process, rather than merely being a catalogue of negative remarks as it very often appeared to be, since this might only generate animosity and ill-feeling on both sides.

In a seminal paper on pupil involvement in curriculum development and innovation, Hull (1985) describes methods by which teachers and pupils might come together to analyse the task of classroom management, and the introduction of innovatory teaching practices.

Video tapes of current school practice and of the innovation as it was practised elsewhere were shown:

'Discussions which followed the feedback sessions were incisively analytical with respect both to their own practice and that of children and teachers in the other school' (Hull, 1985, 3);

this apparently confirmed the research hypothesis that, 'pupils could join with their teachers in critical appraisal of the aims and implications of new forms of school work and that such discussion did prove to facilitate implementation of innovation in the classroom.' (ibid p.3)

The logical extension of this research was to involve teachers and pupils in the analysis of the normal classroom situation in the hope that it would create the essential link between teaching and learning, which together are education.

The capacity of pupils to be constructively analytical about their learning experiences seemed to be demonstrated during the present research. Pupils did not appear to be merely acting a part or playing a game, but were genuinely pleased to be able to talk openly and freely about their lives in school: the noticeable feature was that they were anxious that their teachers should be allowed to read their comments.

It is clear that this would have been a much more potent exercise if both groups had been able to watch examples of classroom interaction together making comments to each other perhaps through a 'neutral' chairman.

Much of the research was done with small easily identified groups of pupils who were to some extent regarded by some teachers as non-cooperative and disruptive, but Hull cites

Bruner's view that such behaviour is itself a form of communication since the classroom often allows them no other avenue for a 'critique of classroom experience'(Hull,1985,5) - what Bruner called 'enactive negotiation'.

Hull's findings seem to be similar to those of the this study:

'Pupils do, indeed, 'grow' into valued and responsible colleagues when they are provided with the opportunity to do so by their teachers. Furthermore the pupils who appear to 'grow' most readily when they are accorded collegual status tend to be those who conventionally make up the front line of disaffection. The single clearest outcome of both studies to date is that pupils who are characteristically 'disruptive' in classes turn out to be the most penetratingly analytical members of the researching class.'(Hull,1985,5)

It may be that the groups of pupils chosen for interview in the present research had, by their behaviour during lessons, helped to confirm some subconscious ideas held by the writer. The views they express may not only reflect their own bias, but also that of the writer. It is hoped however that this research will inspire critical self-analysis within the department. If as a result of that exercise the department concludes that the findings are not an accurate reflection of the situation then at the very least it will have focussed minds upon a number of central issues.

Observation in the classroom cannot provide a full picture of events any more than a camera lens can show everything. The observer selects what he considers to be important or significant and in so doing may reject or miss much that may be regarded as being equally important. In the classroom it is impossible to concentrate upon the speech and actions of the teacher whilst simultaneously recording the reactions and remarks of all pupils. Any record may be regarded as a caricature or sketch which, if skillfully drawn, will illuminate the essential features of the classroom and sharpen the awareness of the participants.

There is a sense in which the report of a study is only a beginning since it is possible with hindsight to look back and see how to change and improve what has been done and to see other avenues to investigate. In the case of evaluative research there is no one solution since case-study research always involves 'the study of an instant in action' and a different researcher or a different time might lead to an entirely different analysis. (Adelman et al, 1976) The present research suggests a number of questions which others might choose to address: how effective will the new Nuffield Combined Science course be in developing genuine interest in science amongst mixed ability groups in comprehensive schools; what strategies could be adopted, or have been adopted, to try to solve the problems which the complexities of scientific language create and research into the effect on girls attitudes to science if there was a change in emphasis away from the male orientated concern for change, discovery and invention to a greater concern with the implications of science on people's lives.

Perhaps one of the more exciting topics for future research concerns the problem of 'negotiation' between teachers and pupils and whether it would be possible for teachers to accept pupils as partners in curriculum development and innovation so the question of 'us and them' would cease to exist. If teachers were prepared to 'grasp the nettle' then the means might exist by which teachers and pupils might achieve true partnership in education and considerably enhance their own professional development.

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## L I S T   O F   A P P E N D I C E S

# APPENDIX A

# SCHOOL AIMS AND OBJECTIVES

## APPENDIX A

## Social, Pastoral and General Aims

1. To recognise both the value of the individual and the needs of the community in which the individual is placed.
2. To provide for the particular physical, intellectual, spiritual and social needs of each individual and to meet these so far as is practicable within a caring community, so as to promote secure self respect.
3. To develop in the individual, self-awareness, moral courage and concern and respect for others expressed in sensitivity, tolerance and co-operation.
4. To recognise and foster the basic virtues of honesty, reliability, diligence, sincerity, kindness and reverence.
5. To recognise that the school, the family and the community interact with each individual and with each other and to develop appropriate relationships, contacts, and means of communication, the school recognising its obligation to contribute actively to the community.

(These aims will not only be reflected in the general organisation of the school but will have implications for the ways in which curricular aims are implemented).

## Curricular Aims

1. To encourage an enquiring mind and to foster a lifelong desire to learn.
2. To equip each pupil with skills in learning and self assessment.
3. To encourage clear thinking and discrimination, and the ability to be self-critical, particularly in relation to fact and feeling, bias and prejudice.
4. To provide opportunities to make individual judgements and decisions, to translate them into actions and to evaluate their results.

5. To encourage striving after high standards and perserverence, in every aspect of endeavour.
6. To develop the physical, emotional and intellectual strength and resilience to cope effectively with the demands of the future as well as the present.
7. To enable each pupil to acquire the skills and qualifications necessary for securing, entry to, and progress in, future employment and, if appropriate, further or higher education.
8. To develop the ability and willingness, to communicate orally and by means of writing, numbers, symbols and the Arts.
9. To develop the ability to follow, respond to and sustain an argument.
10. To develop creativity.
11. To present to pupils a balanced selection from the total of human knowledge and understanding, recognising the inter relationship of all knowledge.

(The above curricular aims overlap, to some extent, the social, pastoral and general aims of the school just as the curriculum itself necessarily implies certain pastoral, social and general values).

# APPENDIX B

# GENERAL AIMS OF THE DEPARTMENT

GENERAL AIMS OF THE DEPARTMENT

1. To participate in the aims and objectives of the school with emphasis as is appropriate to the subject.
2. To work together in a corporate, integrated and consistent fashion.
3. To be fully prepared for scheduled lessons and to be constantly aware of the meaningfulness of what we do.
4. To provide adequate guidance to other members of the staff, to parents and to pupils.
5. To ensure adequate discipline in laboratories such as to procure safety and good learning condiitons balanced with sufficient freedom of speech and movement as is required to get the best science from both individuals and groups.
6. To regularly assess and monitor the progress of each individual for whom we are directly responsible.
7. To encourage in the pupils:-
   - (a) a lively curiosity about and awareness of the total environment
   - (b) a realisation that all that happens has a cause
   - (c) a questioning of statements that are not supported by adequate proof
   - (d) an ability to make and carry out careful plans for solving problems
   - (e) the necessity and desirability to make careful and accurate observations
   - (f) an awareness of the dangers of jumping to conclusions by not having enough facts or simply by being hasty
   - (g) a readiness to change an opinion or conclusion if later evidence justifies this
   - (h) the value of making reasoned judgements which are not influenced by personal likes
   - (i) a willingness to work in groups, to lead or be led, and to see oneself in relation to others.

APPENDIX B

SCHEME OF EXAMINATION: INTEGRATED SCIENCE A and B CSE MODE 3

REGIONAL ASSESSMENT

A written examination consists of three papers. Each paper consists of A and B sections.

| | | |
|---|---|---|
| PAPER I | - A and B | Objective type questions |
| | | 1 hour each section 40% + 40% |
| PAPER II | - A and B | Larger structured questions |
| | | 3 out 4 questions each section 30% + 30% |
| PAPER III | - A and B | Questions requiring larger prose type answers |
| | | 3 out of 4 questions each section |

AIM OF THE EXAMINATION

To measure the extent to which candidates show that they are able -

1. to recall and understand those facts, concepts and patterns which would enable them to make use of science in work and leisure acitivities,
2. to understand specific patterns which are of importance to the scientist and which lead to better understanding of the world we live in,
3. to identify and use patterns necessary for the solution of scientific (including social and environmental) problems,
4. to make critical appraisal of unfamiliar information as an aid to the formulation or extraction of patterns and the solution of scientific problems,
5. to organise and formulate ideas in order to communicate to others,
6. to understand the significance, including the limitations, of science in relation to technical, social and economic development.

SCHOOL ASSESSMENT

Aim 1 - 6 to be considered and particular attention to be paid to oral and practical work during the last five terms.

The examination does not seek to examine content in the traditional way.

Examination questions are designed to be in line with the methods and philosophy put forward in the Schools Council Integrated Science Project.

Table showing hierarchy of difficulty and complexity upon which questions will be based.

The concepts and patterns which are examined may be divided into three groups:

Group 1 - Building blocks

Group 2 - Energy and change

Group 3 - Interaction and change

DIFFICULTY →

| COMPLEXITY | 1 | 2 | 3 |
|---|---|---|---|
| 1. Recall of concept | | | |
| 2. Recall of pattern | | SECTIONS A | |
| 3. Understanding of concept | | | |
| 4. Understanding of pattern | | | |
| 5. Pattern finding | SECTIONS B | | |
| 6. Problem solving | | | |

It appears that both areas under 2 in the chart above cause pupils the greatest difficulty when they are required to answer the structured questions.

Although I had limited data available to me on the results achieved by the top ability set it did seem that although their marks were higher overall on all sections of the examination paper, they too experienced the greatest difficulty with the same areas of knowledge and its application in answering longer questions.

APPENDIX C1

TAPE TRANSCRIPT - COLOUR

TAPE TRANSCRIPT

Friday, 23rd November $5_2$SCISP

Time: 9.35 - 10.45 Teacher: Mr. S.

KAREN. May I borrow a pencil?

MR. S. Anybody require a pen or a pencil now?

KAREN. I've got one, but . . . (lost in background noise).

MR. S. You don't need it now, get it at break. (Some other muffled voice).

Doubtful, doubtful.

Now we accept colour, most of us, as something taken for granted, 'cos in normal daylight and most of the artificial lighting we do see things around us in colour. In fact without even stopping to think what the colour is and where it comes from. We had a clue where colour comes from when we passed white light through a prism when we accidentally almost were thrown into the whole business of the full spectrum of visible colour. Now we got to the point where we recognise that those are separate qualities of light because of their different wavelengths, so in a sense the prism analysed the colour and we put that to advantage by putting in a piece of apparatus called a spectrometer which we used to analyse the wavelengths from three sources.

Now many Americans have dismantled old English buildings and taken them out to America and rebuilt them again - not as replicas, but as the identical thing apart, perhaps, from a few modern innovations like new modern cement and so on. If we break down, we can build up - we've seen this with some chemical reactions which take it one way, get some substances, and then by treating them appropriately we can go back to where we were. Sometimes we can't.

It's always on the cards that we can reverse processes, so if we can break down white light into all the separate colours perhaps we can think about putting those colours together again to make white light. Now there's one snag here because at primary school when you dabbled with colour you were playing with paints in the main, and everybody remembers the mucky mess they made when they mixed paints. You think you'll mix this with that so you mix blue with yellow and you get a beautiful green, but you're not content with that so you wonder what you'll get if you mix everything together - and what do you get? (Several inaudible responses from pupils).

MR. S. Well I imagine they're mucky, but can you be more precise. What do you get?

SEVERAL VOICES. Brown.

MR. S. Brown. Brown, dark grey, mucky grey, dirty purple. Yes, you get a dark colour. Whatever you mix you gradually get deeper and deeper into a dirty dark mess when you mix colour. But there you're mixing pigments, you're actually mixing the chemicals which send out all the light messages and getting them all tangled up in a mess. If we paint them, however, on a card like that, just for the sake of it, we've painted them in lots of three . . . shine white light on to them so that you get those messages into your eye of yellow, green, pale blue, dark blue, violet, red, so on - all the colours of the rainbow. And then we spin them, and we all know about illusions . . . if we spin those colours you're going to have a job on to follow say the green because it'll be moving . . . and we're going to have a job following the red so what your eye eventually will do . . . it'll become so comfused that it accepts all the colours and is unable to sort them so what happens now is something that starts happening in your brain - your eye must pick up the messages, but your brain cannot sort them out fast enough to separate the colours, so as you mix those colours in your brain - or as you mix them - I can't do it - what's the first thing you notice that's different from what's happened when you mixed those colours at the primary school?

(Inaudible reply).

MR. S. Pardon?

BOY. Starts going lighter.

MR. S. Starts going lighter instead of darker . . . so instead of the expected mucky mess, dark mucky mess, you start to get a lighter mucky mess if you like. As we go faster and faster we approach whiteness. Well that's as near as we can get with that illusion . . . But it's not really an illusion because it's telling us something about colour and light. It's telling us that in reverse to what we did with the spectrum produced by a prism, we can take those colours and put them back together again to make white light. So what in effect that disc does, it behaves one, - when it is spinning, like a white screen, 'cos if we shone the white light on a white screen it would send back to you a white light message, because it would be reflecting all the colours that were hitting it, back in the same proportion that it received them so that you don't notice any difference.

If, on the other hand we shine white light on a red screen, a red book, a green book, anything over there, well you can see them . . . (unclear on tape) . . . I won't switch this off yet, but the reason why you can see the blue and the red and the green and the brown there is because the white light hits them, but for some reason or other whatever it is, they are coloured with, won't let all the light that hits them come back to your eye. So the white light hitting the green file . . . has only the green sent back to you, only the red is sent back to you from there . . . What happens to the red? . . . Well that's another story, something to think about. We know it's all going there, but we can see quite clearly that only some of it is coming back to us. Let's take that a step further by gathering round here.

(The group move stools around the front bench).

MR. S. Can somebody get those curtains tight together please? Sunbeams coming through, it's a bit of a nuisance . . . as soon as you don't want the sun it comes out . . .

(Long pause and clicking of switches as Mr. S. sets up the apparatus). Right. We can see that we've got three colours - do you recognise them, those that do art?

(Equipment shows beams of red, green and blue light).

BOY. Primary colours . . . (some other remark muffled).

MR. S. Not primary colours? They are primary colours.

(Is Mr. S. wrong I thought they were red, blue and yellow).

If those were paints and you mixed green with red, what would happen?

SEVERAL VOICES. Brown.

MR. S. Get a darker colour, you get brown. Now, these are not pigments, these are . . . (a cough prevented transcription here) . . . which have been produced by passing white light through a filter. Instead of the light bouncing off something it is passing through something to get to your eye. So we are starting off with roughly white light, that's the bulb inside, but somehow or other the filter in the front is allowing only the green through, the red through or the blue through. So we're getting as far as we possibly can, light of only one wavelength or a certain mixture of wavelengths, it's difficult to get it pure.

If you mix those in a paint box, right you all agree you get brown, but if we mix them in light we get something that's lighter, which goes along with that spinning disc, and we're getting something that's approaching what?

SEVERAL VOICES. Yellow.

MR. S. It's a yellow . . . yellowy-orange. Yes. What is missing to make that into white light? What wavelengths are missing? . . . (Pause accompanied by more clicking of switches). Come on, what wavelengths are missing to make that whiter? (Pupil speaks one inaudible word).

MR. S. (Ignores response). Think of your rainbow. You've got . . . Think of the region around green, the region around red. We've got obviously blue involved. (Karen is saying "Ultra-violet" over Mr. S's voice). . . . there it is the short waves are missing. Not the ultra-violet, because it's . . . that's not visible, so you can predict what will happen to that patch in the middle if we add blue to it. What?

TWO VOICES. Lighter.

MR. S. Lighter still, but remember what would happen in paint. You'd have brown already, if you add dark blue to the brown it's hardly worth thinking about is it?

So right in the middle there we've got a patch of lots brighter light and we've got to fish for hours to get the brightness of those lights such that we will get that white in the middle . . . probably never get there because we don't quite know what's missing.

(Sound of more clicking).

It's not that one.

(More clicking).

(Boy makes a muffled comment about the blue).

MR. S. You think that blue's too bright? Well it isn't you see because you see the trouble . . .

(Several voices speaking at once).

BOY. You want to keep that red low.

(Followed by a comment about the green).

MR. S. You never get there with this . . . filters are not pure, but what we can do, we can try the other mixtures. If you mix blue and green in the paint box you get a very dark, deep green. If you mix blue and green in light, you get a nice pale 'turquoisey' blue . . . peacock blue I suppose we could call it. If you mix red and blue you get deep purple.

(Laughter, is this pop culture coming out? Switches clicking).

BOY. Great.

MR. S. (Ignores laughter). But if you mix it in light you get this shocking pink sort of colour . . . very bright, light colour. The main thing is that when we mix light, not only do we change the quality of what we see, but we also get obviously more light

because we're putting . . . adding light together.
Right?
So you actually see it brighter and lighter because there's more light. Now we've seen other occasions where we can use ideas in the lab . . . you saw with the (inaudible) where we can use it on the stage. We've seen the ultra-violet . . . that we could use with special lighting effects and of course the commonest lighting effects are used on the stage are coloured spots . . . 'cos you can obviously do . . . work magic on the stage with coloured spots if you know what light can do, OK? Right, that's it.
(Group move back to own places).

MR. S. Can you just make some notes while they're fresh in your minds, about these ideas of colour mixing, comparing what you've done in art with paints with what we've just done in light, which is something, perhaps you've never done before . . .
Was anybody absent when I showed the ultra-violet writing?

KAREN. Was that on Wednesday?

MR. S. Yes, you'd better come and have a look. Do you want to see this Mr. T.? . . .

# APPENDIX C2

# TAPE TRANSCRIPT - MOLES

TAPE TRANSCRIPT

20th November, 1984 4(1) SCISP

Time: 2.35 - 3.45 Teacher: Mr. R.

MR. R. . . . and which substances have reacted together. Now so far we've had two ways in which we can arrive at how many moles we use. One of these of course is to take the substance, like a piece of magnesium ribbon and do what?

BOY. Weigh it.

MR. R.. Weigh it. Having weighed it, what kind of thing should I weigh it in Julie?

(Julie's answer not audible on tape).

MR. R. I need then to be able to find out how many moles I've actually got in that piece of magnesium ribbon, so I need to know something else. What else do I need to know?

LOUISE. How many things there are in the . . .

MR. R. No! What else do I need to know? I've got the mass in grams of the piece of magnesium ribbon.

BOY. Atomic weight.

MR. R. The atomic weight. Well done. I need to know the mass then . . . Don't talk . . . of a mole of that particular element. In the case of magnesium remember this was 24, we did an experiement on it. Twenty-four grams then was one mole of magnesium ribbon. I've only got less than that . . . I have in fact . . . Mrs. C. weighed this out for me . . . I've only got in fact, 0.05 g, so to convert that into moles, I have to do what? . . . I know the mass of one mole, how do I find how many moles then I've got left? . . . (long pause) . . . If I had 24 g how many moles would I have?

GIRL. One.

MR. R. One mole. How did I work that out? I divided . . .

BOY. Twenty-four by twenty-four.

MR. R. Twenty-four into twenty-four. The mass of one mole into the mass I'd got. If I'd 48 g, how many moles would I have had then?

SEVERAL VOICES. Two.

MR. R. Two moles. If I've only got 0.05 g, how then do I find how many moles I've got?

BOY. Point-0-five . . .

MR. R. Over twenty-four. So that would tell me then how many moles. That's one way. That was the way we learned first. The next way when we were trying to find moles and the ratio of moles, was using a solution and we were not dealing then with just single substances, elements or compounds, but they were in water. To find how many moles I had then I had to look at what it said on the bottle? In this case it says, 0.1 M. What does 0.1 M mean, Roger?

ROGER. Point-one-0. (Several other voices help out).

MR. R. And what does that actually mean?

BOY. Tenth of a litre . . . (Several other voices). In a litre.

MR. R. A tenth of a mole dissolved in water. Now someone here said dissolved in a litre of water. Hands up those of you who agree with him. Two of you, three of you. What does it actually mean? It's not quite the same . . .

(Several voices not transcribable).

MR. R. That's right, made up to one litre, so in other words, I would have to weigh out, the sum of the atomic mass of potassium plus bromine, dissolve it in water, make it up to a litre. That would be one molar, so in fact I would only have to take a tenth of that to make it up to a 0.1 molar solution. Now if I'd been here yesterday there was something else you were going to learn, another way in which we can work out numbers of moles.

For many substances we don't have them in water, we don't have them solid, we have them as a, as a gas, and for them obviously if you were weighing out, if you imagine this say, a mole of oxygen, Sheila . . . A mole of oxygen would be 16 g of oxygen. (sic) 16 g of oxygen, (sic) if you imagine it, would be a lot, it would be very difficult to weigh it so we really need another way, because if we take a mole of any element . . . at conditions that are the same . . . Why would that be important for volume? You were learning about this yesterday, when I was away. Yes?

BOY. Heat.

MR. R. Heat. Yes. If I increase the temperature what happens to the volume, Martin?

MARTIN. It would get more.

MR. R. It would get more, yes. Uh! If I cool it down it would get less. So I have to take into account the temperature, what else might affect the volume?

VOICE. Pressure.

MR. R. Pressure. So that's something else you learned about. If I increase the pressure, what happens to the volume?

(Next voice is not picked up on tape).

MR. R. Less. OK. Yes, so that's it, yes . . . if it gets less then that's it. Now if I'm going to talk about volume having any meaning, I'm going to have to specify that. So I specify what I call Standard Temperature and Pressure. I abbreviate to S.T.P. (writes on board). and what I choose to have is standard temperature as 0C and standard pressure as one atmosphere. Sometimes I quote that in degrees Kelvin, the absolute scale - What is that?

SEVERAL BOYS. 273 K.

MR. R. 273 K, Well done, and so I specify (writing on board) volume in those conditions, and the interesting thing is this really, that if I were to look at the whole range of gasses, carbon dioxide, nitrogen, oxygen, sulphur dioxide, whatever, and if I were to measure the volume, not of an atom, because some of those are compounds, it would have to be an avagadro number of molecules, in other words a mole of them, I'd find that they all have the same volume approximate, that is and that volume is 22.4 litres. (Writes on board). Can anyone tell me what 22.4 litres is in centimetres cubed? . . . How many centimetres cubed in a litre?

VOICE. A thousand.

MR. R. A thousand. So in other words this is the same as

22400 $cm^3$. (Writes on board). So in other words if I have, just like I had a mole weighed out of this, having the same number of particles, or a mole of this having the same number of particles, or if I had a one molar solution, I'd have a litre of it, having one . . . one mole of particles. If I have 22.4 litres of the gas under those conditions, I would again have a mole of particles. So it's got us another way of counting, counting units, that a mole of particles of gas, we can work out in that kind of way. If I have got 22.4 litres of carbon dioxide, 22.4 litres of ammonia, if they reacted together exactly, what would it mean?

GIRL. One to one.

MR. R. It would be a one to one ratio in terms of moles, it would also be a one to one ratio in terms of individual . . .

BOY. Atoms.

VOICE. Molecules.

MR. R. Not atoms. Molecules, that's right. So it gives us another way of finding moles . . . counting moles. Now the experiment you're going to do is one which uses two of those ways. We're going to use the way we started off with, the way which should be familiar to you to find the number of moles of magnesium. How do we do it? . . . I know the mass of it. I know the molar mass. I dissolve, as Zachary says, one into the other, to find the number of moles of this, and I'm going to react it then with some 0.2 molar HCl . . . I want it all to react, so I can relate how much (word not clear on tape) . . . is the magnesium, so how much of this will I use?

(Muffled voice not transcribable).

MR. R. More than, I need this in excess, so Mrs. C. has given you plenty of this, so that all of this will react completely. And what's the gas? . . . Well you should be able to tell me, some of you, I've got hydrochloric acid, magnesium ribbon.

(Muffled voices).

MR. R. Metal and acid . . . We've got some people here telling us . . . Anyone else? It gives us?

(Several Mutterings).

MR. R. Hydrochloric acid and magnesium ribbon. He's trying to tell you.

BOY. Hydrogen.

MR. R. Hydrogen, that's right . . . So . . . Listen please don't play with that . . . So we get hydrogen gas bubbles, and I was talking to Mr. T. before the lesson about these. (Refers to gas syringes). These are ways of collecting gas, the gas syringes of this sort were produced . . . well there weren't any when I was at school, about 1960's solution, and although they seem relatively loose they are gas tight. It's quite amazing always to me, and what we'll be doing then is starting off with this so that it is at zero, and as the hydrogen gas is produced allowing it to fill this up till it stops.

Now you can help it a little bit, but I don't want you trying to drag it up like this because you'll be dragging all sorts of contents of the boiling tube through. You need just to see that it is loose, so if you twist slightly as it's doing it, it should itself . . . the pressure inside, move it. You can adjust it then just so that it is in fact there by its own pressure, the same as atmospheric pressure. And it should then register how much hydrogen is produced. If, for example, I got 60 $cm^3$ . . . Just leave it please . . . 60 $cm^3$ of hydrogen produced, how could I find then how many moles?

GIRL. Divide by the volume.

MR. R. By the volume of . . . I thought you were going to give me the right answer then . . . I've got 60 $cm^3$ of gas then, produced, how can I find how many moles? . . . What do I know about one mole? . . . It's on the board behind me.

BOY. 22400 $cm^3$.

MR. R. That's right, 22400 $cm^3$ would be one mole. I'm never going to get that in a syringe like that, so I just have to find what fraction of a mole I've got. So if I've got 60 and I divide by 22400 it will tell me how many molars of gas I've got produced. Yes? You follow that?

GIRL. Do you just divide that . . .

MR. R. Into the volume, 22400, just like we were doing with masses to standardise that, because one mole in mass was 24 g and I divided by 24 to find out how many moles of solid I had.

The mole standard for gas is 22400 cm³, so if I divide that into the volume, I get . . . I find then how many moles of that are produced. Does that make sense? And so I'll be able to relate this, as you were doing as you were telling me before, the mole ratio. If say, I found that I had 0.02 moles say of magnesium, and it produced 0.06 moles then of hydrogen gas, what would that tell me? Someone's not listening. Point-0-two moles of magnesium produce 0.06 moles of hydrogen gas would tell me the ratio then would be?

BOY. One to . . .

MR. R. One to?

BOY. Three.

MR. R. Three, so we get the ratio of the magnesium. I start off with the hydrogen . . . Right, I'll put a title then up on the board for this. Before I get on to the experiment put . . . before you get on to the experiment part, I think I'd better just put a little bit of introduction about what we didn't do yesterday, so you know what you're on about, and then I'll put a table up for the results, and you'll be able to get on with the experiment. I'll require again the method . . . (stools banging as the group begins to move) . . . Just a minute, wait . . . and I'll require results and a drawing. OK?

So first write what I put on the board and then . . . (Group move back to their own places accompanied by considerable banging of furniture).

PART OF THE TAPE TOWARDS THE END OF THE LESSON

MR. R. Right, stop please . . . will you look this way please . . . (long pause) . . . just in case, and there are some people don't seem too clear at working this out.

To work out the moles of magnesium, divide the mass of magnesium which Mrs. C. weighed for you, 0.05 g, by the molar mass 24 g. I've given you an example there if you were still in doubt, it's actually the one that's the same for everybody so that's straight forward.

For the moles of hydrogen produced . . . Be looking please, Janet, John . . . Divided the volume in $cm^3$ by 22400, that gives you your moles of hydrogen gas produced. OK?

Now many people have got a ratio that is about 0.002 to 0.003, I won't tell them whether it's right or wrong or not, we'll look at that in a minute, but what would be the properties then of moles magnesium to moles hydrogen? Point nought, nought, two to point nought, nought, three would be?

BOY. Two to three.

MR. R. Two to three . . . Continue looking please. Come on, Nichola, otherwise you won't understand . . . I'm going to . . . I've written here, as I said before, the word equation, let's now just try and write in a formula then. I've put the symbol for magnesium. Magnesium is a solid, we normally put a little 's' in brackets to signify that. Hydrochloric acid, of course, is in solution, in water. What's hydrochloric acid made up of? What elements are present?

LOUISE. Hydrogen and chlorine.

MR. R. Hydrogen and chlorine. In fact that's the formula for hydrochloric acid, simply HCl, but the fact that it's in water . . . I don't think I've mentioned this to you before . . . we signify it by putting a little 'aq', which stands for?

SEVERAL VOICES. Aqua.

MR. R. Aqua.

LOUISE. You have mentioned it before.

MR. R. Have I? Thank you for reminding me. It's nice to know I have done it for once. And what are we getting produced, magnesium chloride, would be MgCl?

BOY. Two . . . one.

MR. R. Now the valency of magnesium is two, I'm afraid the chloride is one, so what should the formula of magnesium chloride be?

BOY. $MgCl_2$

MR. R. $MgCl_2$, and that was in water at the end. What can I put then Louise, you told me I've been mentioning it, what can I put for a gas? . . . Like I put aqua and 's' for solid.

LOUISE. You didn't mention anything about gas.

GIRL. 'g'.

MR. R. 'g', yes, that's right . . . and the arrow upwards, Sheila, means of course gasses tend to . . .? (Several voices taking drown any reply).

MR. R. Right . . . Not yet, I haven't finished yet . . .

There's one thing further we need to do. If I was finishing this equation . . . balance it. Is it balanced? . . . Hands up those who think it's balanced . . . No one, right, so it obviously isn't.

LOUISE. I think it's balanced.

MR. R. Is it balanced then, Louise, with regard to chlorine?

GIRL. No.

LOUISE No, it's not.

MR. R. Because?

LOUISE. It's two on one side and one on the other.

MR. R. Right. How can I balance it then?

BOY. Put one on the other side.

2ND BOY. Put a two in front of that HCl.

LOUISE. Yes.

MR. R. (writes on board) so there we are. Is it balanced now?

SEVERAL VOICES. Yes.

MR. R. It is, yes, and when it's a balanced equation that's a correct equation. You can see how that checks with what you've actually found. What we should actually be writing, of course, should be three, two of them should, according to your results, with three of those.

Strictly speaking . . . I mean your results are correct, what you've done, but then we don't get too confused and get all sorts of rather strange equations. We should have been . . . I don't know why it should have been so consistent, two to three, it should have come to . . . what . . . about . . . one to three, one magnesium to . . .

BOY. Two.

MR. R. Two? Remember, the number of moles are not moles of hydrogen atoms, but hydrogen molecules, so it was a one to one in terms of moles of hydrogen in our equation. What you were trying to tell me was it was two moles of hydrogen atoms, but three moles of hydrogen molecules. Yes? What in fact we should have been finding, and therefore then we're not getting too confused about it would be that we get one mole of magnesium atoms giving one mole of hydrogen molecules. Yes? So put what you get and explain what we would have expected as well, and you can give that final equation . . .

# APPENDIX C3

## TAPE TRANSCRIPT - DISSECTION

TAPE TRANSCRIPT

Wednesday, 5th December | 5$_2$SCISP
Time: 9.35 - 10.45 | Teacher: Mr. S.

MR. S. Gary, leave it.

BOY. Eyeball, eyeball.

RACHEL. Rachel isn't here.

BOY. I've already got two.

SUE. Ugh! They go quickly if you don't cover them.

RACHEL. . . . don't they Bez.

SUE. That's what we said.

MR. S. Have we got anyone else who should be here?

TINA. Sandra.

RACHEL. Oh! Sandra.

MR. S. Sandra's here is she?

KAREN. Yes.

RACHEL. She's gone to see Miss D. Yes. She said something about it . . .

KAREN. An eyeball. (causes laughter).

BOY. Thank you.

MR. S. You can't leave it can you, Gary?

RACHEL. I'm dying to cut that up.

SUE. Oh no! Rachel, you can do it if you want.

RACHEL. Emma, you've got to do it all by yourself. Whose eyeball is it? Sheep?

SUE. Sheep.

MR. S. OK. Put this heading down (writes on board) . . . I think we're now clearly well convinced there's a whole range of waves high to low frequency that we call electro-magnetic spectrum. Only a very small range of that are we able to receive as direct messages which we can interpret, and we do this through our eyes, and the wavelengths we call the visual spectrum. It seems reasonable to try and find out what it is, about our eyes that enables us to process things with.

Now you can't get far looking into your own eye without special equipment that opticians use, which we don't have access to. We can't get a supply of human eyes, the next best thing is to use sheep's eyes, which sadly today are in short supply. All the eyes we've got in the department are on the table. (laughter) This was because of an oversight at the butchers, he'd forgotten to gouge out the sheep's eyes over the last six months. We've had a rush around. It's doubtful if $5_1$ will get any eyeballs.

SUE. They can have ours. (A lot of noise from group)

MR. S. Alright come on . . . So to find out what's inside an eye to try and interpret what the . . . is there, we must get inside it, look into it and we do this in as technical a way as possible. We don't rive at it, we don't chop it without a little bit of forethought . . .

SUE. I'm not chopping it.

RACHEL. I am.

MR. S. . . . but before we do that and the whole thing becomes unrecognisable, just have a look at the eyeball itself. See if you can recognise anything on the outside of it . . .

SUE. We haven't got an eyeball.

RACHEL. Course we have . . .

MR. S. . . . draw . . . back a bit and make a few notes about what you've discovered just by looking at the outside, what you think is there.

(Much squeaking and laughing as group begin to touch eyes).

RACHEL. Hey Bez! He's looking at you.

BOY. It's like jelly.

MR. S. You can touch it, it's in preservative . . . if you're squemish and you don't like it to be in contact with your skin, you can use paper towel to hold it or even foreceps to hold . . . to hold it.

(Again much laughing and giggling).

MR. S. Alright, alright, don't be silly . . . Emma (sharp tone).

EMMA. What? (hurt tone).

MR. S. Every time I look round I see your grinning inane face. Now will you settle down.

EMMA. (quietly) I'm just a happy person.

RACHEL. Go on Emma get it picked up . . .

EMMA I can't.

SUE. Eat it, go on eat it.

RACHEL. Oh yes, it'd be nice.

EMMA. Rachel, how can you do it?

RACHEL. It's just like touching a piece of meat. Go on, you do it . . . it's just like touching a piece of meat, it's just being soft.

EMMA. It's not fair.

MR. S. Three points to consider. I've put on the blackboard.

(Girls continue to work some making various noises of disgust).

RACHEL. Don't squash his eyeball.

MR. S. What's the matter?

EMMA. Look don't. Will you leave it? No. I'll do it in my own time. (Note of panic in her voice).

MR. S. What's that? Come here. Come here. What's that? What's that? (Emma continues to protest).

EMMA. Bottom of your eye.

SUE. That's your eyeball.

EMMA. Oh! Your eyelid.

MR. S. An eyelid.

EMMA I don't know how you can touch it.

MR. S. What do you think that stuff is?

EMMA. Is that like the retina?

MR. S. No, that's . . .

EMMA. Skin.

MR. S. No, no. Don't think of anything pre-conceived.

EMMA. Skin.

MR. S. That stuff . . . Look at it . . . You've worked in the kitchen haven't you and you've seen stuff like that.

EMMA. Muscle, skin, fat.

MR. S. What are these bits of, this stuff look?

EMMA. Meat.

MR. S. Yes, bits of fibrous meat look, you've seen it. What's meat? What's meat?

EMMA. Flesh.

MR. S. Flesh. What's flesh?

EMMA. Part of the body.

| | |
|---|---|
| MR. S. | It's muscle. Meat is muscle. |
| MICHAEL. | Mr. S. could I buy a pen please? |
| | (Mr. S. moves away as girls continue playing jokes on each other and making numerous remarks. Emma is still not happy about touching the eye). |
| SUE. | Get off. Oh! Will you behave. Oh! Stop it. |
| RACHEL. | Press that in. |
| EMMA. | I'm not touching it. |
| SUE. | I'm moving. |
| RACHEL. | (Holding eye) Hello . . . I'm watching you. |
| EMMA. | I don't like the eyelid it's horrible . . . what are you supposed to do to it Rachel? |
| MR. S. | The stuff that looks like meat is muscle. |
| KAREN. | The stuff that looks like what? (no answer). |
| MR. S. | Can you make some kind of a drawing to show what you've discovered on the outside of the eyeball that might be important. |
| KAREN. | What did you say? (still no answer). |
| SUE. | Mr. S. I'm not touching it, you can't make me, now get off. |
| RACHEL. | I can't get his eye out. |
| EMMA. | Ygh! You horrible person. |
| | (Several voices at once - Sue makes a comment about Rachel being absent for four days in two weeks). |
| EMMA. | That protects . . . |
| RACHEL. | Get it touched, Bez . . . |
| | (Inaudible comment). |
| SUE. | Swimming today girls . . . that's probably why she missed it she doesn't like games. |
| BOY. | Bez, she's just touched that thing at the back. |

| | |
|---|---|
| RACHEL. | How do you make his eyeball come out? |
| IAN. | Ugh! You rive it out you devils. |
| RACHEL. | It's looking at me. |
| IAN. | Where's it gone? Where's it gone? (Begins humming). |
| EMMA. | Where's she put it? |
| RACHEL. | It won't hurt you Susan . . . (rest of comment inaudible). |
| IAN. | Feeling better now? |
| MICHAEL | Did yours have a lal (small or little) thing on? |
| IAN. | It's a bit grotty int it? Don't wiff at it. |
| SUE. | That thing was alive and blinking . . . once upon a time. |
| EMMA. | It's watching again. |
| RACHEL. | It's just like the lamb you had yesterday in cookery Bez. |
| EMMA. | Yes. |
| SUE. | I didn't eat it. I only had . . . |
| RACHEL. | You did, you ate it . . . |
| MR. S. | (To whole class). I said nothing about stabbing or cutting it . . . do not cut anything or stab anything, you'll spoil it for later. |
| SUE. | What did you say we've got to do Mr. S? Kind of draw it? |
| MR. S. | Just try to draw an eyeball, with the important attachments, the things that you think are important. |
| EMMA. | Do you have to take the eyelid and stuff back? |
| MR. S. | Don't take anything off, you can bend things back and move things about. |
| EMMA. | Well will you bend it back for me 'cos I don't want to? |
| RACHEL. | I'll do it, Emma. |

EMMA. Not in front of me Rachel, do it over there.

SUE. Stop it.

EMMA. Oh! I really do feel bad . . . I don't know how you can do it.

RACHEL. Oh! It nearly popped out.

SUE. Oh! Mr. S. I don't like this at all.

EMMA. Thank you, Rachel.

MR. S. You ain't seen nothing yet.

SUE. Well, I'm not cutting anything up.

RACHEL. I'm dying to get inside.

MR. S. Well Rachel will do it for you.

RACHEL. I'll do it.

SUE. She will 'cos I'm not.

MR. S. You have a quick shufty. You can have a quick shufty when she's done it.

EMMA. Do we have to do some more of this stuff like cutting eyeballs up?

SUE. What's a quick shufty?

RACHEL. Throw up.

SUE. Throw up?

MR. S. No, it isn't actually . . . Look . . .

RACHEL. Hey, Mr. S. what happens if you get that preservative stuff in a cut.

SUE. I'm not looking at it 'cos it's . . .

MR. S. It'll, it'll help it to heal, keep germs out, it'll stink.

SUE. Are our, are our eyeballs soft like that?

RACHEL. That's hard because it's been . . . uhm . . .

SUE. That's soft.

RACHEL. It's harder than yours . . .

MR. S. Well there . . . it's not . . . it's not . . . Your eyeballs are fairly soft at the front . . . You never get a chance to poke them like that.

EMMA. Oh! I don't like it looking at me.

KAREN. Emma, I dare you to eat it.

SUE. I'll have nightmares about this thing tonight.

KAREN. If Rachel was here she would eat it . . .

(The lesson continued with the girls working on the eye and making a drawing).

RACHEL. What should I write "flesh", Susan . . . Mr. S?

MR. S. Yes?

RACHEL. Is part . . . part of its actual meat isn't it . . . and then this is skin.

MR. S. Yes. That's, that's . . . that's meat, it's obvious meat is that.

SUE. So if you cooked that you could eat it? Could you eat that eyeball?

RACHEL. People eat eyeballs.

MR. S. Yes, 'course they eat eyeballs . . .

RACHEL. What's that sticking out of the back? That's something to do . . . that's connected to something isn't it.

MR. S. Well that's obviously a rather special looking cable isn't it? I mean it looks like an electric cable.

RACHEL. Yes.

SUE. It's a muscle.

RACHEL. It's a vein.

MR. S. It's not muscle, it's not vein and it's not hollow.

RACHEL. Tendon.

SUE. It smells awful.

| | |
|---|---|
| MR. S. | Have you read, (looking towards his notes on board) "Eyeballs move. Is there any muscle?" Yes. "Eye-balls must connect with the brain". "Can you see a broken connection"? |
| RACHEL. | Oh! |
| SUE. | Yes I see. |
| EMMA. | Yes, it's right at the back. |
| SUE. | Poor thing. |
| MR. S. | That's what connects it to its brain. |
| SUE. | I was trying to draw that, can you just turn it round please? No, not that way . . . |
| MR. S. | Well I . . . Which way? |
| SUE. | A bit more . . . I'm not touching it, Mr. S. |
| MR. S. | Side view's best. |
| SUE. | No, I'm drawing it look, I'm drawing it already. |
| RACHEL. | Eyeball. |
| | (Girls continue to work reasonably quietly for a few moments). |
| SUE. | Is there any muscle? God, their must be some muscle somewhere. |
| EMMA. | There is, it's that there. |
| SUE. | Ta! Sandra! |
| RACHEL. | That's the muscle above the eyebrow look . . . that bit. |
| Emma. | Yes . . . and that bit is as well. |
| SUE. | How can you feel it? |
| RACHEL. | (Laughs). |
| | (Discussion once again revolves around difficulties of touching the eye and the girls compare handling food in cookery, e.g., fish, with handling the eyeballs. |

It seems to be possible to handle fish, but gutting them would be a different matter . . . although Emma paradoxically described that as "Hellish" which means great fun).

SANDY. (Quietly). Can you tell me what you've got to do?

RACHEL. You've got to get to have a look at the eye and try to establish what different pieces, different bits are.

SANDY. Mm!

RACHEL. And see what . . . sort of like, answer those questions that are on the board and sort of like just write about it.

SANDY. And then you dissect it?

RACHEL. I don't . . . I'll have to wait until he says so.

SANDY. Right . . .

MR. S. Right, will you gather round. Uhm! Finish off what you're doing. There's a lot more to do, a lot more complex stuff to look at and draw, so just come and gather round here. Don't bring your stools, just come and stand round . . .

(Group gather round a bench close to the blackboard).

MR. S. Because we're short of eyes there's one fact I've got to tell you . . . you won't find by investigation, and that is that the eye is virtually a hollow ball . . . a tough hollow ball with contents. Just go back to what you've just done . . . you spotted very easily the solid round rubbery connection to the brain. Connections to the brain are called 'nerves', that's to do with seeing with the eye, with 'optics', it's the optic nerve.

You've seen muscle, which must connect to bone in order to get movement . . . it's got to pull at something, so within the eye socket, the muscle on your eyeball will connect to the bone at the back of your eye socket.

Some of you may have seen little spots of fat for cushioning and you've seen eyelids, but that's about all you've seen.

Now remember, therefore, that the eye looks one way and the optic nerve goes out the other way, so we can look at the eye in two halves, the front half and a back half.

So if you picture your eyeball in position in your head and then translate that to the eyeball you've got on the table, you'll cut it the right way round.

You've got to come round it this way, towards you and back and round again so cutting the front half of the eye away from the back half.

Now to do that it's a good idea to trim off the . . . rubbish from outside . . . smooth it all off . . . (Groans from girls in group).
Now somebody already tried this and they snipped too hard and they've damaged the back, they've cut the optic nerve out actually. When you've trimmed enough of it off, then comes the tricky bit, because you've got to push quite hard to get through the tough casing, and your fingers are there and if you push too hard and get too excited about it you'll

push right through and impale the point on your fingers. So get a firm grip, take one point of your scissors and push. This isn't going to . . .

(Class began laughing rather nervously).

. . . push till that goes in. So long as it goes in in line that way, sort of sideways into the eyeball you will not damage anything of importance. Once you're in, you're away, because all you've got to do is cut the front end of the eyeball away from the backside. Right? Then put the two halves on the table in front of you.

GIRL. So you cut it in half?

MR. S. Yes. Before you do anything else . . . look at what there is in the back half and the front half, draw it in position before you start dismantling it, then very carefully and precisely take the eyeball apart, front half, then back half, bit by bit to find out all you can about what's inside the eyeball, always remembering what the eyeball's got to do. It's got to pick up light messages. It's got to somehow . . . send an image of what you see to the brain. OK? Go away and do it.

(Group moves back to own places).

RACHEL. Mr. S. . . . Where's Mr. S? Do you cut that lid off?

MR. S. Cut the lid off. Cut off all . . . any surplus matter, it's the inside we're after now. (Moves away).

RACHEL. Don't be so soft . . . honestly . . . Oh! Mr. S. will you shut that curtain please.

EMMA. Do you . . . (rest inaudible).

RACHEL. No . . . I don't think you do . . . Bez, you're being soft. Come and watch this it's really good . . . Sandra, pick it up . . .

SANDRA. No.

RACHEL. . . . Do you want that bit? Should I cut that bit off?

MR. S. No, don't cut the optic nerve off.

SANDRA. Which is the optic nerve?

MR. S. We've already gone over that . . . that. (slight irritation).

SANDRA. What that one there . . . ?

RACHEL. What's up Bez?

MR. S. (First part inaudible) . . . preservative. The eyeballs are in formalin, it won't do you any harm, very good for bad colds, sore throats and what have you.

SUE. What is?

BOY. What is?

MR. S. Formalin vapour.

RACHEL. It's hot stuff.

MR. S. What's the matter?

EMMA. Are you supposed to cut the eyelid off as well Rachel?

RACHEL. Yes . . . All the surplus matter. (In a mimicking voice).

(Class begin to make more noise).

SUE. You're not cutting in there you know.

RACHEL. Mr. S. . . . Mr. S., should I stick it in here? Do you stick it in there?

MR. S. Yes.

RACHEL. It won't go in there you know . . . Oh! It's gone in now. I've got it in now.

BOY. Watch it Sandra, it might bite.

RACHEL. Hey Bez look at this.

EMMA. Horrible . . . I don't want to stick it in . . . Oh! You bastard . . . I've just cut myself. (Has just stuck the point of the scissors into her finger).

RACHEL. Susan. I've done it, Sue . . . Hey! Bez. Hey! Look.

EMMA. Mr. S., I've just brought blood. I've just cut myself, Mr. S.

RACHEL. Hey! Can I do yours Emma as well?

EMMA. I've just cut myself.

MR. S. Where?

EMMA. Just on my finger.

MR. S. How've you done that?

EMMA. With that stupid thing. It's not hurting, it's not that bad.

MR. S. Have you stabbed it?

EMMA. Yes.

MR. S. Well it will be well sterilised so . . .

EMMA. I'm not going to drop dead . . . Oh! I feel bad.

RACHEL. Come on, Emma.

(A few moments later).

MR. S. Don't proddle it too much Emma, till you've made some record of it, it's nice, it's alright.

SUE. Oh! It's not as bad as I thought it would be this, Mr. S.

MR. S. Once you're inside it's nice. One of the wonders of nature this.

(Moves off to deal with some boys who are messing around).

RACHEL. It's alright now, Bez, it's all, it's nowt to see . . . just like a baked bean without any red skin on it, it's just white skin it's dead.

EMMA. Like a baked bean?

RACHEL. Yes.

EMMA. God, I feel really bad.

GIRL. Ha! Ha!

RACHEL. This jelly's dead weird, look, it's dead stiff.

EMMA. I know it is isn't it.

RACHEL. I want to cut the eyeball open.

EMMA. It's like jelly you put on your hair . . .

(Bell rings for end of first lesson).

RACHEL. It's dinner.

MR. S. (From across the room). This is silly. You can't afford to fool about. Gary with some of this formalin stuff in his eye. It's not nice stuff to get in your eye. (Said to whole group).

KAREN. What's formalin?

MR. S. The stuff the eyeballs are preserved in.

EMMA. (Laughing). At least you'll have a preserved eye, Gary.

RACHEL. What's this black stuff, Mr. S., what sort of stuff is it?

MR. S. Well it's like the inside has been painted with black stuff to stop light being reflected.

RACHEL. Oh! I see.

MR. S. Insides of cameras are black aren't they? (Moves away).

RACHEL. By it's weird stuff.

MR. S. (To whole group). Any of you know anything about cameras . . . If you think, the camera does a very similar job to your eyes, it picks up the same waves and it puts an image on the film. The inside of the camera is black, inside the eyeball is black. I wonder why?

I think you know enough about light to work that one out.

EMMA. What else are you doing? (Inaudible response).

KAREN. Well I think that's the most interesting experiment we've done.

EMMA. Yes. I agree.

RACHEL. Well I've got all of that stuff out of that one.

KAREN. Have you got all the jelly out?

RACHEL. Out of one of them . . . that one with the eyeball in . . . I don't know how people can eat eyeball . . . that's what they put in your steak and kidney pie . . .

# APPENDIX D

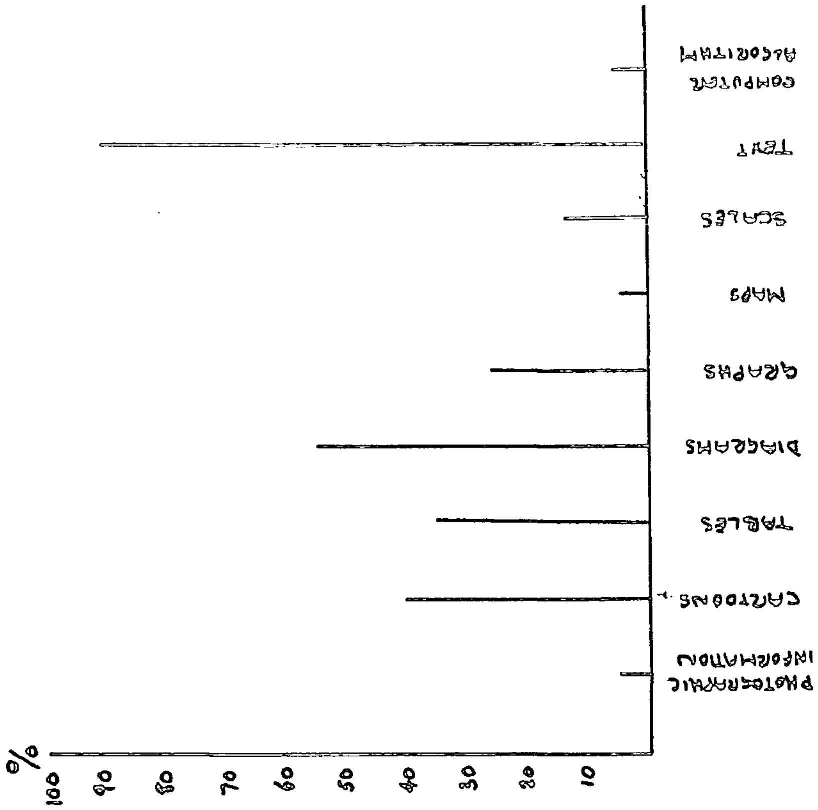
APPENDIX D

## S.C.I.S.P. READERS

* * 1. Human Groups
* * 2. Human Behaviour
* * 3. Darwin and Evolution
* * 4. The Diversity of Life
* 5. Cells
* * 6. Patterns of Reproduction, Development and Growth
* * 7. Patters of Population
* * 8. Patterns and Their Importance to Scientists
* 9. The Gatwick Airport Story
* 10. The Park Hill Story
* 11. Electrification of British Rail
* * 12. Man and The Urban Environment
* * 13. Sound, its Uses and Misuses
* * 14. Uses of Electromagnetic Radiation
* * 15. Length and its Measurement
* 16. Earth Patterns
* * 17. Rocks and Minerals
* * 18. Weather Patterns
* * 19. Machines and Engines
* * 20. Friction
* 21. The Detergent Story
* 22. The Polythene Story
* 23. The P.V.C. Story
* 24. Man in Space

* Indicates Books Analysed For Sex Bias.

## TEXTBOOK ANALYSIS

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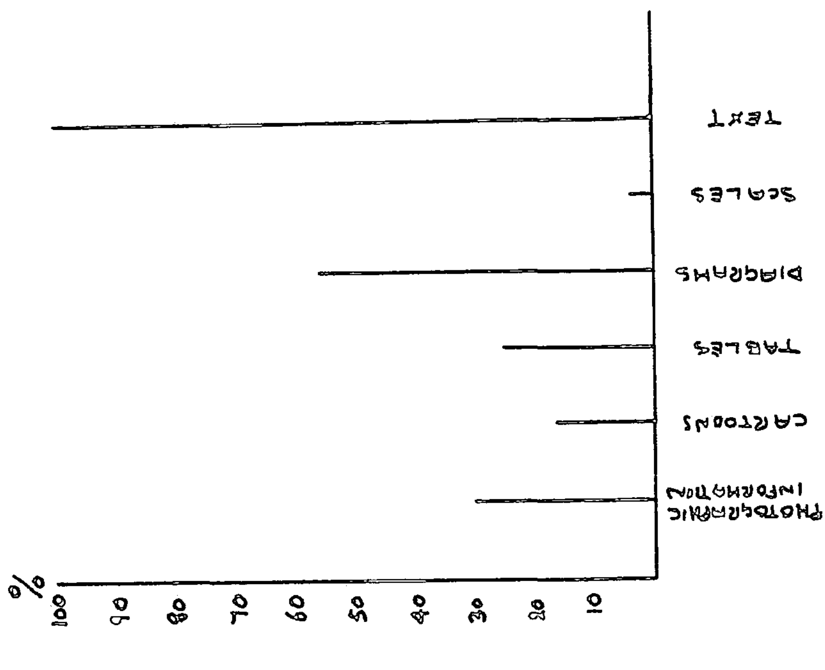


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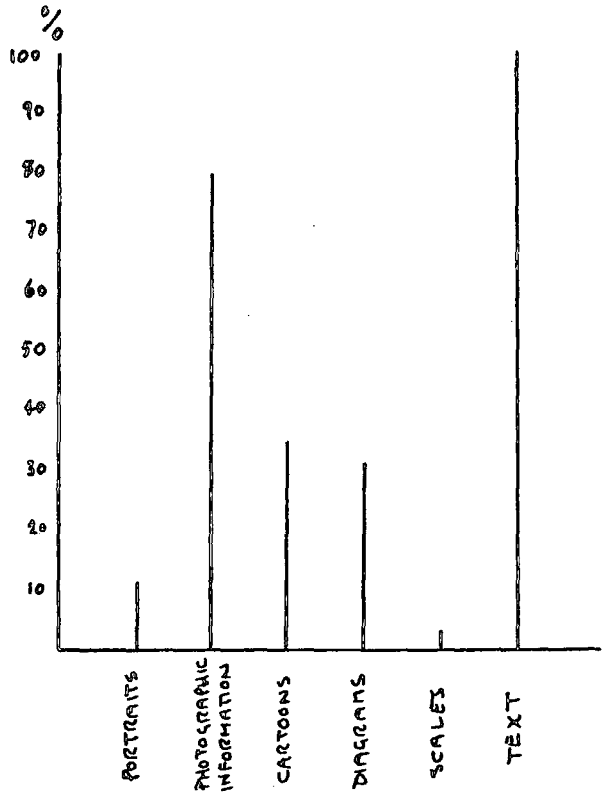


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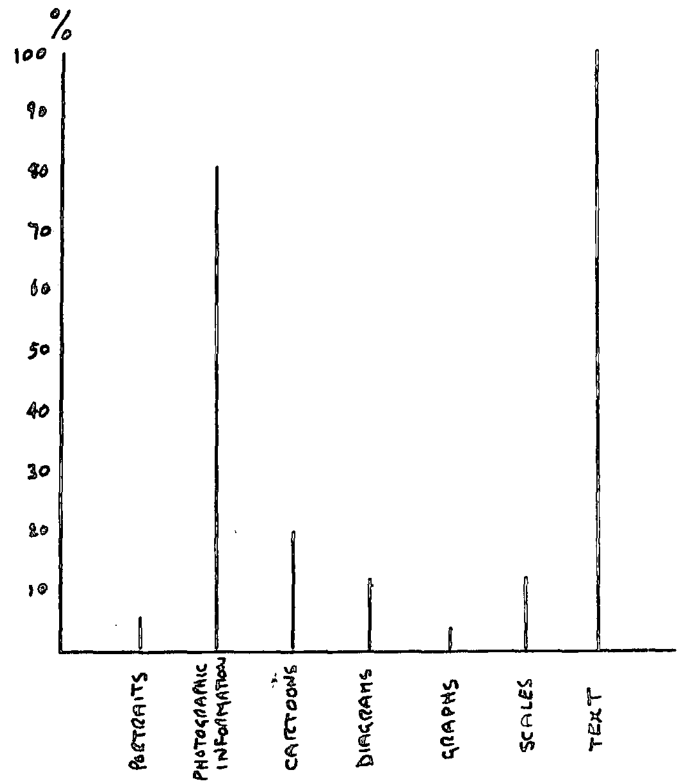


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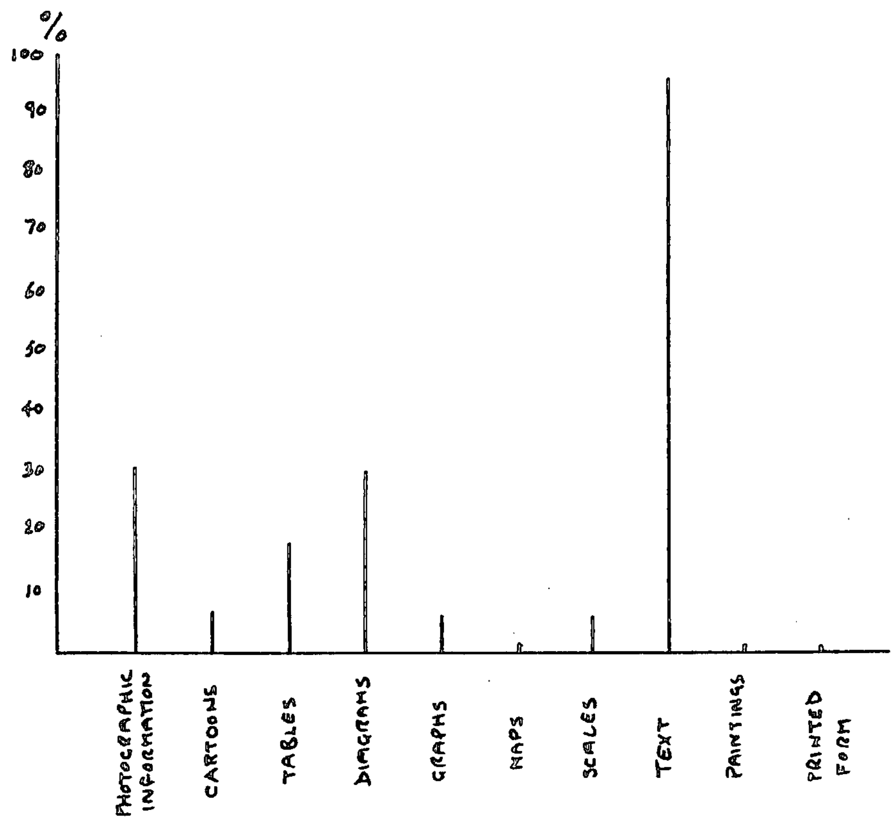


SCISP PATTERNS 1

BUILDING BLOCKS

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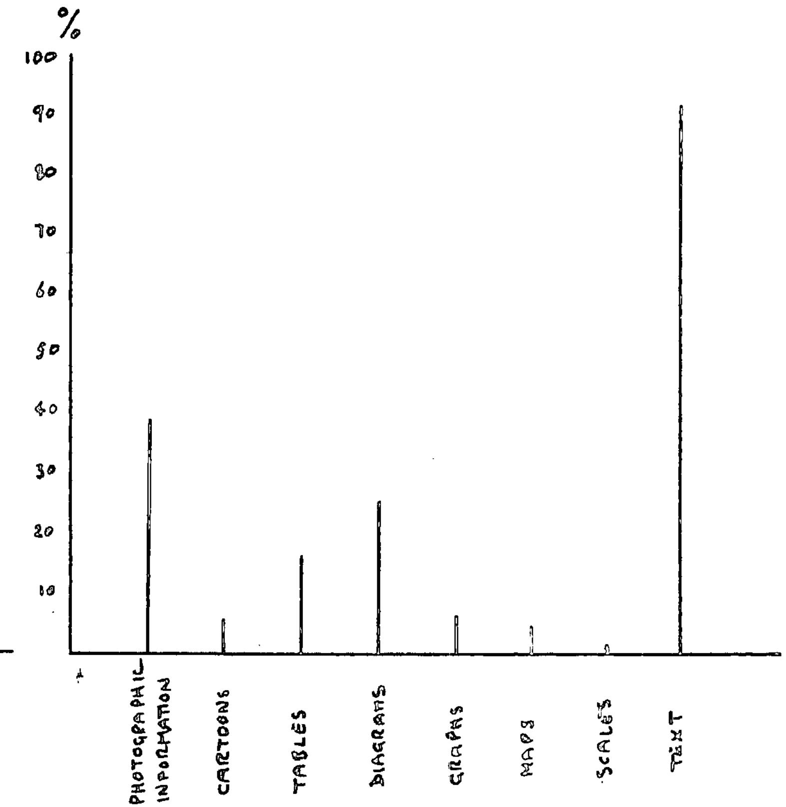
SCHOOLS COUNCIL / LONGMAN / PENGUIN BOOKS. 1973




SCISP PATTERNS 2

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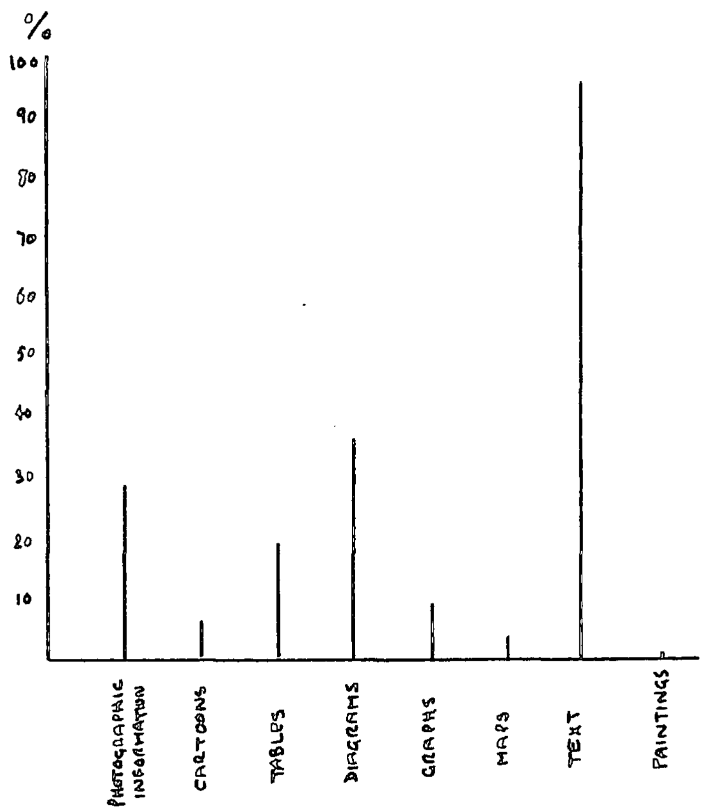


SCISP PATTERNS 3

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BAUSOR, J., HALL, W. and MOWL, B.

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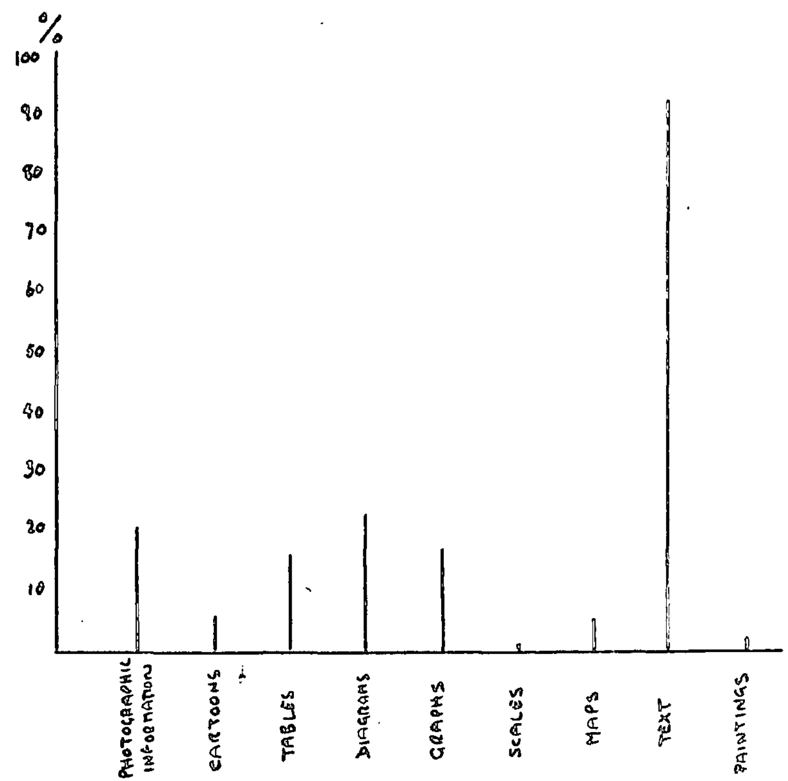
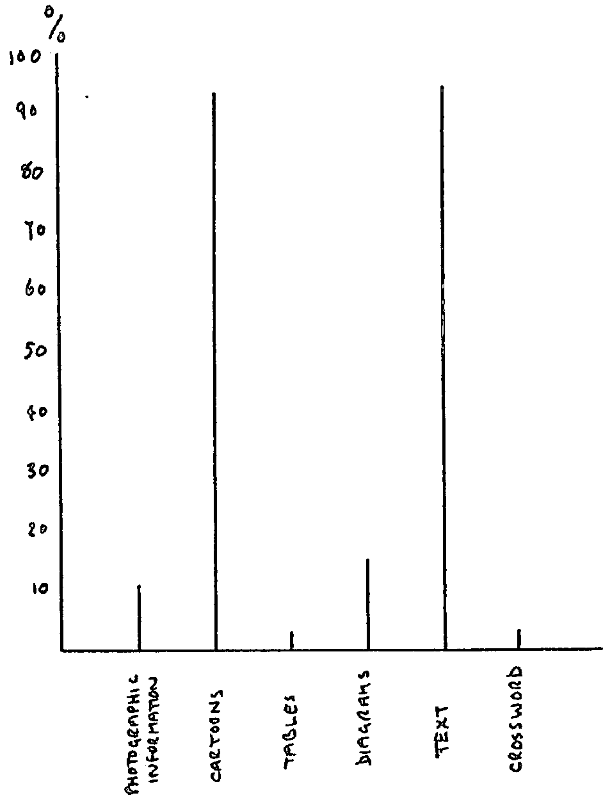



SCISP PATTERNS 4

INTERACTIONS AND CHANGE

MOWL, B., HALL, W. and BAUSOR, J.

LONDON : SCHOOLS COUNCIL / LONGMAN. 1974

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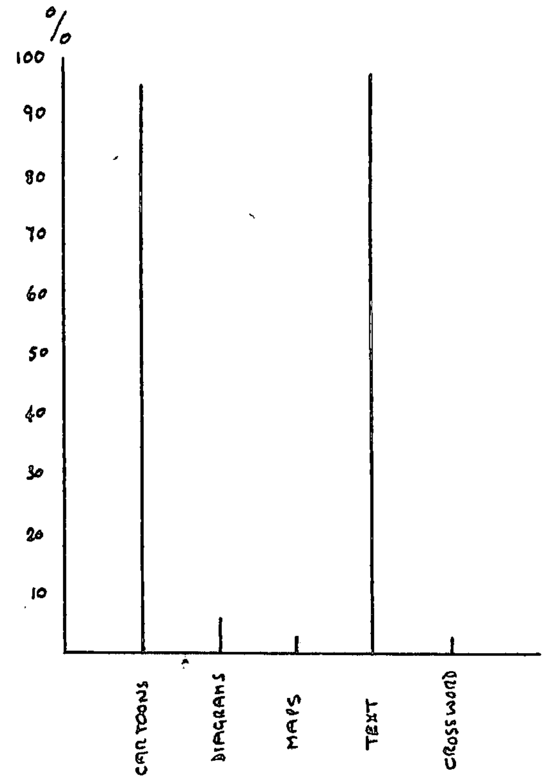


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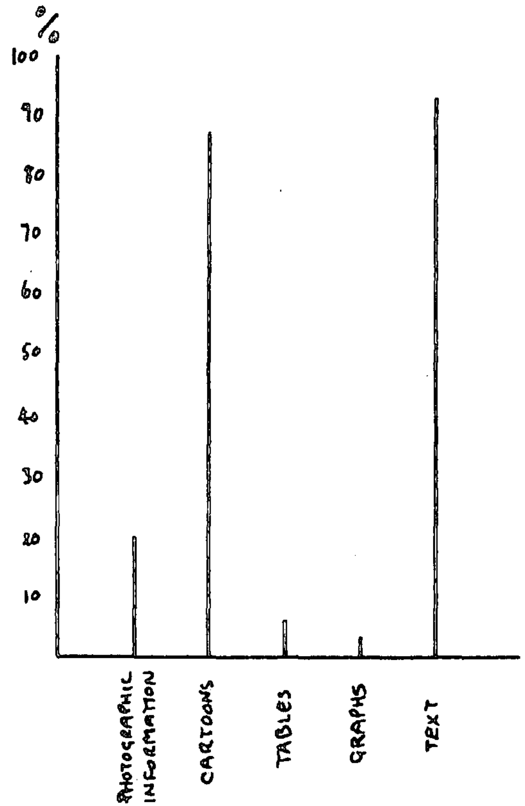


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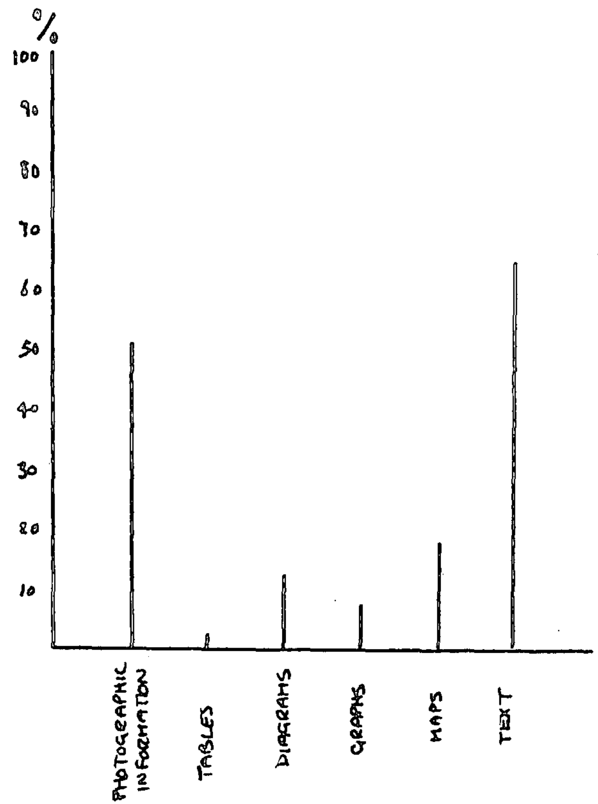


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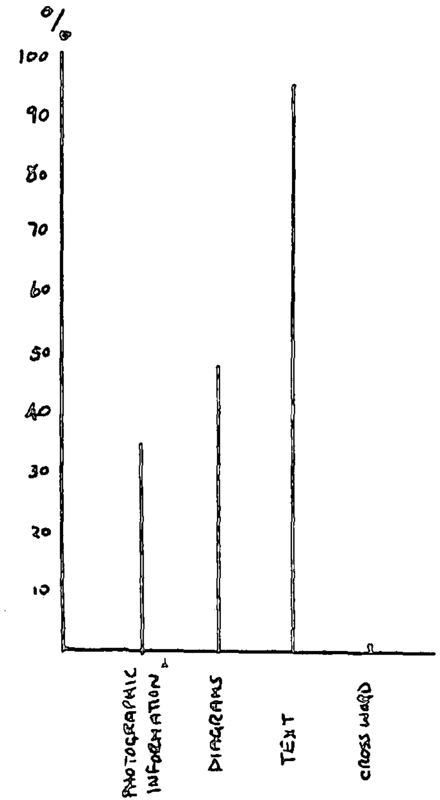


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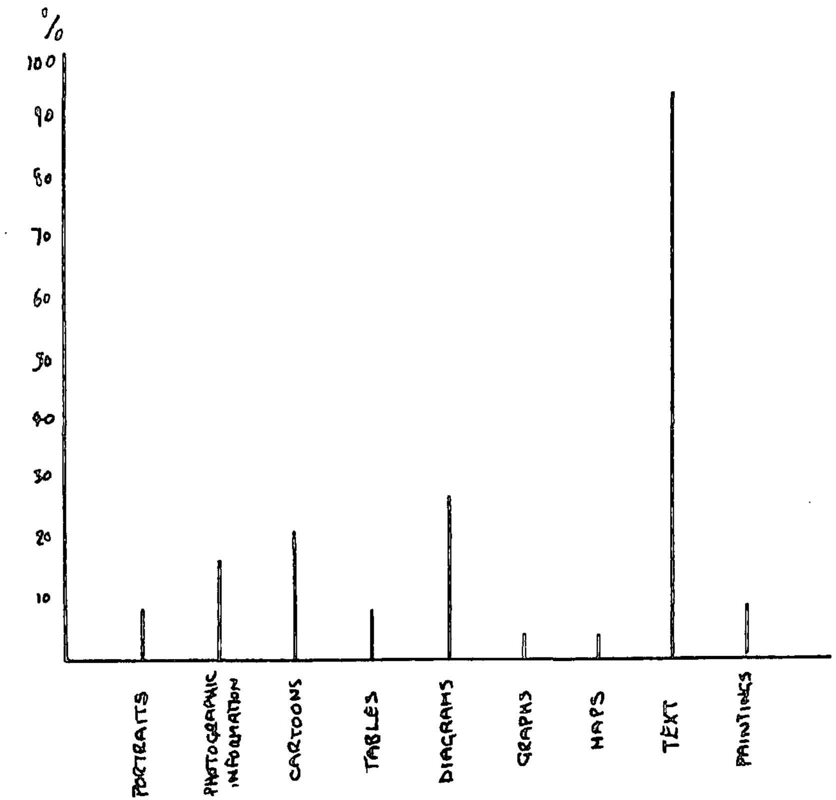


BIOLOGY FOR THE INDIVIDUAL BOOK 7
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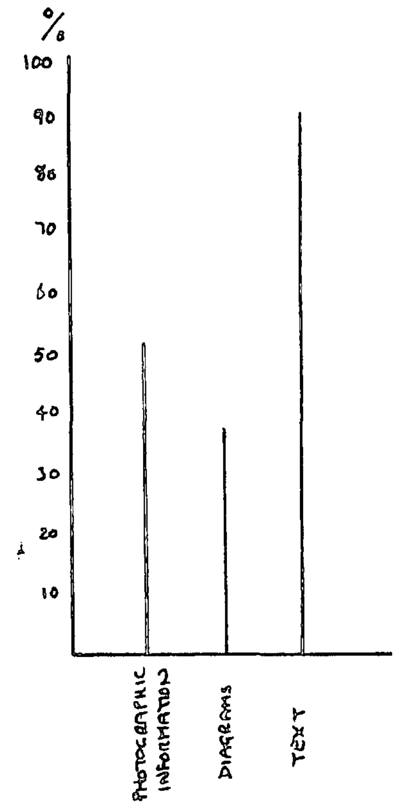
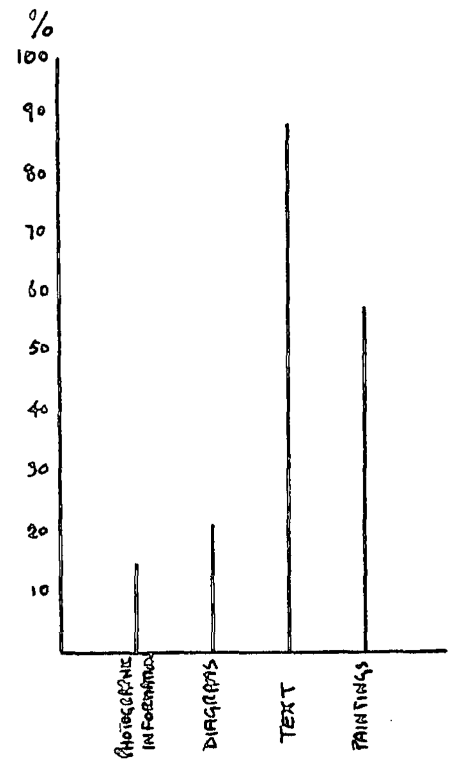



BIOLOGY FOR THE INDIVIDUAL BOOK 8
PLANT REPRODUCTION
REID, D. and BOOTH, P.
LONDON: HEINEMANN EDUCATIONAL BOOKS
1980. 21 PAGES.

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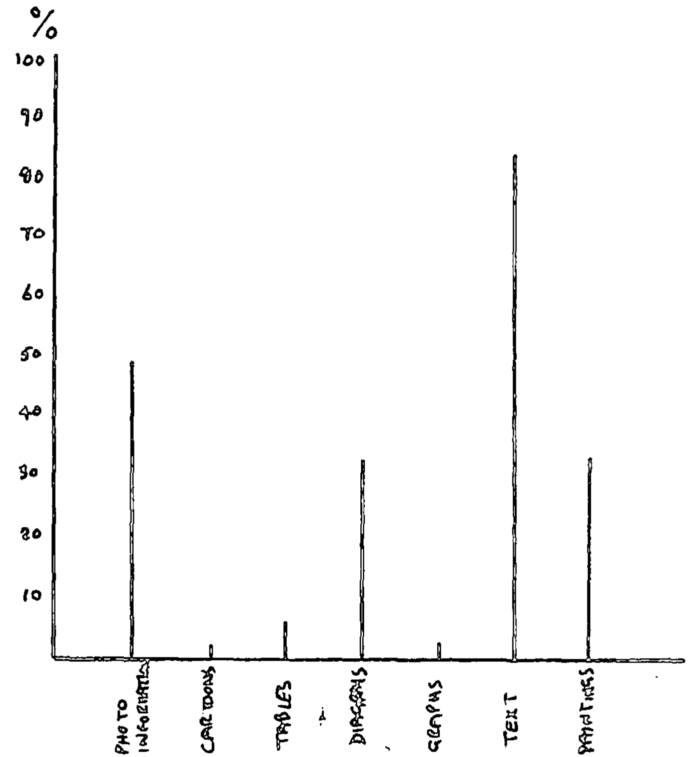


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# Senses 2



## Investigating your temperature sensors

For this investigation you need a water bath kept at a temperature of 75 C. with three test tubes of water in it. Also, a tea towel or some tissues. The tubes will need to have been in the bath for a few minutes to make sure that they are all up to the right temperature.

When you are ready, take one of the tubes, dry it quickly then put it in turn against each of these parts of the skin on your hands and arms:

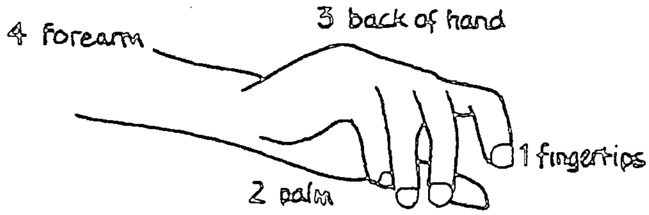
1. your fingertips
2. the palm of your hand
3. the back of your hand
4. your forearm.

You can try the outside of your elbow too if you like.

The test tube should feel warmer in some places than others. Where does it feel warmest? Where does it feel coolest?

Put the tube back into the water bath and check your results with another tube. Try to go round the skin areas more quickly this time.

You can show your results on a diagram like the one here. Copy it into your notebook. Colour red the area where the tube felt warmest, yellow for the next warmest, green for the next and blue for the area where the tube felt coolest.




## Investigating your sense of touch 1

You need a partner and two sheets of paper for this.

Close your eyes and get your partner to drop the piece of paper onto the back of your hand. If you can feel it fall get your partner to tear it in half and drop it again. Go on until you find the smallest piece of paper you can feel. Keep it to stick in your notebook. Test your partner in the same way.

A test like this, which tells you the most or least of something that you can sense, is called a 'threshold sensitivity' test. Write a few words about it in your notebook.

## Investigating your sense of touch 2

You will need a blindfolded partner for this(!). Also eight cardboard 'tiles' about 6cm x 6cm each covered with a different material from the list shown in the table below, and a piece of softwood about the same size.

| surface | fingertips | | | back of hand | | | forearm | | | forehead | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| blotting paper | | | | | | | | | | | | |
| clear acetate | | | | | | | | | | | | |
| linen | | | | | | | | | | | | |
| plastic foam | | | | | | | | | | | | |
| sandpaper | | | | | | | | | | | | |
| softwood | | | | | | | | | | | | |
| tissue paper | | | | | | | | | | | | |
| velvet | | | | | | | | | | | | |

The idea is that you touch the fingertips of 292
your partner (who is wearing a blindfold) with each of the tiles in turn and he or she has to say what they are covered with. You swop the tiles round and try them in a different order until you have tried each one three times.

If your partner gets it right you put a tick in the correct box in the table – if wrong you put a cross.

Write in your notebook, your answers to these questions: ▷

When you have tested your partner on the fingertips, go on to the back of the hand (as in the table), then to the inside of the forearm and the forehead. Do three 'presentations' for each tile.

Then put on the blindfold and let your partner test you.

What does the investigation tell you about your sense of touch?
Which parts of your skin are most sensitive?
Which are least sensitive?
Why did we ask you to do so many tests?
Why did we ask you to swop the tiles round?
How do your results compare with your partner?
How does your touch sensitivity compare with your temperature sensitivity?

## Investigating your sense of taste and smell

nce again, you will need a blindfolded artner. To make things even more difficult he r she must wear, for some of the time, a lastic peg (of the type used by underwater wimmers) on the nose! Also you will need a ink, a supply of drinking water, a clean easpoon, and chopped fruit and vegetables as hown in the table. ▷

| Food | reaction nose plugged | nose unplugged |
|---|---|---|
| Apple | | |
| Banana | | |
| Potato | | |
| Onion | | |
| Orange | | |
| Lemon | | |

he idea is that you feed your partner with one the foods taken at random from the list (whichever takes your fancy, in any order). If your partner can easily say what the food is you put a tick in the table. If the food is difficult to recognize you put a cross.

After each test he or she rinses the mouth in clean water. Then you repeat the tests with his or her nose unpegged. Of course, you change places and do the whole investigation again.

Before you move on, both of you should try eating a bit of apple whilst you are smelling the dish of chopped onion.

What does the investigation tell you about your senses of taste and smell? Write about it in your notebook.

You could try a similar investigation with different flavours of crisps.

The idea is that you touch the fingertips of your partner (who is wearing a blindfold) with each of the tiles in turn and he or she has to say what they are covered with. You swop the tiles round and try them in a different order until you have tried each one three times. 298

If your partner gets it right you put a tick in the correct box in the table - if wrong you put a cross.

Write in your notebook, your answers to these questions: ▷

When you have tested your partner on the fingertips, go on to the back of the hand (as in the table), then to the inside of the forearm and the forehead. Do three 'presentations' for each tile.

Then put on the blindfold and let your partner test you.

What does the investigation tell you about your sense of touch?
Which parts of your skin are most sensitive?
Which are least sensitive?
Why did we ask you to do so many tests?
Why did we ask you to swop the tiles round?
How do your results compare with your partner?
How does your touch sensitivity compare with your temperature sensitivity?

## Investigating your sense of taste and smell

Once again, you will need a blindfolded partner. To make things even more difficult he or she must wear, for some of the time, a plastic peg (of the type used by underwater swimmers) on the nose! Also you will need a sink, a supply of drinking water, a clean teaspoon, and chopped fruit and vegetables as shown in the table. ▷

| Food | reaction: nose plugged | reaction: nose unplugged |
|---|---|---|
| Apple | | |
| Banana | | |
| Potato | | |
| Onion | | |
| Orange | | |
| Lemon | | |

The idea is that you feed your partner with one of the foods taken at random from the list (whichever takes your fancy, in any order). If your partner can easily say what the food is you put a tick in the table. If the food is difficult to recognize you put a cross.

After each test he or she rinses the mouth in clean water. Then you repeat the tests with his or her nose unpegged. Of course, you change places and do the whole investigation again.

Before you move on, both of you should try eating a bit of apple whilst you are smelling the dish of chopped onion.

What does the investigation tell you about your senses of taste and smell? Write about it in your notebook.

You could try a similar investigation with different flavours of crisps.

READABILITY

The following extracts were chosen for checking the readability level using the computer software on a Research Machines 380Z micro-computer:

TEXTGRADER

JOHN MAHONEY and PETER MEIKLEJOHN

Hutchinson Software.

The extracts were chosen at random so far as content was concerned, but at fairly regular intervals throughout each textbook. In the case of school worksheets one extract was taken from each in order to gain a general impression of the level for which they might be suitable.

(Punctuation in the passages has been largely ignored since it is not important in the use of these readability scales.)

Science Activities Book 1 New Nuffield Combined Science 11-13.

Page 2.

The exhibits have been chosen to give you an idea of the things you will be looking at and finding out about in your science lessons. Also the exhibits will give you the chance to practise being a scientist concentrating hard so you see or hear or smell or feel things you would normally miss. The exhibition might seem confusing it might make your head spin but dont worry about it it is just the same for all scientists. They are interested in everything in the world including themselves so it can be difficult to decide where to start. When they have such a problem scientists look. closely at one thing at a time and worry about the rest later.

Page 7.

In this investigation you are going to use your bunsen burner to heat things which are listed in the table further down the page. Before you begin think carefully about keeping yourself safe. Here are some of the ways that good scientists avoid painful accidents. Good scientists always wear safety specs when they are heating things. They always tie their hair back if it is long. They never look directly down on something being heated. They remember that things like tripods and tin lids soon get too hot to handle safely. They always heat small amounts of new substances until they know what is likely to happen.

Page 12.

The pollen grains in the pictures have been magnified about two thousand times by a very powerful microscope. Yours will not magnify as much probably somewhere between 50 and 100 times. Can you find out exactly how much? There is a clue in the strange words such as X5 written on the eyepiece and objectives. To observe pollen grains through your microscope breathe on a slide to mist it over then dab a flower onto it. Draw pictures of the pollen grains as you see them and label them with the names of the flowers. Say how much your microscope was magnifying when you looked at the pollen.

Page 17.

The idea is that you feed your partner with one of the foods taken at random from the list whichever takes your fancy in any order. If your partner can easily say what the food is you put a tick in the table. If the food is difficult to recognise put a cross. After each test he or she rinses the mouth in clean water. Then you repeat the tests with his or her nose unpegged. Of course you change places and do the whole investigation again. Before you move on both of you should try eating a bit of apple whilst you are smelling the dish of chopped onion.

Page 23.

This is an investigation which will take a little time and involve you in preparing some apparatus. First you will need to make a collection of cylindrical containers of as many different sizes as possible. For instance they could range from a spice drum to a large dried milk container. You should aim for at least six. Then you will have to put sand or leadshot ask your teacher about this into some of them so that one or two of the smallest weigh more than one or two of the largest also so that some of quite different sizes weigh the same.

Page 28.

Make a hole about 2mm across in a clean dry milk bottle top. Put a small drop of water in the hole. Get your eye very close to the drop with the thing you are looking at just underneath it. Try different sizes of holes. Which gives you the best results? Another model uses glass drops. Your teacher will show you how to make these. Take a piece of thick card 8cm by 3cm and make a hole near one end. Lay a glass drop on the card so it rests in the hole. Tape its stem to the card.

Results for Average Grades of 6 Passages:

Main results with suggested areas of use

Primary and lower secondary material:

Mugford :9.95 Years

Fry :X = 6.27; Y = 134.95

Secondary material:

Flesch :12.54 Years

Fry :X = 6.27; Y = 134.95

Fry Reading Level 12+ Years.

FOCUS - A Reader: New Nuffield Combined Science 11-13.

Page 2.

She is a forensic scientist a person who works on crimes and accidents. Often she does her work at the scene of the crime examining things like footprints fingerprints and tyre marks. She may collect fibres and small pieces of cloth and samples of soil paint and blood. All of these will be taken back to the laboratory for investigation. Some scientists do wear special clothing even white coats like doctors and dentists but you could find them wearing wellies a skirt jeans collar and tie overalls or a wet-suit. In fact scientists don't look too different from you. Its not so much the things that scientists do that make them scientists its how they do them.

Page 7.

The fossilized skeleton of a dinosaur which swam in the seas of 185 million years ago. The fossil is similar to one of many which were discovered about a hundred and fifty years ago by Mary Anning the daughter of a carpenter at Lyme Regis in Dorset. Mary's discoveries caused a storm amongst the scientists of the day, and some became very angry with her. The scientists could not agree on an explanation for the fossils what they were how long they had been there and so on. Since then many scientists have spent their lives observing and studying fossils trying to fill the gaps in our picture of life millions of years ago.

Page 12

In England in 1848 a doctor called John Snow was trying to find ways to control the dreadful disease cholera. There were many explanations for the disease some people said it was caused by bad food, others blamed rats or insects or bad air. Dr Snow was confused until one day almost by accident he discovered that lots of people who got the disease seemed to have one thing in common they took their drinking water from the same public pump. It turned out that filthy water was leaking from a nearby sewer and polluting the pump water. John Snow went on to prove that the popular ideas were wrong.

Page 17

You have four kinds of sense receptors. Three are sensitive to coloured light red light green light or blue light. The surprising thing is that you can recognise hundreds of different shades of colour using just these three kinds of receptors. Scientists have an explanation for this but it is very complicated and you will have to learn much more about light before you can understand it. Part of your brain stretches out like a thin finger to reach each retina and pick up their signals. Colour blindness is caused because one or two of the three kinds of colour receptors do not work properly.

Page 22.

Suppose you are eating an apple. Each of your senses is giving your brain information about it. The reports which your brain could be getting are shown in the picture. From these reports the brain makes up a picture of a red scrunchy fresh juicy firm round apple. As it builds up the picture your brain makes use of its reference library your memory. Can you see where? Your brain combines all the reports from your senses into a full story about the apple. Suppose you were given a fake plastic apple? How would the reports differ? What about a sour tasting cooking apple?

Page 28.

Percival Lowell studied the planets for fifteen years and drew dozens of careful sketches of his observations. The sketches showed more than five hundred canals in great detail with blobs which Percival called oases where the canals crossed. He wrote about changes in the appearance of the canals from one season to the next explaining the changes by saying that farming must be taking place on their banks. As we said other scientists found it difficult to see the canals at all but the public were convinced. As the years went by many stories and plays were written about Mars and Martians.

Results for Average Grades of 6 Passages:
Main results with suggested areas of use
Primary and lower secondary material:
Mugford :11.85 Years
Fry :X = 5.16; Y = 141.54
Secondary material:
Flesch :14.52 Years
Fry :X = 5.16; Y = 141.54
Fry Reading Level 13.5 Years.

PROBE - A Reader: New Nuffield Combined Science 11-13.
Page 3.
Back in 1965 the telescope was used to pick up some important radio waves from outer space. The scientists decided that these waves had been produced at the start of the universe seven thousand million years ago. They had been travelling towards Earth ever since. The idea caused great excitement amongst scientists all over the world. If they could observe the signals well enough they might get

clues to the way the Universe began! Today there are many radio telescopes all over the world. Scientists are still working on their ideas about the start of the universe. Here is another 'message-changing' instrument in use.

Page 9.

About a hundred years ago, length measurements were in a dreadful mess. Travelling merchants had to carry scales like the one in the picture. They had to choose the right 'inch' for the country they were in. You can imagine the problems. Doors made from lengths of wood cut in one country might not fit the door frames in another. It was specially worrying to scientists who wanted to share their measurements with other scientists all over the world. People in several countries tried to do something about it but nothing much happened until 1790.

Page 15.

It had been difficult for scientists to see that the natural way for things to move was in a straight line at a steady speed for ever. This was because, on Earth, friction and air resistance soon slow things down. But nowadays we have seen films of people moving in space or in spacecraft and the idea makes more sense. If the astronaut in the picture accidentally gave himself a push he might go off in a straight line at a steady speed for ever and ever. For this reason, in the days before rocket 'back-packs' MMU's - Manned Manoeuvring Units , astronauts were always fastened to the ship by a safety line.

Page 21.

Without friction it would be impossible for us to walk. It would be impossible to get a bike or car moving. Socks and tights would not stay up, and shoe laces would not stay tied. You couldn't strike a match and most cigarette lighters would not work. So you can see that friction is very important to us. Technologists make use of it not only in the design of tyres, but in the design of brakes. The instrument in the picture measures the friction between materials used to make the brakes of large trucks. The two great wheels at the left and right are spun up to a high speed using an electric motor.

Page 27.

Day after day, for eight years, Tycho and his assistants made thousands of careful measurements. The measurements were repeated over and over again, often using more than one design of instrument. The results were so good that they are still used by today's scientists. Sadly, Tyco's temper made him many enemies at Court. One story tells that, one day a great nobleman came to visit the observatory. During the visit he tripped over Tycho's beloved dog, which you can see in the picture. The nobleman kicked the dog, and Tycho lost his temper and threw him out of the observatory!

Results for Average of 5 Passages:

Main results with suggested areas of use:

Primary and lower secondary material:

Mugford :10.59 Years

Fry :X = 6.75;Y = 144.33

Secondary Material:

Flesch :13.46 Years

Fry :X = 6.75;Y = 144.33

Fry Reading Level 13 Years

Extracts from Patterns 1 Building blocks by Hall,W. and Mowl,B.Schools Council,(1973). This Pupils' manual is one of a series designed to provide a scheme of work in science specifically for the Schools Council Integrated Science Project.The books are not regarded as textbooks, but rather to be guides to pupils' study of science and the work of scientists.

Page 8.

The following suggestion should enable you to answer that question. Plot a graph of the entries in columns 5 and 6 of your table as shown, using a different symbol for each material. What conclusion can you draw from your graph? Use the graph to formulate a simple mathematical pattern about the relation between mass and volume. This relation illustrated by your graph ( for a particular substance ) is one called 'proportionality'. We say that the mass of a piece of iron is proportional to its volume. We can equally well say its volume is proportional to its mass. For different objects of the same material the mass and the volume can be different.

Page 44.

How do these assumptions probably differ from the real situation ? Using the beads or matchsticks to represent organisms and bearing the assumptions in mind, work out the number of organisms in the population for each of the next six years. It is, of course, quite possible that you will not need beads or matchsticks as a help; you may prefer simply to calculate these figures. Construct a graph with years on the horizontal axis and number of organisms on the vertical axis. Just as we need tools like a telescope to help us extend our powers of observation, so we need 'mental tools' to help us extend our thinking.

Page 69-70

Separate a fleshy segment of onion from its neighbours. Snap the segment into two and see if this provides a small piece of ragged almost transparent, 'skin' at the broken edge. Grip this skin gently with the forceps and peel off a larger segment. Place it in a drop of water on a glass slide (avoiding folding the skin over on itself) and gently lower the coverglass over it with the mounted needle (figure 5-1). This will prevent air bubbles being trapped. (Air bubbles appear as black curved lines. If you do have some trapped bubbles choose an area to look at that is clear of them.)

Page 99.

Groups in the class can make samples of copper chloride, copper sulphate and copper nitrate in the following way. To about 5cm3 of dilute acid add one measure of black copper oxide and warm the mixture. Cool and filter off the excess copper oxide, collecting the filtrate in an evaporating basin. Gently warm the evaporating basin until most of the water has boiled away and remove the Bunsen burner. The heat of the gauze and tripod will be sufficient to remove the rest of the water, leaving the salt. Repeat the spectroscopic analysis for each of the three salts which are formed (you will have to obtain two of the salts from other groups).

Page 141.

Among the new techniques which the experts have to offer, one of the most important is the use of fertilisers. It is worth noting that the best-fed countries in the world are also the ones which use the greatest amount of fertiliser. A leading American agricultural scientist, Dr Robert White-Stevens, has estimated that if 10 dollars' worth of fertilisers and 5 dollars worth of pesticides were used on every acre of the world's arable land world food production would be doubled in the next decade. In 1961, under the Freedom From Hunger Campaign, a programme was launched by FAO in cooperation with the world's fertiliser industry to test and demonstrate the efficiency of the various kinds of fertiliser applied to differing crops and soil conditions.

Results for Average Grades of 5 Passages

Main results with suggested areas of use

Primary and lower secondary material:

Mugford :11.85 Years

Fry :X = 4.93; Y = 150.69

Secondary material:

Flesch :16.1 Years

Fry :X = 4.93; Y = 150.69

Fry Reading Level 15 Years

Extracts taken from worksheets used with 4th year pupils in Integrated Science.

Title: To find the relative number of reacting ions in the reaction between lead nitrate and potassium iodide.

The quantity of precipitate produced will depend on the numbers of moles of potassium iodide and lead nitrate available for combination. If we keep the number of moles of one of these, say potassium iodide, constant, then the height of precipitate produced will vary with the number of moles of lead nitrate used providing we are not adding lead nitrate in excess, for then it will make no difference and the height will remain constant. By adding increasing numbers of moles of lead nitrate to separate constant numbers of potassium iodide and measuring the height of precipitate we can find the maximum number of moles of lead nitrate required.

Title: SOME EXPLANATORY NOTES ON THE CORROSION OF IRON

Rusting of iron requires the presence of water and oxygen. It is electrolytic ie by some means a cell must be produced so that the electron flow can bring about the formation of rust. This can result from (a) iron with impurities, (b) iron with iron oxide, (c) differing oxygen concentrations in the water. To illustrate the mechanism of rusting we will use an example of type (a). Imagine a piece of iron exposed to the atmosphere as shown below. Metals tend to readily form positive ions so there will be a tendency here for iron atoms to go into solution in the water becoming Fe2+ ions.

Title: Energy in Chemistry.

Like poles repel each other therefore energy will be needed to bring the two magnets together in directions X and when together they will spring apart when released. ie they have this repulsion potential energy which increases the nearer they are together. Because the charges are unlike they will attract each other and when they are released they will move together. ie they possess attractive potential energy prior to being released. This is given by the product of forces and distance so that the greater the distance apart they are the greater their potential energy. An atom is made up of charged particles so that they will experience attractive or repulsive forces between themselves depending on their charge.

Title: THE ENDOCRINE GLANDS

The master gland hormones from this gland control all other glands to some extent. Part of the gland is concerned with growth, overactivity in childhood causes giantism, deficiency results in stunting or dwarfing, overactivity in adults causes enlargement of the head and hands and mental backwardness (acromegaly). Another part controls the water balance of the body, disease here leads to excessive weak urine, high blood pressure and faulty bowel and bladder action. This gland in the female works in close association with the ovaries in the regulation of ovulation, menstruation, pregnancy and childbirth. The thyroid. Produces thyroxin which controls the rate of body metabolism.

Title: Investigation into the decomposition of Hydrogen Peroxide

We can represent hydrogen peroxide as H2O2 ie one mole contains two moles of both hydrogen and oxygen atoms. We see that it contains per mole one mole of oxygen atoms over that in water. It can very easily lose this oxygen and become water according to the following equation. It can also lose its oxygen to other substances in chemical reactions. Substances which give up oxygen in this way we call oxidising agents. If a beaker of hydrogen peroxide is left on the bench it slowly decomposes into water and oxygen. This requires energy. Can you suggest where this energy comes from?

Results for Average Grades of 5 Passages

Main results with suggested areas of use

Primary and lower secondary material:

Mugford :12.6 Years

Fry :X = 5.2; Y = 163.5

Secondary material:

Flesch :18.89 Years

Fry :X = 5.2; Y = 163.5

Fry Reading Level 17+ Years

Extracts from 5th Year worksheets given to Integrated Science Groups.

VELOCITY QUESTIONS MECHANICS

A trolley starts from rest on an inclined plane and moves down it with uniform acceleration. After 3 seconds its velocity is 15ms-1. Calculate its acceleration and velocity after 10 seconds. John and Mary start walking at the same time from the SW corner of a field whose South side is bounded by a straight stone wall. John walks alongside the wall at 5.5kmh while Mary sets off at 6kmh along a straight footpath across the field, which makes an angle of 50 with the wall. Find, by means of an accurate scale drawing the velocity of Mary relative to John and their distance apart after 10 minutes.

Title: ECHO LOCATION (Extract 1)

An English scientist named Hartridge suggested in 1920 that the animals gave out high-pitched sounds and received the echoes informing them of obstacles ahead. This is now known to be the case but it was twenty years before Hatridge's theory could be proved with the aid of electronic apparatus to make and receive these high-pitched sounds. While in flight the bats continually emit their ultrasonic squeaks of a frequency around 50 kilocycles per second. These are quite inaudible to the human ear and must not be confused with a lower note about 7 kilocycles emitted frequently. This latter squeak can be heard by man.

Title: ECHO LOCATION (Extract 2)

All this developed from a somewhat primitive method of estimating distances using a ship's fog horn. A rough estimate of the distance from an iceberg or a cliff could be obtained by giving a blast on the horn and then counting of using a watch to measure the time needed for the echo to return. The real steps forward in echo location radar and sonar were developed during World War II for finding the position of enemy ships and submarines. Unlike the other types of echo location radar makes use of radio-waves of very high frequency. Pulses of waves are produced by a specially designed radio transmitter.

Worksheet 8a on Problem Solving.

Imagine that you have been given a low voltage high current power pack. If the power pack is working properly it will have an output of 1 volt and will supply up to 10amps dc. But you don't know whether or not it is working you have to find out that's the problem. The most obvious way to test the pack would be to connect a voltmeter across its terminals and see if you get a reading. But you have to think of three other ways of testing it ie three other experiments you could do. The experiments must be different from each other as possible.

pH and indicators

An indicator is a substance which you add to a solution to test the pH of the solution. The indicator changes colour depending on the pH. A colour chart helps you to get the result. Different indicators show different colour ranges. The pH number indicates the acidity alkalinity of a solution. The problems. Find the pH of three standard solutions using Universal Indicator. Use these standard solutions to investigate the colour range of a mystery indicator. Use the mystery indicator (marked MI) to estimate the pH of solution x.Hints on procedure. Decide on the apparatus you will need and collect it together.

Title: Britain Before Man

Precambrian time constitutes the first 4000 million years of Earth history though there is no record in British Precambrian rocks of the first 1600 million years of this era. For much of it we know only of events that occurred deep in the crust and which moulded the ancient crystalline foundation of the British Isles. But in the last 400 million years there is evidence of river plains and sea troughs in which the Highland rocks were deposited and in South Britain of extensive volcanic activity. While cycles of uplift tilting and erosion shaped the emergent land of Britain world climate cooled.

Results for Average Grades of 6 Passages

Main results with suggested areas of use

Primary and lower secondary material:

Mugford :12.55 Years

Fry :X = 5.65; Y = 153.25

Secondary material:

Flesch :16.51 Years

FRy :X = 5.65; Y = 153.25

Fry Reading Level 15 Years

**DO NOT PUT YOUR NAME ON THIS SHEET**

**FIRST AND SECOND YEAR SCIENCE SURVEY**

YEAR: FIRST / SECOND (Put a ring around the year you are in).

SEX : GIRL / BOY (Put a ring around your sex).

1. Describe a scientist in a few short sentences.

2. Name as many scientists as you can. Do not worry too much about spelling.

3. If you had to write something on any subject connected with science what would you write about?
(Just give a title)

4. What do you think about science in school?
In a few sentences tell me your opinions.

THANK YOU FOR YOUR HELP.

BRIAN THORN

APPENDIX E

FIRST AND SECOND YEAR SCIENCE SURVEY

# APPENDIX F

# PUPIL PROFILES

# PUPIL PROFILES AS EVIDENCE OF ATTITUDES TO SCIENCE

During the summer term of 1984, the school introduced a pilot scheme of profile reports which were designed to give more thorough and detailed analysis of a pupil's progress through school. One half of the profile provides a check list of skills, attitudes and attributes which the teacher is expected to assess on a five-point scale, but the other part of the profile affords an opportunity for staff, parents and pupils to record their comments about each subject area. This was the part of the report I was particularly interested in as I hoped that it would afford an opportunity for 'triangulation' of evidence in conjunction with observations and interview data.

This innovation in reporting within the school arose partly in response to the national call, by the Secretary of State for Education and Science, for a much more detailed system of reporting and assessing young people so that they might leave school with a comprehensive document - a 'record of achievement' as it is sometimes called.

The second reason for profiling being introduced was that it followed naturally out of the work being done in the Social and Personal Education programme in the school. This programme had been gradually phased into the school curriculum largely because of the enthusiasm of the second deputy head and a handful of teachers who recognised the value of such a course, following their attendance at courses run by the Career and Counselling Development unit based at Leeds University.

Originally the course, which seeks to increase pupil' self awareness of others, and develop a range of skills which will be useful when they have left school, had not been accepted by the Headmaster as part of the formal curriculum, because he claimed that it was impossible to find the time required on the timetable. He believed that to take anything out would be to destroy and eminently sensible and balanced curriculum in the upper school. He had put the case to a head of department meeting, but had not been able to persuade any department to voluntarily give-up time.

The solution, which was an unsatisfactory one to those who were most involved, was to run the new programme during the 25 minutes registration and assembly time on two days each week. This compromise was accepted, at least as a first step towards eventual integration with the rest of the curriculum, but there remained many staff who were far from convinced. The objections centred around the feeling that such work required a good deal of specialised guidance training and no in-service training had been promised. There was also strong feeling that teachers were being expected to give up non-teaching time and become involved with more lesson preparation in their own time for something which they saw as a management imposed task.

There were also several members of staff who violently disagreed with the whole idea of discussing pupils' attitudes to school and asking for their views on a wide range of topics. It was felt that if life-skills had to be developed then this should be done in the context of the existing curriculum though they apparently could not say why it had not been done before.

However, there was sufficient 'outside' interest being shown in this type of course, not least by the LEA, which had produced a statement of intent for secondary schools, that the Headmaster was able to pressurise sufficient teachers to say that they would at leas try: in practice some did little more than complete the register as they normally did and most of the preparation of materials fell to the enthusiasts who had been given the title of 'year co-ordinators'.

The fourth year were chosen as the pilot group, but the task of completing the first set of profile reports was regarded by many teachers as an unnecessary and time-wasting chore. In the event several teachers restricted their reporting to 'Quite good' or similar brief comments as a form of protest.

Some of the pupils saw this new system of reporting as a golden opportunity to say what they thought about some of their teachers, the subjects and the way they were being taught. Needless to say the staff who had been singled out for this treatment were far from happy that such comments were being allowed on documents which were public to all intents and purposes.

This set of profiles showed that, in the main, most of the pupils had great difficulty in making any sort of objective assessment of their own abilities or potential. Each one of them had been given a sheet with a number of suggested topics they might cover, but it was clear that many had simply used the phrases from the sheet in an attempt to say something. It is difficult to imagine that a fourteen year old boy would naturally write that he enjoyed 'learning new perspectives' in science.

A second set of profiles was completed, by the same year group now in their fifth year, during my period of observation and appeared to generate much less antagonism among the staff, though one boy was heard to remark that after filling in six of these subject forms he was just putting anything down to get it out of the way.

I decided to look at the profiles to try to discover whether the attitudes and opinions expressed by the pupils were consistent with those expressed during my interviews and to try to discover how far these views coincided with those of the science teachers who taught them.

The earlier set of profiles revealed that the boys generally had positive attitudes towards science with most of them believing that they worked quite hard and were doing well: this latter feeling was particularly prevalent amongst those boys who were taking agriculture or the non-examination course, applied physical science, these boys are of average or below-average ability.

When pupils admit to not working hard, losing interest or being bored they usually associate that with the fact that they find the work difficult to understand which leads them to lose concentration and turn their minds to other activities.

Staff comments about such pupils usually concentrated upon the pupils being 'resentful of criticism', 'far too complacent about preparing for the future' and 'talks too much, thinks too little'.

There was little indication that teachers gave much credence to pupils' comments, a point which is made by Furlong.

'I start from the assumption that pupils' explanations of their own behaviour in class are often of a different order from those of their teachers. Other research has shown that teachers usually 'explain' pupil behaviour in purely educational terms. Thus rather than refer to the pupils' reality, teachers have a tendency to draw on what they consider to be specialist knowledge to understand why children act as they do. For example, two common explanations of delinquency are, 'She comes from a deprived neighbourhood' and 'she never had a father'. Teachers using such explanations see themselves to be drawing on specialised 'sociological' and 'psychoanalytic' knowledge respectively. Whatever the apparent bases of these 'specialist' explanations (and teachers have an infinite variety to choose from to fit every purpose) they have one factor in common - this is their uniform neglect of the pupils' perspective'. (Furlong, 1977, 63).

Reading through the teachers' comments (these were written on the forms after the pupils had written their comments) there is in most cases a striking lack of empathy between the teachers and those pupils who admit to having difficulties, but who have generally 'switched-off' the subejct. There do not appear to be any obvious moves, in the comments, to try to open channels of communication, to rekindle interest or to look at the areas of learning difficulty with a view to trying to help the pupils to feel some sense of achievement.

The teachers seem, in most cases, to have formed an expectation of how a pupil ought to act and behave in science lessons and anyone who does not conform to that model is only worthy of negative and highly critical comment.

Possibly the most frequent comment to be written on the profile reports is that a pupil needs to learn the work more thoroughly. Such a comment appears to miss the point. If a child does not understand then there may be many reasons for this: has the child been at school regularly; has the child got some unidentified physical handicap such as a hearing defect or faulty vision; does the child have any emotional problem which might be causing a loss of concentration; is the child able to write adequate notes from which to learn the work - there will be many other factors which could affect learning, but they are not often sought.

In general girls profile reports reveal much more uncertainty and emphasise the difficulty which girls experience in science particularly when dealing with topics such as the 'mole concept', 'valency' or $p^H$.

Unlike the boys, who tend to stress their enjoyment of practical work, the girls do not, for the most part, place the same emphasis upon this aspect of the work. Gratification, for girls, seems to come from the study of the social issues connected with science, they enjoy considering the effects which science has upon society and the moral and ethical issues connected with such topics.

It is interesting to note that there are virtually no girls, with the exception of those who take CSE Human Biology, who mention the benefits of the science course they are taking to them as individuals - other girls only mention it as a qualification, a means to an end. The Human Biologists are very positive that the work has increased their store of knowledge and has helped them towards a greater understanding of the working of their bodies, how they should take care of themselves and how it will enable them to look after others.

These benefits must be seen alongside the fact that many of the girls experienced considerable difficulty in coping with the vocabulary, particularly the 'long words'.

Almost without exception the comments made by the girls about Human Biology were positive, but they also showed that the girls had been able to identify their own weaknesses and strengths in a realistic fashion.

It was noticeable that the teacher's comments were also very positive in that they were obviously written with the benefit of the pupil's comments to hand. Weaknesses and deficiencies were highlighted, but were not given undue emphasis and there were always encouraging comments designed to lift the pupil's self-esteem and provide a motivation for increased effort.

By contrast the general science course was not popular with most girls because it was considered to be too difficult, with topics such as electricity and mirrors being mentioned as presenting the greatest problems.

Examination success is seen as the sole mark of achievement in science by the girls as I have already mentioned, so that all pledges to work harder and to revise more thoroughly were given because the goal was to achieve good examination grades. Enjoyment was rarely applied to science by the girls, so that the general tone of their remarks was one of having to tolerate science as a necessary evil in the pursuit of certification.

At the same time the profiles written by the girls carried with them a generally low opinion of their worth in the subject. The greater number do not see themselves as being capable of doing science successfully and one wonders how this message has become so firmly and so widely accepted.

Teachers' comments, more often than not, centred upon academic achievement which could be measured by academic success. Nowhere in the comments was there any real evidence of the ideals of science education as laid down in the aims and objectives of the courses. Skills and processes which were being developed and modes of thinking and reasoning barely received a mention as the main theme of the comments seemed to be centred upon learning - presumably factual learning - and attitude.

AN ANALYSIS OF GIRLS' PROFILES

The profiles are not seen as part of the learning process as may be seen from the example below where the teacher criticises notes and homework, but does not give any clues about what is wrong or what ought to be done to improve the situation. The final comment seems to suggest that the girl has deliberately set out to convince herself that science was beyond her understanding.

PUPIL: 'Science is a complicated subject for me. I find it hard to learn and understand. My exam result was not very pleasing. To get a fair grade in science, which I need, I must revise more thoroughly for my final exam this year. Science is not one of my favourite subjects, but sometimes it is interesting and I enjoy it'.

TEACHER: 'Some progress has been made in her 'Thinking' about science, but her notes and homework are well below standard.

This (attitude) has been a problem all the way through. (Girl's name) very early on convinced herself that she could not do science and as a result has never done herself justice'.

The girl admits to finding the subject difficult to learn and understand, but she has not entirely rejected the subject as many would and points to three things which might be used to advantage by the teacher. The girl 'needs' the subject - a reference to an examination pass requirement - she finds the subject interesting and she enjoys it.

The teacher does not make use of these points however as he highlights the inadequacy of her homework and her notes, but nor does he make the connection between those deficiencies and her inability to understand the subject. No matter how hard the girl revises from those poor notes she is not going to make progress in her understanding and neither will inadequate notes help much with factual recall.

If, over the course, the girl has been working from a background of inadequate notes then it would not take very long for her to be convinced that she could not do science, because her grades, presumably, confirmed this every time she took a test.

Nowhere is there any evidence that the teacher has understood the pupil's problem and seen an opportunity to provide remedial help.

A second example shows similar problems of achieving pupil/teacher interaction to solve learning difficulties, and again shows the pre-occupation with examination success.

PUPIL: 'Unfortunately science is not one of my better subjects and it tends to show. Some aspects of the subject I understand easily and clearly, whereas there are others which I don't understand at all.

My mock exam result was average, really I was hoping for it to be a little better. Hopefully with a lot of revision my final exam result will be better. I feel that my progress is improving slowly.'

TEACHER: 'Very little learnt and understood, but mostly a good record of work. Practical work and written tests have been about average for the year group.

(Girl's name) has not been prepared to put in the hard work required. Her approach has been far too superficial for success in this subject'.

The teacher confirms the pupil's statement that she does not understand some of the work, in fact she understands very little, and she has not learnt it despite having a 'good record of work'. The record of work may well be impressive in terms of presentation and even in content because the girl has diligently copied what she has to do, but without the understanding which leads to learning.

In commenting about the superficiality of the girl's approach, is the teacher referring again to the record of work which is perhaps only cosmetically 'good'? The teacher identifies lack of hard work as the cause of the problem, but he does not go deeper into exactly what must be done to correct the problem. He does not see a role for himself in identifying those aspects of the work which the girl admits are difficult to understand.

After reading the report the girl is no nearer to finding the source of her difficulties than she was before because no clues have been given which will help her to focus on them. Her only answer is to imagine that by spending more time revising she can solve her problems, but there is no indication that her revision techniques are adequate, so she may never improve.

The following comment by a girl seems to usefully encapsulate the difficulties, attitude and interests of many of the girls on the SCISP course.

'I don't fully understand all the subjects that we have studied in science, but I'm prepared to tackle them if I am faced with the problem.

I seem to lack the background knowledge for certain problems, especially electricity.

Many of the words in science confuse me.

I prefer learning about the social problems connected with science because this interests me more'.

The way that teachers tend to suggest that the responsibility for solving learning difficulties rests with the pupils may be seen in this comment.

'She is working hard to improve her understanding and given confidence should do well'.

Confidence will surely come when the girl achieves understanding of the work, it will not be given in the way a present is given, nor will it be given in the sense that it will follow automatically from something the girl does. The teacher gives no indication that he sees it as part of his responsibility to help with developing understanding so that confidence will grow.

A similar problem of confidence was to be found in this report:

PUPIL: 'I was very disappointed with my "mock" exam results as I spent a great deal of time revising and trying to understand my work.

I have difficulty in dealing with the problems which occur in the exam papers'.

TEACHER: 'Good. (Girl's name) continues to work very hard. Her knowledge of the work is good; her basic understanding is good, but she must work hard to maintain and improve her confidence at problem-solving.

A very good attitude to work. Confidence and determination are what are now needed'.

This girl has clearly indicated in her comments a capacity for hard work and a desire to succeed through achieving understanding, but she is not happy in the problem-solving situation. The teacher then, rather unhelpfully, urges her to 'work hard to maintain and improve her confidence at problem-solving', but the girl has lost her confidence because she only achieved a disappointing exam result even though she felt that she had made a great effort.

She clearly does not know what to do to begin solving problems, and so needs to be given some advice, guidance and reassurance but the teacher does not begin to supply this, in fact he thrusts the problem back at her without any support or apparent understanding.

Pupils in schools quickly build-up a picture of their own abilities in relation to their peers using a variety of cues supplied, usually by the teacher, but perhaps by other pupils. Sometimes however the child may not receive an accurate message as the following example shows:

PUPIL: 'I quite enjoy the subject although some parts can be boring. I am glad that I am not taking the exam because I don't think I would do very well in it'.

TEACHER: 'Quite good. (Girl's name) is actually better equipped for the examination than she believes. In many ways it is a pity she decided not to do it.

Good - (Girl's name) looks interested and for the most part works hard'.

The girl, clearly did not believe that she could perform well enough in an examination to achieve even the lowest level of success in a CSE examination, or at least a grade which would satisfy her need for self-respect. The teacher on the other hand believes that she has the ability. The question which must be asked concerns how the girl has become so convinced of her own low ability and why the teacher has not managed to communicate his belief that she was capable and boost her confidence to the point where she was at least prepared to try.

Such a loss of confidence must occur over a prolonged period of time during which time the pupil must receive signals that tell her that examinations are not for her in this subject.

The interesting point in this example is that the girl was not simply avoiding examinations because she was, in fact, entered for a wide range of subjects to different examination levels, indeed she was also entered for another science examination.

There are many instances where pupils offer, in their comments, information which points to a genuine interest in science, but the teachers rarely respond to these in a positive way by using them as the basis for developing wider scientific interests.

PUPIL: 'I find most aspects of science very complicated and of little interest, i.e., valency, the mole, $p^H$ tests. I like learning such things as drug abuse, dangers of smoking and drinking etc., - Things that have effects on the society. If I am interested in what we are learning, then I take an active lively approach to my work. If I am not interested in the subject then I get easily distracted and get bored, so then I make little progress'.

TEACHER: 'Can make progress when the mood allows her, but (Girl's name) has been very inconsistent. She has avoided doing homework.

Very variable (attitude) - from the rebellious to the co-operative. She often seems to have a head too full of other interests to be bothered with her science'.

The pupil is very open about when and why she loses interest but the teacher chooses to ignore the positive side which she presents in the form of an interest in the social implications of science, instead he concentrates on the negative aspects of behaviour: her inconsistency, her inattention and her rebelliousness. Because the girl does not receive any praise or commendation those negative aspects of behaviour may well be reinforced.

AN ANALYSIS OF BOYS' PROFILES

Boys profiles reflect a similar picture, with apparent appeals for help often being ignored or not noticed by their teachers.

PUPIL: 'I find science very complicated and difficult to understand; this has caused me to find it boring and stop my progress. Although (Teacher's name) thinks I don't try I always attempt the exercise, but always get bogged down with the detail'.

TEACHER: (Boy's name) is not without ability, but he has found it difficult to follow the logical progression of the work. He has just about floundered to a full stop.

(Boy's name) has not been willing to really work hard to overcome his difficulties. He has adopted a rather defeatist attitude. He has not been responsive to efforts to help him.

These comments refer to a boy who has a long history of problems with communicating his thoughts in the written word, though he has considerable oral skills - he did receive very encouraging reports from two subject areas which rely heavily on the written word - English and History - where he was praised for his efforts.

He has the additional problem of being very weak in mathematics being only just capable of basic arithmetic calculations.

Perhaps in view of these problems, which are well-documented and should be known to the teacher, he has been somewhat harsh and unsympathetic in his comments.

In comments about another boy a teacher comments that,

'Until the trial exam results I would have said "next to none"', by which he refers to the boy's achievement. He then goes on to give credit for this exam performance when he says that the boy 'certainly pulled the stops out'. However when commenting about attitude to work he makes the following statements:

'(Boy's name) has continued with his "acting dumb" silliness - The trouble is the "act" rubs off on to reality. He seems largely unconcerned about the final outcome. He has been his own worst enemy - and it does not help to make lame excuses for not playing his part'.

There was a real opportunity for the teacher to capitalise upon something which was positive and quite unexpected by the teacher and which might have led to increased motivation in the boy. The teacher has laboured the point about previous poor attitude and also suggests that the boy is largely unconcerned about the final outcome, but would the boy have 'pulled the stops out' if he was really unconcerned?

There were a number of interesting comments by pupils about the fact that they had begun to find science more interesting when they had begun to work harder and had stopped 'messing about', but there was no indication whether this was the result of some form of externally imposed discipline, the result of a personal decision or simply being able to see the examinations looming ahead.

It was also interesting to note the differences which occurred between the comments which a teacher made about pupils who appeared to be about the same academic standard.

Contrast the following comment with those about the last pupil mentioned; both are being predicted to achieve the same grade, but one appeared to conform to the teacher's model of a 'good' pupil whilst the other did not.

TEACHER: '(Boy's name) has conscientiously maintained a slightly above average standard. His practical assessments have been rather disappointing.

He has always shown a willingness to work to the best of his ability. He has a very stable and commonsense approach to the subject'.

Furlong (1977) suggests that if we adopt some of the insights offered by Schutz sociology of knowledge it may be that teachers 'do not simply respond to the world in terms of psychological drives or cultural norms. Rather they actively construct their world by participating in a socially derived body of knowledge; they impose structure and organisation on their world'. (Furlong, 1977, 163).

He goes on to suggest that by studying their accounts of what they do we may find that they have provided a major resource for exploring their common-sense knowledge.

We can look at teachers' accounts of pupils to discover how they typify pupils in a way which is easily recognisable to other teachers.

Pupils may be seen as 'hard workers', 'lazy', 'disruptive' or 'sensible', 'mature' or 'immature'.

According to Schutz, typifications can be used by social scientists in gaining some leverage on what actors consider important in their subjective worlds. he suggests that for a name to be provided for something must indicate its "relevance" to the "linguistic in-group"'. (Furlong, 1977,175).

Within each of these typifications there are a host of connected categories into which pupils are pigeon-holed by teachers, but why do teachers typify pupils in this way?

Blanche Geer views teaching as a conflict situation which can be filled with tension.

'We can approach understanding of one source of the conflict between teacher and pupil if we think of teaching as an attempt to change the pupil by introducing him to new ideas'. (Geer, 1971,3).

The conflict model which Geer uses was proposed by Homans (1951) and takes the following form:

'A (the teacher) originates interaction for B (the pupil) by imparting knowledge or directing him to it. At the same time, A accepts the obligation to see to it that B responds as he (A) wishes. In fulfilling his responsibility, A evaluates the correctness of B's response and controls B's behaviour during the interaction sufficiently to make correct response possible . . . Teaching, in this model, is making the pupil learn; and a teacher's task is one of so managing the conflict his efforts may provoke that submission is temporary and the pupil's spirit unbroken'. (Geer, 1971,4).

Possibly most teachers would argue that this is not an accurate model of teaching today, but it still seems to present a picture of life in many English classrooms.

It is against this model that we can put some perspective on the actions of those pupils who do not conform to the demands of the teacher. They appear to deliberately undermine the teacher's position of authority and prevent him from fulfilling his responsibilities therefore the teacher must defend his own position and does this by 'labelling' the pupil according to the nature of his deviant behaviour.

In completing reports about pupils the teacher often uses a language which is part of the culture of the teaching profession and access to this language is, as Schutz explains, restricted to the 'in-group'.

'Any member born or reared within the group accepts the ready-made standardized scheme of the cultural pattern handed down to him by ancestors, teachers and authorities as an unquestioned and unquestionable guide in all the situations which normally occur within the social world'. (Schutz, 1971,32).

This in-group membership provides teachers with a recognised and accepted knowledge base and authority position from which to make their statements and rarely are they challenged which perhaps makes it not too surprising that they are not too enthusiastic about having another view juxtaposed with their own on a report form - it might throw the authority position into question.

APPENDIX G

EXAMINATION RESULTS

## EXAMINATION RESULTS

I decided to look at examinations results as evidence of the growth in importance of science education in the school particularly since the introduction of eight periods of science for all in September 1979.

In fact, the concept of 'science for all' was introduced when the school was re-organised, with science forming a compulsory element in the curriculum for all pupils. Over the years the importance attached to science by the school has been emphasised by its curricular position and by the increase of science provision for the below-average pupils from four periods to eight periods.

I was particularly interested to compare the results for boys and girls since the nature of the assessment procedures in integrated science give opportunities to display abilities across a range of testing methods including multiple-choice and longer essay-type answers.

Furthermore with the growing interest in 'girls in science' I wanted to investigate the results for signs of increased academic success which might reflect this increased awareness.

When the school became comprehensive in 1971, approximately twenty-five per cent of all pupils were entered for external examinations in science. This figure compares with what has happened over the last six years when over eighty-seven per cent of those who have remained at school after Easter (leavers at this time are about six to seven per cent of a year group) have taken at least one science examination.

In 1972 of course many pupils would have left school at the end of their fourth year, but the fact remains that all young people in the Dale now receive a very full science education and most obtain certification of their studies.

It should be noted that the figures for examination results in 1979 and 1980 are somewhat different from subsequent years due to the different curriculum pattern which was offered then. Agricultural Studies was one of the subjects in an options group comprising mainly practical subjects therefore it was possible for academically able boys and girls to opt for it so that they were actually able to gain three science qualifications since they also took Integrated Science which was a double subject.

The other major difference during those two years was that human biology had not been introduced, therefore the first set of results which reflected the policy of eight periods of science for all pupils came in 1981.

Analysis of the science examinations results in Table I reveals that the number of candidates, both boys and girls, entered for the O Level Integrated Science examinations has remained remarkably constant over the years despite some marked differences in the numbers of examination candidates in the year as a whole. Surprisingly in 1979 when there was a relatively large number of boys in the year group only eight boys were entered for Integrated Science O Level, a situation which was reversed in 1984, with few girls being entered.

The figures do seem to suggest a decline in the number of girls who are being entered for O Level examinations in the department and of those entered only about half pass Integrated Science A and usually slightly more pass Integrated Science B, but the figures are not consistent.

Effectively what this means is that between 10 - 15 per cent of all girls are entered for O Level examinations and roughly half that figure

## TABLE I

| YEAR | ENTRIES | | BOYS SCISP | BOYS SCISP | GIRLS SCISP | GIRLS SCISP | TOTAL CANDIDATES | | |
|---|---|---|---|---|---|---|---|---|---|
| | B | G | A | B | A | B | BOYS | GIRLS | ALL |
| 1984 | 14 | 5 | 64.3 | 64.3 | 100.0 | 80.0 | 40 | 47 | 87 |
| 1983 | 13 | 6 | 53.8 | 84.6 | 33.3 | 33.3 | 50 | 62 | 112 |
| 1982 | 13 | 5 | 53.8 | 61.5 | 40.0 | 60.0 | 55 | 55 | 110 |
| 1981 | 11 | 7 | 63.6 | 63.6 | 45.5 | 36.4 | 52 | 48 | 100 |
| 1980 | 17 | 7 | 64.7 | 52.9 | 57.1 | 71.4 | 60 | 46 | 106 |
| 1979 | 8 | 11 | 75.0 | 75.0 | 54.5 | 63.6 | 59 | 63 | 122 |

O LEVEL PASSES AS A PERCENTAGE
OF SCISP O LEVEL ENTRIES

pass each subject. The number of girls who pass both A and B is very small.

By comparison the entry figures for boys are much higher, generally between 20 - 28 per cent though the figures for 1984 reveal that 35 per cent of all boys were entered for O Level Integrated Science.

The pattern of O Level and O Level equivalent CSE passes (TABLE II) reveals that with the exception of 1979 the number of passes for girls has been significantly lower than for boys, indeed over the six years the girls have only gained 58.1 per cent of the O Level passes obtained by the boys.

The passes which girls have obtained have been generally at lower grade levels than the boys and the better performance in obtaining 24 grade 1 CSE passes probably reflects the greater numbers of girls taking CSE General Science and Human Biology, the latter being perhaps easier to pass. A large number of boys do not take a second science examination because they take applied physical science which is a non-examination course.

It is worth noting that if pupils transfer into the school during the fourth and fifth year it is very unusual for them to have taken integrated courses in their previous schools so they invariably have to take General Science and one of the three science options - girls usually take human biology, this improves the results in that subject.

The overall results in the CSE Integrated Science examinations do not follow the same pattern as for O Level if the average grades are taken as an indicator of performance.

For Integrated Science A the boys average grades range from 2.4 to 3.5

## TABLE II

| GRADE / YEAR | BOYS A | BOYS B | BOYS C | BOYS 1 | BOYS TOTAL | GIRLS A | GIRLS B | GIRLS C | GIRLS 1 | GIRLS TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 3 | 8 | 7 | 0 | 18 | 0 | 3 | 6 | 0 | 9 |
| 1983 | 0 | 5 | 13 | 2 | 20 | 0 | 1 | 2 | 2 | 5 |
| 1982 | 2 | 4 | 9 | 6 | 21 | 0 | 0 | 5 | 7 | 12 |
| 1981 | 3 | 6 | 5 | 3 | 17 | 2 | 4 | 3 | 2 | 11 |
| 1980 | 2 | 2 | 16 | 6 | 26 | 1 | 0 | 8 | 7 | 16 |
| 1979 | 1 | 4 | 7 | 10 | 22 | 2 | 3 | 8 | 6 | 19 |
| TOTALS | 11 | 29 | 57 | 27 | 124 | 5 | 11 | 32 | 24 | 72 |
| % | 5.6 | 14.7 | 28.9 | 13.7 | 63.2 | 2.5 | 5.6 | 16.8 | 12.2 | 36.7 |

O LEVEL SCISP GRADES A - C AND
CSE GRADES 1 IN SCIENCES (ALL SUBJECTS)

and seem to show a steady decline in grade levels over the six years and a similar trend appears in the Integrated Science B results, which range from 2.6 to 3.5

The girls average grades over the same period have shown similar wide variations covering more than one grade difference in both Integrated Science A and B, but there is no consistent pattern to their results. (TABLE III).

I decided to investigate the rates of success in other examination subjects to compare boys' and girls' performances to see whether the results showed any similarity with the science results. (TABLE IV).

As may be seen from the table of results girls perform significantly better on English, but particularly over the last few years their mathematics results have been much lower than the boys and there is evidence of a gradual downward trend. In a subject such as history, in which one might expect girls' verbal abilities to have a positive effect on the results, their superiority seems to have been lost since 1980. A similar position obtains in geography which reveals a relatively stable percentage of O level passes over the six years, but the girls levels of achievement have dropped dramatically.

It would appear from my analysis of examination results in selected academic subjects that girls are less successful in achieving academic success than boys with the outstanding exception of English language. It also appears that this trend has become more marked over the last three or four years, a phenomenon which might need to be investigated by the school.

As further evidence of performance in examinations I compared the trial examination results for the CSE Integrated Science group (Set 2) for

<u>TABLE III</u>

| YEAR | ENTRY | BOYS | | ENTRY | GIRLS | |
|---|---|---|---|---|---|---|
| | | A | B | | A | B |
| 1984 | 8 | 3.5 | 3.5 | 20 | 3.7 | 3.8 |
| 1983 | 13 | 3.2 | 3.0 | 23 | 2.7 | 2.9 |
| 1982 | 17 | 2.9 | 3.5 | 22 | 3.0 | 3.3 |
| 1981 | 21 | 2.5 | 3.0 | 15 | 3.1 | 3.7 |
| 1980 | 13 | 2.6 | 2.8 | 18 | 2.6 | 2.7 |
| 1979 | 18 | 2.4 | 2.6 | 22 | 3.1 | 3.1 |

CSE INTEGRATED SCIENCE A and B
AVERAGE GRADES FOR BOYS AND GIRLS 1979 - 84

the period 1978 - 85 comparing the mean marks for each of the six separate sections. (See Appendix B for Scheme and Aims of Examination).

I had expected to find that the first paper on Integrated Science A and B would reveal that girls tended to do less well than boys because the paper is an objective test requiring short answers, which do not allow the girls to use their verbal skills. In practice there was no clear pattern since in some years the girls out performed the boys and in others the situation was reversed.

Looking at the two paper 3's I expected that here the girls would be at an advantage because the papers seek longer written answers, but there was no difference between the means of the mean marks; they were identical at 15.7 marks and 12.1 marks.

The greatest difference, though still small, was to be found in paper A2 which revealed that the boys were one and a half marks better on average, but the figures also show that both boys and girls perform badly on this paper as they do on B2. Neither sex has been able to obtain even one third of the marks available on this paper in the eight years analysed.

## TABLE IV

| YEAR | MATHS | | ENGLISH | | GEOGRAPHY | | HISTORY | | SCIENCE A | | SCIENCE B | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | G | B | G | B | G | B | G | B | G | B | B |
| 1984 | 20.0 | 12.8 | 25.5 | 38.3 | 32.5 | 12.8 | 27.5 | 21.3 | 22.5 | 10.6 | 22.5 | 8.5 |
| 1983 | 12.0 | 1.6 | 20.0 | 32.3 | 24.0 | 8.1 | 28.0 | 24.2 | 24.0 | 3.2 | 24.0 | 6.5 |
| 1982 | 18.2 | 7.3 | 32.7 | 47.3 | 25.5 | 10.9 | 16.7 | 18.2 | 20.0 | 10.9 | 18.2 | 10.9 |
| 1981 | 15.4 | 10.4 | 32.7 | 35.4 | 30.8 | 16.7 | 17.3 | 14.6 | 13.5 | 14.6 | 13.5 | 8.3 |
| 1980 | 11.7 | 15.2 | 25.0 | 52.2 | 35.0 | 37.0 | 18.3 | 32.6 | 23.3 | 13.0 | 23.3 | 21.7 |
| 1979 | 13.6 | 22.2 | 23.7 | 46.0 | 32.2 | 31.7 | 25.4 | 33.3 | 20.3 | 14.3 | 20.3 | 15.9 |

O LEVEL GRADE A - C AND CSE GRADE 1 PASSES
AS A PERCENTAGE OF GIRLS AND BOYS
TAKING EXTERNAL EXAMINATIONS

# TABLE V

## $5_2$SCISP TRIAL EXAM RESULTS ANALYSIS 1978 - 85

| BOYS ENTRY | YEAR | INTEGRATED SCIENCE A A1 | A2 | A3 | INTEGRATED SCIENCE B B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| 19 | 1978 | 275 | 146 | 309 | 310 | 87 | 177 |
| | MEAN | 14.5 | 7.7 | 16.3 | 16.3 | 4.6 | 9.3 |
| 13 | 1979 | 255 | 81 | 211 (12) | 137 | 109 | 115 (12) |
| | MEAN | 19.6 | 6.2 | 17.6 | 10.5 | 8.4 | 9.6 |
| 12 | 1980 | 267 | 116 | 243 | 170 | 102 | 153 |
| | MEAN | 22.3 | 9.7 | 20.3 | 14.2 | 8.5 | 12.8 |
| 11 | 1981 | 195 | 74 | 190 | 112 | 94 | 107 |
| | MEAN | 17.7 | 6.7 | 17.3 | 10.2 | 8.5 | 9.7 |
| 17 | 1982 | 361 | 107 | 293 | 256 (16) | 139 | 209 |
| | MEAN | 21.2 | 6.3 | 15.9 | 16.0 | 8.7 | 13.1 |
| 10 | 1983 | 201 | 84 | 119 | 114 | 100 | 143 |
| | MEAN | 20.1 | 8.4 | 11.9 | 11.4 | 10.0 | 14.3 |
| 8 | 1984 | 137 | 73 | 102 | 82 | 70 | 91 |
| | MEAN | 17.1 | 9.1 | 12.8 | 10.2 | 8.8 | 11.4 |
| 15 | 1985 | 296 | 163 | 190 (14) | 172 | 162 | 231 (14) |
| | MEAN | 19.7 | 10.9 | 13.6 | 11.5 | 10.8 | 16.5 |
| | MEAN OF MEANS | 19.0 | 8.1 | 15.7 | 12.5 | 8.5 | 12.1 |

## TABLE V

### $5_2$SCISP TRIAL EXAM RESULTS ANALYSIS 1978 - 85

| GIRLS ENTRY | YEAR | INTEGRATED SCIENCE A A1 | A2 | A3 | INTEGRATED SCIENCE B B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| 14 | 1978 | 207 | 77 | 234 | 212 | 50 | 118 |
| | MEAN | 14.8 | 5.5 | 16.7 | 15.14 | 3.6 | 8.4 |
| 15 | 1979 | 294 | 63 (16) | 260 (15) | 184 | 121 (16) | 153 |
| | MEAN | 19.6 | 3.9 | 17.3 | 12.3 | 7.6 | 10.2 |
| 15 | 1980 | 321 | 125 | 305 | 176 | 103 | 199 |
| | MEAN | 21.4 | 8.3 | 20.3 | 11.7 | 6.9 | 13.3 |
| 18 | 1981 | 299 | 69 | 282 | 171 | 109 | 138 |
| | MEAN | 16.6 | 3.8 | 15.7 | 9.5 | 6.1 | 7.7 |
| 23 | 1982 | 418 | 143 | 318 | 333 | 226 | 298 |
| | MEAN | 18.2 | 6.2 | 16.4 | 14.5 | 9.8 | 13.0 |
| 18 | 1983 | 374 | 185 | 253 | 225 | 174 | 257 |
| | MEAN | 20.8 | 10.3 | 14.1 | 12.5 | 9.7 | 14.3 |
| 16 | 1984 | 261 | 109 | 179 | 151 | 131 | 201 |
| | MEAN | 16.3 | 6.8 | 11.2 | 9.4 | 8.2 | 12.6 |
| 11 | 1985 | 251 | 79 | 155 | 124 | 93 | 188 |
| | MEAN | 19.5 | 7.2 | 14.1 | 11.3 | 8.5 | 17.1 |
| | MEAN OR MEANS | 18.4 | 6.5 | 15.7 | 12.0 | 7.6 | 12.1 |

# APPENDIX H

# BRIEF HISTORY OF THE SCIENCE DEPARTMENT

## A BRIEF HISTORY OF THE SCIENCE DEPARTMENT

It was in 1959 that the role of "head of science" first began to evolve in the dale when the present head of science was appointed as the first science tacher at the new modern school.
He recalls his interview:

"I wasn't a meek and mild sort of fellow . . . I had an element of conceit about myself I knew I was going to do a good job and I said to the headmaster, 'Look I want a scale post straight away' - I was a probationer. I wanted a scale post and I pressed for it" - he got it.

His reason for entering teaching are interesting and throw some light on his general philosphy of education.

After graduating from university as a botanist he obtained a diploma in agricultual science and, disillusioned with academic life, he decided to go into agricultural advisory work, but was soon struck by the tremendous "problems of ignorance" when trying to communicate with farmers. This he saw as a consequence of their education which had been in all-age village schools and probably did not extend much beyond primary level.

It was whilst he was questioning his decision to go into advisory work that he got a temporary teaching job in a school in Hull where the headmaster fired him with the enthusaism to undertake post-graduate training in education.

It was at this time he first came into contact with, "this silly prejudice about the separate sciences", but he was more concerned with science education for the modern school pupil and decided that that was where he wished to teach.

Having obtained his first post he "dabbled" trying to discover for himself what science and science education was all about: being free of examination pressures he could do this.

This was the time of early developments in Nuffield Secondary Science which was to bring general science "out of the doldrums" so that "it began to make some sense".

He began by teaching half-classes until the school expanded when a part-time teacher was appointed to work with him. At the end of his first year the headmaster had 'suggested' that he might start a school farm.

For most of the next eleven years the teacher continued to experiment with science doing anything which interested him or his pupils, but he particularly remembered the flashing light displays they created. Science teaching then was very much a question of bringing the outside in and trying to understand it in an atmosphere which was free from formal academic structure.

When comprehensive re-organisation was first mooted in the late 60's the teacher decided that he did not wish to move therefore he must become head of science, and began to act accordingly despite the fact that there were possible candidates for the post from the grammar school involved in the re-organisation.

The head of the grammar school was appointed to be head of the new comprehensive school which was planned to be on the site of the modern school. Strong local opposition to this decision caused the local authority to revise its plans on the basis of a split-site school - the two premises were thirteen miles apart.

Despite great reservations from the academics in the area, but with the support of his headmaster the teacher was appointed head of science in the comprehensive school: the first of what he sees as several lucky breaks in his career because in open competition he doubts whether he would have got the job.

During the planning for the new school he remembers being excited by the prospect of O and A level teaching which would be academically extending after so many years in the modern school: at the same time he pondered the task of integrating the able with the less-able in a science curriculum.

During the transitional period he got his opportunity to teach the more-able pupils and began to realise that there were many "fundamental scientific issues that were being completely skated over and taken for granted by rote-learning".

He entered a period of fundamental reassessment of his teaching: a reawakening which made him realise that he was unaware of what was being done elsewhere, so he enroled for a heads of departments course at Leeds University.

The department, which now consisted of the head of department and the three grammar school scientists had decided to adopt the Nuffield Combined Science course for the first two years and had begun writing their own integrated course for third year pupils which would feed them into separate science courses in the fourth and fifth years.

Science provision at the time of the merger was:

| GRAMMAR | MODERN |
|---|---|
| A level Physics, Chemistry, Biology | CSE Biology and Human Biology |
| O level Biology (compulsory), | CSE Agricultural Studies Mode 3 |

| Physics and Chemistry (Options) | School Farm |
|---|---|
| CSE Environmental Science Mode 3 | 1½ Scientists 1 lab + 1 room |
| 3 scientists 2 labs | |

The head had plans for a full range of O and CSE options requiring three labs on each site and six full-time science teachers. Pruning by the local authority reduced staffing to head of department plus four and three labs on one site and two on the other - senior science had to be based on the grammar school site.

At the Leeds course the head of department explained his plans for an integrated third year course to Fred Archinhold who enquired whether he had heard about the Schools Council Integrated Science Project which was being trialled in schools at the time. The head of department said that he had not, but he was invited out of interest to attend a meeting in Sheffield.

This meeting fired the head of department with enthusiasm for the SCISP approach as the Phase two schools were being briefed.

"And there something seemed to click and I just began now to see, to get the answer that I'd been questioning myself on. What is science teaching all about? What should we be teaching?

But then out of the blue he was invited to join the other Phase two schools to replace a school which had dropped out.

He accepted - this is seen as the second lucky break - but he had not realised, "that I'd have to clear it with County Hall and the headmaster, so then the really . . . the infighting really began".

The task was to convince the headmaster that a new-look science curriculum should be developed in the turmoil of re-organisation - this was three months before the new school was to open.

The following evidence was supplied by the head of department from his personal records and though it was unsigned it is thought to have been written by the headmaster elect:

1. 'Subject boundaries have always been arbitrary; no person would argue them to be absolute. The development of learning is surely the development of categories of knowledge in which the rules of the game are similar. This is a means of simplification, a way of getting order out of a vast field of human experience, and subject divisions are only a step in this process which goes further within the subject itself. Development of learning, involves structuring of knowledge and I see this project (SCISP) as questioning the present structuring but also suggesting another.

No teacher should teach his subject in isolation and I think the interaction of subjects from two viewpoints is a point of strength. I question whether more psychology and sociology is required than that which should be dealt with through the conventional subjects; in fact separately I believe they would lack relevance.

I am all in favour of weight being given to the social consequences of science. But to be a psychologist one needs to master the cold logic and reasoning of science and also the feelings of understanding and compassion seen best through the arts. If this arguement were developed further it would lead to the conclusion that all subjects should be taught together - an intellectual suet pudding which would baffle everyone.

2. It should be noted that there are different levels of subjects. Secondary subjects are very much dependent on other subjects for their basic elements. These basic core subjects must be fully mastered before the secondary subject can be understood. Thus biochemistry can only be reached through basic chemistry and biology'.

These points of view were not very encouraging to the enthusiastic head of department and he recalled spending many hours at the head-masters home being "grilled" about his plans. In fact the headmaster eventually accepted the idea, but only as a limited experiment for third years and then it may have only been a timetabling expedient to solve his options problems according to the head of department.

Before the next major decision had to be made the headmaster died very suddenly to be replaced temporarily by his deputy, who, after some initial reservations gave the scheme his full approval.

Two members of the department had left the school because they were unhappy with the new plans leaving only the chemist from the old grammar school staff and he and the head of department have taught the fourth and fifth year SCISP ever since.

In a bid to gain the support of the people of the dale who were still upset at the loss of the grammar school the head of department issued a set of notes to parents which outlined the new science position, but he also asked his ex-grammar school colleague to write an article giving his view, and these were supported by the views of the newest member of the department who had been recruited to teach Combined Science and Agriculture.

When the new headmaster took up his post in January 1973 he saw no reason to interfere with the 'new science' though he himself is a chemist with no experience of teaching integrated science courses.

At this time the pupils in the fourth and fifth years who were taking the integrated courses were given eight periods each week and it was expected that they would take either the double O level integrated science examination or the CSE Integrated Science double subject Mode 3 examination which the head of department had pioneered when the project was first introduced into the school.

When he had first suggested that such an examination, based on a reduced number of 'patterns' from the O level syllabus, people had said that it could not be done, but he persisted and finally it was accepted and by 1974 he had sufficient statistical evidence from the examinations to prove his point.

The below-average pupils only had four periods of science at this time as the other four periods were allocated to a practical options block which included agriculture, but it was not regarded as an educationally sound pattern of subjects since most were taking three practical subjects.

In 1978 the third stroke of luck appeared in the shape of an offer from the DES to the local authority of some extra money for school building and the authority seized the opportunity to end the fiasco of the split-site school by rushing through plans for a new block to replace the grammar school provision.

Although the new building could, in no way replace what had been lost it did afford an opportunity to design three new laboratories, two of which were specifically planned with SCISP in mind.

As the school was at last united the headmaster took the opportunity to rationalize the science provision, so that everyone would have eight periods each week - much easier to timetable. So science for the less-able was to consist of four periods of General Science and four periods of one of three science options: Human Biology, Agriculture or a non-examination course Applied Physical Science.

The latest chapter in the development of the department began in September 1984 when the school was invited to trial the New Nuffield Combined Science course.

# APPENDIX I

# THE QUESTIONNAIRE

## THE QUESTIONNAIRE

The questionnaire I chose to assess pupils' attitudes to science was the modified version of the Science Pupil Opinion Poll which was developed at the National Foundation of Educational Research by a team under the leadership of Dr. L. S. Skurnick (1971), from the questionnaire form 104 which had been designed specifically for testing science attitudes.

Although the question on the modified questionnaire had been re-written to refer to specific sciences, i.e., physics, chemistry and biology. they had all originally appeared in a 'science' format on the original questionnaire therefore I re-wrote them in their original form.

There are thirty-three items in the questionnaire although only twenty-nine are actually used in the measurement of the five factors which are claimed by the author.

Items 3, 29, 31 and 32 are the items not included in the factor analysis, but I left them in because I felt that as single items they might help to throw some additional light on the attitudes of pupils to science education.

Scale 1 - items 1, 2, 4, 6, 11, 12, 17.

Pupils scoring highly on this scale find this subject fun, something to be enjoyed and to be eagerly anticipated during the school week with the suggestion that they would enjoy doing more of this type of work.

The authors cite D. R. Krathwohl et als (1964) 'Taxonomy of the Affective Domain' and place this factor as being closest to 'satisfaction in response', or as they also call it the 'fun factor'.

Scale 2 - items 14, 18, 23, 24, 26, 27, 28.

High scores indicate enjoyment and interest in practical aspects of science work with particular emphasis placed upon working as a member of a group in problem solving.

'Such pupils reject the description of the subject as jargon and they consider the subject to be within their intellectual grasp'. (1).

Skurnick and Jeffs (1971) refer to such pupils as 'practical investigators'.

Scale 3 - items 5, 7, 9, 13, 15, 16.

This scale reveals the worth and value which pupils place on the study of the subject for its own sake even to the extent of it being an outside interest and linked with possible career aspirations. It therefore seeks to identify the 'committed scientists'.

Scale 4 - items 21, 22, 25, 30, 33.

Skurnick and Jeffs (1971) suggest that there may be 'a practical - theoretical or a concrete - abstract dichotomy' which is present which differs from the practical element in Scale 2 which seeks to use practical work as an avenue to further investigation and speculation. Here it is concerned more with levels of understanding and comprehension in that pupils prefer the work to be presented in a non-abstract form which directly involved them in the practical solution of problems, but which also allows them to determine the structure and pace of their work. Time to speculate and think about the work is appreciated in the search for comprehension.

Scale 5 - items 8, 10, 19, 20.

QUESTIONNAIRE Q3.

These items are designed to reveal those who have a long term interest in science as a career and who have sought and obtained parental approval for their ideas.

REASONS FOR ADMINISTERING THE QUESTIONNAIRE

I wanted to test whether there was a strong measure of enjoyment of science particularly in the third year since this had been mentioned by the two teachers concerned as a strong feature of their work with that year.

It was felt that enjoyment played a major part in what they saw as a successful introduction to the Schools Council Integrated Science course.

In my interviews with pupils a number of references were made to the fact that they had enjoyed science more in the third year and I wondered whether the present pupils in that year shared their feelings and whether there was any noticeable decline in the 'fun' aspects of science as pupils progressed through the school.

There were indications in my interviews with pupils that they enjoyed the practical work because it allowed them to work as a co-operative group in tackling a problem, but at the same time there were others who felt there were advantages to working on ones own.

There appeared to be a feeling that perhaps science is too 'wordy' a subject in that teachers very often use a large number of words to say something which pupils are able to translate for themselves into relatively few words.

Pupils would probably doubt the link which Skurnick and Jeffs (1971) make between the subject not being bedevilled by jargon and at the same time linking this with the ability to cope with the subject intellectually.

The feeling would probably be that if the subject can be explained in jargon-free language then they are able to grasp the ideas and concepts, but find great difficulty otherwise.

I would expect to find rather low-scores on this fifth scale which identifies the 'career scientist' because of the nature of the school catchment area being largely rural with few pupils coming from homes with significant scientific backgrounds. Pupils with an interest in science to this level will largely come from middle-class families who are normally identified as 'in-comers' by the locals. However because of the way the intake is possibly skewed towards the lower-ability levels it is unlikely that there will be large numbers of pupils who see themselves as having careers in science. In the locality of the school there is no industry which could be said to be an influence in encouraging pupils to want to pursue scientific careers in the way that perhaps the large petro-chemical industries possibly influence young people on Teeside for example.

The fourth scale is one which I believed might strongly suggest the practical bias of the pupils, because several had claimed that they would much rather do something or even watch something rather than have a verbal explanation. Pupils claim that 'doing' something for themselves considerably increases the chances of their understanding the work particularly if they are given sufficient time to observe and discuss the findings of these observations with each other.

Scale three is not one upon which I would expect very many pupils to score high marks because they do not seem to be the sort of questions most young adolescents would respond to in a positive way in that they seem to be alien when compared with youth culture and the normal life-style of the majority of pupils in a comprehensive school.

QUESTIONNAIRE Q5.

## PROBLEMS ENCOUNTERED IN ADMINISTERING THE QUESTIONNAIRE

I decided to administer the questionnaire a fortnight before the end of the Spring term, but in the event a number of factors arose which had some influence upon the data I was able to collect:

1. At the time the school was hit by an epidemic of influenza which meant that large numbers of pupils were absent from school.
2. One of the Teacher Associations decided to use the school in its industrial action in support of their pay claim which resulted in all pupils, with the exception of the fifth and sixth forms being out of school for three days.
3. Re-arrangement of end-of-term events because of disruption caused by the industrial action.
4. Two of the science staff were absent from school on a number of days during that fortnight in connection with examinations and curriculum development and they preferred to have the questionnaires completed during their lessons because it would create a better atmosphere.

## PROBLEMS OF THE SAMPLES

The sample of third year pupils is probably a good representative sample of the boys as it has caught most of them, but the girls sample is rather low and represents roughly a third of their total. This year group are all involved in the same science course, namely the first year of the Schools Council Integrated Science Course and they have all had identical experience during the first and second years being taught Nuffield Combined Science.

The samples in the fouth and fifth years present problems in that they no longer have the same experience because at the end of the third year there is differentiation according to ability.

QUESTIONNAIRE Q6.

Roughly the top 50% of the ability-range go into two groups and study Schools Council Integrated Science but the remainder follow a General Science course based upon Nuffield Secondary Science; this is for half of their science time and they then choose from Applied Physical Science (non-exam), Human Biology and Agriculture for the remainder of their time.

I decided that there probably was no real problem as I was considering science in general rather than individual subjects.

# PUPIL OPINION POLL

## SCIENCE

Please ring the appropriate items below.

| Year | Courses | Sex |
|---|---|---|
| 3 4 5 | SCISP APS HB AG | B. G. |

The purpose of this questionnaire is to find out what you think about science as it is taught in your school. The questionnaire contains a number of statements about science.

We want to know what you feel and think about these ideas and whether you agree with them or not.

This is not a test and there are no right and wrong answers. We would like you to give your own opinion of each of the statements in the booklet.

Directions

Read the sample item below.

Sample item

I would rather read a book than watch television.

| A | B | C | D | (E) |
|---|---|---|---|---|
| Strongly agree | Agree | Not sure | Disagree | Strongly Disagree |

Each statement is followed by five lettered alternatives, A to E which are used to indicate how far you agree or disagree with the statement. Thus, if you strongly disagreed with the statement you would mark alternative E as illustrated above.

Each statement in the booklet looks like the sample item. When you read each one carefully, also read each of the alternatives given below it. Then decide which ONE answer best fits your feelings and mark the box for that answer on your answer sheet. Please choose only one alternative for each statement and try to respond to every statement. If you mark a wrong letter by mistake, erase the mark carefully before putting in the correct one.

Do not think too long on any one statement. Give the first 'natural' answer as it comes to you. Try to answer every one of the items in the booklet.

## SCIENCE IN MY LIFE 

1. I enjoy science lessons more than other lessons.

| A | B | C | D | E |
|---|---|---|---|---|
| much | slightly more | about the same | less | much less |

2. Two hours of work in a science laboratory are more fun than a week of work in other subjects.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

3. There are too many facts to learn in science.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

4. Science lessons are a waste of time.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

5. I like to talk with people about new discoveries in science.

| A | B | C | D | E |
|---|---|---|---|---|
| very much | much | some | a little | not at all |

6. I do well in science.

| A | B | C | D | E |
|---|---|---|---|---|
| very well | well | average | poorly | very poorly |

7. I would like to be given a science book or a piece of science equipment.

| A | B | C | D | E |
|---|---|---|---|---|
| very much | I would be pleased | it would be all right | I don't think I would like it | not in the least |

8. My mother wants me to be a scientist.

| A | B | C | D | E |
|---|---|---|---|---|
| very much | much | some | not sure | not at all |

9. I would rather be a member of a 'pop group' than a member of a science research team.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

10. I would specialise in science if I had the chance.

| A | B | C | D | E |
|---|---|---|---|---|
| definitely yes | very likely | maybe | not likely | never |

11. I look forward to science lessons.

| A | B | C | D | E |
|---|---|---|---|---|
| always | most of the time | sometimes | seldom | never |

12. I would enjoy school more if there were no science lessons.

| A | B | C | D | E |
|---|---|---|---|---|
| much more | slightly more | just as much | less | a great deal less |

13. I should like to belong (or like belonging) to a science club.

| A | B | C | D | E |
|---|---|---|---|---|
| very much | some | a little | not sure | not at all |

14. Science is just a load of technical terms which are hard to remember.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

15. I would like to work with people who make discoveries in science.

| A | B | C | D | E |
|---|---|---|---|---|
| all the time | most of the time | occasionally | seldom | never |

16. I do science experiments in my spare time about:

| A | B | C | D | E |
|---|---|---|---|---|
| once a week | once a month | once every three months | once a year | never |

17. I think the school should have more science periods each week.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

18. I find science difficult to understand.

| A | B | C | D | E |
|---|---|---|---|---|
| extremely difficult | difficult | in between | easy | very easy |

19. My father wants me to become a scientist.

| A | B | C | D | E |
|---|---|---|---|---|
| very much | much | some | not sure | not at all |

20. I should like to become a scientist.

| A | B | C | D | E |
|---|---|---|---|---|
| very much | much | some | a little | not at all |

## LEARNING ACTIVITIES

21. I would much rather do experiments in science than read about them.

| A | B | C | D | E |
|---|---|---|---|---|
| always | most of the time | sometimes | seldom | never |

22. I would rather do a science experiment than listen to a lecture on the same topic.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

23. I want to learn for myself why science experiments turn out the way they do.

| A | B | C | D | E |
|---|---|---|---|---|
| very much | much | a little | not sure | not at all |

24. It is fun to guess the outcome of science experiments

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

25. It is the experiments in science that make me understand it.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

26. Working in the science laboratory is fun.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

27. Trying to solve a science problem is interesting.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

28. I would rather work out how to do a science experiment by myself than be told.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

29. I enjoy discussing science problems raised in class with my friends.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

30. You can learn more from a science text book than by doing experiments.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

31. Science teachers always ask questions to which they know the answers.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

32. More science equipment is needed in schools.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

33. Science experiments demonstrated by teachers are more interesting than the ones you do for yourself.

| A | B | C | D | E |
|---|---|---|---|---|
| strongly agree | agree | not sure | disagree | strongly disagree |

## ANALYSIS OF THE RESULTS OF THE SCIENCE QUESTIONNAIRE

The purpose of the questionnaire was not to produce a detailed statistical analysis, but simply to try to obtain a broad impression of the general response to science among pupils in the three years taking SCISP.

On the first scale which attempts to measure the degree of fun which pupils express they have in science it may be seen that all third year pupils, both boys and girls show that they enjoy the subject. (See page ). The results for the fourth and fifth years indicate a decline in enjoyment each though the low mean score in the fifth year was largely attributable to three girls who obviously do not enjoy science. The boys results show that they continue to enjoy science throughout their course.

The results on scale two show a strong orientation towards practical work amongst boys and girls with only a slight difference being shown over the three years. These figures are perhaps to be expected since the evidence in my research interviews revealed a strong preference for practical work as it provided pupils with a visual image which helped them to achieve understanding more easily than listening to a verbal description or by reading about an experiment.

Boys showed a deeper general interest in science and scientific method as measured by scale three than the girls though their interest was not deep in terms of seeing science as having a central place as a life interest. Girls generally and particularly by the fifth year were definitely quite sure that science would not feature to any large extent in their lives.

Scale four was concerned with the practical orientation towards problem-solving as opposed to the abstract/theoretical approach. The results for both sexes reveal a very strong preference for work which allowed them to spend time observing and doing experiments before considering their results. These opinions accord with the emphasis which is placed on investigative practical work in the science department suggesting that the pupils find the methods by which science is taught generally meet their learning needs. Perhaps this also indicates something about the general level of intellectual development of these adolescents being lower than the formal stage, which might account for the difficulty they have in handling abstract concepts.

The final factor was designed to reveal the strength of commitment to a possible life in science and this produced the expected results with no-one in any year being totally committed to science at this stage though there was a small number in each year group who were moderately interested. Only one girl showed any interest in science as a career and even then she only stood out because of the low scoring of her peers.

The overall impression of the results is that despite the fall in amount of fun or enjoyment which the girls claim to get from science they are keen on the approach therefore the results seem to suggest that there may be other factors to consider other than the flat rejection of the subject. It is interesting that the girls were also positive on the question of practical work since it has often been stated that girls prefer to read books or watch someone else, and it is also clear that this enjoyment is not only because the girls prefer 'active' science, but because they clearly see it as an aid to increasing their ability to learn.

Boys clearly enjoy the science course and find that the approach suits them which again is not surprising in an area which earns its living from practical activity. Although few boys expressed interest in science as a career there was more evidence that the boys envisaged that science would play a part in their lives.

If all factors are aggregated then only a very small percentage of perhaps ten per cent or less were very negative towards science and only two girls seemed to reject it completely.

RESULTS OF THE SCIENCE QUESTIONNAIRE

SCALE ONE - THE FUN FACTOR — ITEMS 1, 2, 4, 6, 11, 12, 17. MAX 35 MIN 7

| | | | |
|---|---|---|---|
| YEAR 3 | GIRLS | RANGE 16 - 31 | MEAN 22.4 |
| YEAR 4 | GIRLS | RANGE 10 - 25 | MEAN 18.6 |
| YEAR 5 | GIRLS | RANGE 8 - 23 | MEAN 17.0 |
| YEAR 3 | BOYS | RANGE 17 - 33 | MEAN 24.7 |
| YEAR 4 | BOYS | RANGE 12 - 30 | MEAN 22.1 |
| YEAR 5 | BOYS | RANGE 14 - 31 | MEAN 21.0 |

SCALE TWO - PRACTICAL INVESTIGATORS — ITEMS 14, 18, 23, 24, 26, 27, 28. MAX 35 MIN 7

| | | | |
|---|---|---|---|
| YEAR 3 | GIRLS | RANGE 16 - 27 | MEAN 21.5 |
| YEAR 4 | GIRLS | RANGE 14 - 26 | MEAN 20.6 |
| YEAR 5 | GIRLS | RANGE 13 - 29 | MEAN 19.8 |
| YEAR 3 | BOYS | RANGE 15 - 33 | MEAN 23.8 |
| YEAR 4 | BOYS | RANGE 17 - 30 | MEAN 24.3 |
| YEAR 5 | BOYS | RANGE 11 - 28 | MEAN 23.0 |

SCALE THREE - COMMITTED SCIENTIST — ITEMS 5, 7, 9, 13, 15, 16. MAX 30 MIN 6

| | | | |
|---|---|---|---|
| YEAR 3 | GIRLS | RANGE 7 - 20 | MEAN 12.3 |
| YEAR 4 | GIRLS | RANGE 7 - 15 | MEAN 10.5 |
| YEAR 5 | GIRLS | RANGE 7 - 16 | MEAN 10.5 |
| YEAR 3 | BOYS | RANGE 6 - 23 | MEAN 14.5 |
| YEAR 4 | BOYS | RANGE 9 - 23 | MEAN 15.8 |
| YEAR 5 | BOYS | RANGE 8 - 20 | MEAN 14.6 |

<u>SCALE FOUR - CONCRETE SCIENTISTS</u> <u>ITEMS</u> 21, 22, 25, 30, 33. MAX 25 MIN 5

| | | | |
|---|---|---|---|
| YEAR 3 | GIRLS | RANGE 17 - 25 | MEAN 21.1 |
| YEAR 4 | GIRLS | RANGE 14 - 22 | MEAN 19.1 |
| YEAR 5 | GIRLS | RANGE 12 - 24 | MEAN 18.8 |
| YEAR 3 | BOYS | RANGE 10 - 24 | MEAN 19.1 |
| YEAR 4 | BOYS | RANGE 16 - 25 | MEAN 20.5 |
| YEAR 5 | BOYS | RANGE 16 - 24 | MEAN 21.0 |

<u>SCALE FIVE - CAREER SCIENTISTS</u> <u>ITEMS</u> 8, 10, 19, 20. MAX 20 MIN 4

| | | | |
|---|---|---|---|
| YEAR 3 | GIRLS | RANGE 4 - 15 | MEAN 7.3 |
| YEAR 4 | GIRLS | RANGE 4 - 10 | MEAN 6.6 |
| YEAR 5 | GIRLS | RANGE 4 - 12 | MEAN 5.6 |
| YEAR 3 | BOYS | RANGE 4 - 14 | MEAN 7.6 |
| YEAR 4 | BOYS | RANGE 4 - 15 | MEAN 8.0 |
| YEAR 5 | BOYS | RANGE 4 - 14 | MEAN 7.6 |